The Use of Electronic Monitoring (EM) Technologies in Alaskan Fisheries

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January, 2011

Introduction

The term electronic monitoring (EM) is very broad and can include a wide range of technologies such as Vessel Monitoring Systems (VMS); electronic logbooks; video (including cameras, digital recording systems and monitors); and the integration of video with other data sources such as radio frequency identification (RFID) tag readers, net pinger hydrophones, winch sensors, and hydraulic pressure monitors. For purposes of this paper, we use the term EM to describe the use of video cameras, which may be integrated with other electronic sources of data.

EM has become an increasingly viable technology for monitoring some types of fishery activities and enhancing observers' ability to collect data. As early as 2002, NMFS began exploring the use of EM technology in Alaskan longline fisheries as a tool to ensure compliance with the use of seabird deterrence devices and as a management tool to identify seabirds caught on a longline. In 2004, the Council assessed the range of EM being used in fisheries (MRAG 2004) and, by 2006, the National Marine Fisheries Service (NMFS) completed several EM projects that helped to assess the general efficacy of EM technology in commercial fisheries. These projects included evaluating the effectiveness of EM technology to monitor the discard of prohibited species catch (PSC) on a factory trawler and monitor and enumerate discard aboard rockfish catcher vessels in the Gulf of Alaska.

At the June 2006 North Pacific Fisheries Management Council (NPFMC) meeting, NMFS presented a discussion paper about the issues associated with the implementation of EM (Kinsolving 2006). This paper highlighted several issues that needed to be resolved prior to implementation of a large scale EM program. These issues included: 1) the cost of implementing EM, which can be similar to, or higher than, the cost of observers depending on the monitoring goal; 2) difficulty determining how to apportion costs between NMFS and the fishing industry; 3) the ability of EM to quantify species was untested against observer data; and 4) the level of EM technology could become "fossilized" at the time implementation takes place.

Since 2006, EM technologies have continued to evolve and the use of video, in particular, has seen considerable interest. Several different video applications have been developed in the North Pacific and elsewhere and many of these applications have been in experimental settings where their ability to meet identified monitoring objectives were tested and evaluated. Several successful EM video projects have been conducted in Alaska and EM in a surveillance capacity is currently regulated and will expand under Amendment 91. However, to date, we do not have any operational systems in Alaska where we routinely collect the video imagery and extract information from it for fisheries management.

In this paper we summarize the work that has been done evaluating the potential use of EM in commercial fisheries off Alaska and describe the required use of EM in the Amendment 80 and Amendment 91 fisheries. We also provide an update on national and international conferences and workshops to illustrate how different regions and countries are applying EM in fisheries management and identify several potential candidate applications for EM.

EM Studies in Alaska

Gulf of Alaska Rockfish Fishery

Alaska Groundfish Databank, in conjunction with NMFS, has conducted several studies to assess the efficacy of EM for recording and quantifying the discard of halibut from trawl catcher vessels in the Gulf of Alaska (GOA). These studies sought to address the challenges of large scale implementation, where a fishery would be managed using the data obtained from EM systems; these challenges included: 1) the durability of EM equipment under Alaskan fishing conditions; 2) precision and accuracy of the data collected by EM; 3) infrastructure issues related to cost, enforcement, fleet management, and integration with the catch accounting database; and 4) the need for timely data for quota fishery management

The first of these EM studies was conducted during the summer of 2005 and occurred prior to the implementation of the Rockfish Pilot Program (McElderry 2005). The goals of the study were to: 1) determine if EM systems would perform reliably in Alaskan waters; 2) determine when and where discards occur; 3) identify species of fish being discarded; 4) enumerate halibut discards; 5) determine EM costs; 6) evaluate whether EM could replace observers; and 7) determine if there would be industry support for an EM system.

EM systems were deployed aboard 10 trawl catcher vessels during the GOA rockfish fishery. Two cameras were used to observe the entire trawl deck and two additional cameras were deployed to view each discard chute. At the end of the project, two independent reviewers examined the footage to determine when and where discard occurred and to enumerate halibut. The results of the study demonstrated that EM could be reliable in Alaskan waters and could meet the basic goals of determining when and where discard occurred. One key finding was that the effectiveness and practicality of EM was highest when discard volumes were low. Additionally, the crew rarely used the discard chutes so EM reviewers had to rely on the wide angle cameras that provided coarse footage of the entire deck. Since the crew discarded from multiple locations and discarded multiple species simultaneously it was difficult for EM reviewers to track all discard events. Fish with similar appearance (e.g., species in the flatfish and rockfish families) could only be identified to the family level rather than to species. The project also concluded that although EM might be able to replace some duties of an observer, some level of observer coverage was needed to collect biological information. While industry showed strong support for the program, the costs for EM in this study were higher than that of observer coverage. However the study had intensive onsite technical support so it is possible that the costs might be lower in a fully implemented fishery.

In 2007, NMFS and Alaska Groundfish Databank conducted the first phase of a two phase study to test the ability of EM to obtain accurate halibut counts under the Rockfish Pilot Program (Bonney and McGauley 2008). The goals of Phase I were to 1) determine if it was feasible to restrict halibut discard to only one location, 2) determine if the counts obtained from EM were accurate, and 3) determine if accurate lengths for halibut could be obtained using EM. In this study an EM system was deployed on a single vessel in an experimental setting. Again two cameras were used to observe the entire deck and two cameras viewed the single discard chute. Discard was restricted to only halibut and only one location. NMFS and Alaska Groundfish Databank staff conducted an at-sea census and obtained lengths for each of the halibut discarded to compare with those obtained using EM. Video footage was examined by two independent reviewers at the end of the season. The results of the study showed that it was feasible to discard only halibut and in only one location. The observer-based estimates of halibut weight and numbers were not significantly different from the total (at sea discard census plus landings) values.

Precision of the EM estimates was high, while the precision of the observer estimates was low, in particular at the haul level.

Following on the success of the Phase I study, the Phase II study was conducted during the 2008 Rockfish Pilot Program fishery (Bonney et al. 2009). The goals of the study were to 1) determine the time lags between vessel arrival in Kodiak and data available to quota managers under different scenarios; 2) investigate the development of NMFS catch accounting data base infrastructure for handling EM data and linking EM data to the source delivery; 3) determine whether EM systems can be effectively deployed on a wider variety of vessels fishing under real world conditions; 4) more fully assess the costs associated with various components of an EM program (equipment, support, and analysis); and 5) assess the qualitative effectiveness of EM for quantifying halibut and ensuring compliance with discard rules.

EM was deployed aboard four trawl catcher vessels that represented one cooperative for the entire Rockfish Pilot Program fishery. Each vessel was allowed to design their discard chute. At the end of each trip, the hard drives were removed and mailed to Canada for review. The results showed that accurate counts and lengths of halibut could be obtained using EM but, to be successful, additional crew training was needed and the chutes needed to be more uniform in design. In this study the costs for EM were higher than the cost of observer coverage and the time lag of up to two weeks to receive the data was unacceptable for NMFS and industry quota managers. Both the costs and the time lag were related to the amount of human review necessary to obtain a full census and a length estimate for each halibut. Also, while EM appears to be an appropriate mechanism for accounting for halibut bycatch, it cannot replace a human observer for collecting catch data that must be spatially explicit at the haul level.

Video Analysis

One of the largest costs in the implementation of an EM system is related to the amount of time that is needed for a human to review the video. Depending on the specific monitoring requirements it may be feasible to sample the video to obtain the information required. However if the objective is a full census of halibut PSC discard, then human review of all video footage is necessary.

The time lag before EM data were available to quota managers and the high cost of an EM program were two concerns highlighted in the EM pilot studies conducted in the rockfish fishery; both of these issues were related to the amount of time required for a human to review the video. To address this topic, NMFS contracted with Mamigo, Inc. to test the feasibility of automating the process of video review to obtain counts and lengths of individual halibut PSC. The software developed by Mamigo, Inc. was able to automate the count of halibut and performed the counts much faster than if a human completed the review. However, the lower than expected frame rate and the manner in which the crew discarded the halibut made it difficult to obtain lengths automatically. This software does show promise in lowering the video analysis costs and reducing the review time necessary to obtain a census. Improvements in video equipment and modification of crew sorting behaviors could enhance the speed at which video could be reviewed and enable the software to obtain lengths automatically. This software was developed specifically to automate the count and length measurement of halibut on rockfish trawl catcher vessels; however, with additional software development other applications in different EM fishery programs could benefit from having the video footage automatically parsed down before human review of the video.

Halibut Longline Fleet

Over the past decade, there have been several studies evaluating the potential use of EM in the halibut longline fishery in Alaska. In 2002, the IPHC, under contract to NMFS, investigated options for monitoring bycatch of endangered seabirds in the longline fleet (Ames et al, 2005). That study suggested that EM could produce accurate data and enable compliance evaluation for seabird avoidance devices. Specifically, the EM video observations were successful in detecting streamer line deployment and relative position on 100 percent of the daytime sets when 2 cameras were used. In addition, a high proportion of the seabird bycatch was able to be detected using EM. However, additional work was needed on species identification of seabirds from the video.

In 2002 and 2004 the IPHC, in collaboration with NMFS, conducted two studies to examine the accuracy of fishing effort and catch composition data collected by EM relative to the traditional at-sea observer method (Ames 2005; Ames et al. 2007). These projects were undertaken aboard commercial fishing vessels under contract to the IPHC. In the first study, the catch data from EM were similar to the data collected by observers; however, the EM data documented fewer fish for 7 of the 17 species categories investigated because the video analyst grouped catch into more general species categories than did the sea sampler following observer methodologies.

Recommendations from the 2002 study, including improved camera configurations, were incorporated into the study design of the 2004 study and agreement between the EM data and the observer data increased. However, the observers recorded slightly fewer individuals of some species categories, which was opposite to the finding in the 2002 study. Although some species identification limitations were found, the studies demonstrated the effectiveness of EM technology for longline fisheries, and indicated the potential role EM could have in the design of a functional and cost-effective monitoring program. The study also highlighted that data provided by human observers are also subject to error and comparisons between EM and observers had no absolute standard of reference in this study.

In 2007, NMFS, the IPHC, and Pacific States Marine Fisheries Commission initiated a study to evaluate the potential of EM as an alternative tool to monitor bycatch on Pacific halibut longline vessels. Specifically, estimates of bycatch (numbers of fish) based on dedicated fishery observer documentation (census) were compared with estimates of bycatch based on review of EM video recordings and, where possible, with estimates based on standard Alaska Fisheries Science Center (AFSC) Observer monitoring (Cahalan et al. 2010). This study was conducted on commercial fishing vessels under normal fishing conditions, building upon the previous studies (Ames 2005; Ames et al. 2007) which were conducted on chartered vessels.

EM systems were installed on four vessels that voluntarily participated in this study. Data were collected on 13 fishing trips in the Bering Sea and the Gulf of Alaska. Unanticipated technical problems were experienced that resulted in incomplete data capture where video images were not recorded for some fishing events and fishing periods. These technical issues were resolved in all cases. Note however that both EM –based and observer –based monitoring methods experiences lapses in data collection. Lapses in EM data capture tended to encompass large portions of, or entire, fishing trips while lapses in observer data capture tended to be interspersed within individual trips.

Comparison of species identification of catch between standard observer monitoring methods (monitoring a sample of each set), complete observed-based documentation of catch (a nominal census of catch), and EM-based documentation of catch (a nominal census of catch) showed statistically unbiased and acceptable comparability for almost all species except for some that could not be identified beyond the species grouping levels used in management. Similarly, comparisons of total species-specific numbers of fish estimated using EM-collected and observer-collected data showed few statistically significant differences.

Although this study was limited in scope and data collection using standard observer monitoring methods was lacking, catch and bycatch estimates could be estimated from both the EM and observer data collected. Comparisons of catch estimates generated from the two monitoring methods did not show evidence of systemic differences. Hence, based on the results of this limited study, this type of EM could be used as an additional tool for catch monitoring in the commercial halibut fishery. Note however that its potential use would need to be determined by the specific monitoring requirements of each management application and that EM may not be the best alternative in all situations. While EM is not an alternative to observers for the collection of certain biological specimens (e.g., otoliths, scales, etc.) from the catch, with the further development of EM systems and procedures, estimation of bycatch species composition in numbers of fish in the Pacific halibut fishery could be achieved with a high degree of accuracy.

EM in the Amendment 80 and Amendment 91 fisheries

Amendment 80 Bin Monitoring

During the development of Amendment 80 to the Bering Sea and Aleutian Islands (BSAI) Fishery Management Plan, there was concern about pre-sorting of catch inside the bin prior to the observer's sample. NMFS was unable to entirely ban crew from entering the bin for all vessels; therefore, three bin monitoring options were set in regulation to help ensure that no presorting activities were occurring and the observer sample consisted of unsorted catch. One of these options relies on EM.

According to the bin monitoring requirement no crew may enter any bin or tank preceding the point where the observer samples unsorted catch, unless certain criteria are met. The vessel owner or operator must comply with this requirement unless they have requested, and NMFS has approved, one of the following 2 monitoring options:

- Line of sight option: From the observer sampling station and the location from which the observer collects unsorted catch, the observer must be able to see all areas of the bin where crew could be located. This requirement may be accomplished by creating a viewing port inside the bin.

- Video option: A vessel may provide and maintain cameras, a monitor, and a digital video recording system for all areas of the bin where crew could be located. The video data must be maintained and made available to NMFS upon request for no less than a 120 day period.

Prior to implementation of the EM bin monitoring option, NMFS asked several vessels to carry EM systems for one season to test the durability of the systems and allow the vessels time to understand how the systems operated prior to implementation. About half of the vessels participating in the Amendment 80 program have chosen the video bin monitoring option. In this application, EM serves as a compliance monitoring tool for enforcement and allows the observer to monitor all areas of the bin where crew could be located ensuring that pre-sorting does not occur prior to sampling. There were some initial technical issues with the Amendment 80 systems; however, those were quickly resolved and overall, EM works well in this application.

Amendment 91 Salmon Bycatch Monitoring

Amendment 91 to the Fishery Management Plan for Groundfish of the BSAI Management Area is being implemented in January 2011 to manage Chinook salmon bycatch in the Bering Sea pollock fishery. The regulations for Amendment 91 contain the second EM monitoring requirement that NMFS has implemented in Alaska.

Amendment 91 creates Chinook salmon PSC limits on the Bering Sea pollock fishery for the first time. To monitor the Chinook salmon limits, NMFS is striving for a census, or a full count, of Chinook salmon bycatch in each haul by a catcher/processor and each delivery by a catcher vessel. The census method is complicated because NMFS needs to ensure that all salmon bycatch is retained and made available to the observer. Observers cannot be present at the sorting of bycatch aboard pollock trawlers at all times because they are required to complete other duties. Thus, NMFS has implemented a series of requirements including installation of a video system, with a monitor located in the observer sample station, to provide views of all areas where salmon could be sorted from the catch as well as the secure location where salmon are stored[1]. In this application, EM serves as a compliance monitoring tool for enforcement and allows observers to monitor all areas were salmon could be sorted from the catch. NMFS is currently monitoring the implementation of this new application of EM.

Monitoring global development of EM technology

In addition to the studies and the regulatory implementation of EM, NMFS staff have organized and participated in several national and international conferences and workshops to learn how other regions and countries are applying EM in fisheries management.

In 2008, NMFS, NPRB, and the NPFMC conducted a workshop to assess the state of EM technology across the nation and internationally. One session discussed past pilot studies conducted in the US and Canada. Other sessions included industry perspectives; legal, management, and enforcement concerns; and research and development advancements. The workshop concluded with a synthesis of the discussions (AFSC, 2008). The workshop report identified that EM has potential in the North Pacific but the applicability depends on the specific objectives of the program. In addition, it identified potential directions for further investigation of EM.

For several years, NMFS staff have attended the International Security Conference in Las Vegas. This conference provided useful insight into the realm of possibilities for EM and provided guidance for potential pitfalls often associated when implementing EM programs. In 2010, numerous NMFS staff participated in an international fisheries conference held in Galway, Ireland to learn how other nations were applying advanced technologies to address fisheries management challenges[2]. NMFS staff also attended a European workshop on the use of EM in March of 2010 (Dalskov, 2010) as they too are considering EM for fisheries monitoring applications.

At the national level, a staff member from the regional office and one from the observer program are representatives on the Electronic Monitoring Subcommittee of the National Observer Program Advisory Team. The objective of this subcommittee is to provide recommendations on electronic data collection for observer programs and to coordinate and share electronic monitoring information. The EM committee has been in existence for two years and has provided a valuable mechanism for understanding how other regions are approaching the use of EM and sharing experiences in the North Pacific with others. In particular, our colleagues at the Fisheries Sampling Branch (FSB) of the Northeast Fisheries Science Center (NEFSC) are conducting a pilot program to test the applicability of EM technology to collect catch and fishing effort data aboard commercial vessels. The goal of the study is to evaluate the utility of EM as a means to monitor catch on a real-time basis in the Northeast groundfish sector fleet[3]. We will be

[1] Discussion of the monitoring requirements for Amendment 91 can be found in section 2.2.5.7 of the Chinook Salmon bycatch Environment Impact Statement (http://www.fakr.noaa.gov/sustainablefisheries/bycatch/salmon/chinook/feis/eis_1209.pdf) and sections 6.3.3-6.3.5 of the final Regulatory Impact Review (http://www.fakr.noaa.gov/sustainablefisheries/bycatch/salmon/chinook/rir/rir1209.pdf).

[2] Conference proceedings available at: http://www.marine.ie/fisherydependentdata/Documents/Book%20of%20abstracts/Book%20of%20Abstracts%20master.pdf.

[3] More information available at: http://www.nefsc.noaa.gov/fsb/Electronic%20Monitoring%20Pilot%20Study/Electronic_Monitoring_Pilot_Study.html

monitoring their progress and gleaning any lessons learned, along with cost information, from their experiences.

What is on the horizon?

Data storage & automated data analysis

Currently, there are no operational EM systems in place in Alaska that routinely extract information from video for science or management. As we described earlier, there are two EM applications in place in Alaska where video is used as a compliance monitoring tool and provides a “real time” view for the observer to monitor for pre-sorting and other crew activity. When needed, the acquisition, review and storage of video from these types of programs is straightforward. However, any application where EM data are used for fisheries management will likely be more complex and require greater infrastructure for both industry and the government. Depending of the specific goals of the EM program, a variety of data transfer, analysis, and storage issues will need to be resolved. For example, if video data were going to be used for quota management then a system would need to be developed for physically moving video files to a facility where they could be reviewed. This could prove challenging from remote locations in Alaska. Additionally, data collected for fisheries management is required to be stored, archived, and accessible for further review and/or use in the prosecution of violations and this would likely require a large investment in data storage infrastructure. Finally, although we have promising results from the first attempt to automate the video data analysis, there is a lot more work that could be done to automate parts, or all, of the video review process.

Freezer longline fleet

Recently, the Longline Catcher Processor Subsector Single Fishery Cooperative Act was signed by President Obama which allows freezer longline vessels participating in the BSAI directed Pacific cod fishery to form a single cooperative. Monitoring and enforcement regulations will need to be developed for this fishery cooperative and it is possible that EM could be applicable to meet some monitoring needs. For example, video might be used to monitor compliance with the use of scales to weigh Pacific cod. Or, in a more complicated scenario, video could be used to estimate the number and composition of fish caught as a supplement to observer sampling. During of the summer of 2010, NMFS staff participated in a test of flow scales aboard a freezer longline vessel and part of this test included the use of EM to monitor that all Pacific cod passed over the flow scale and that the flow scale was functioning properly. The EM system worked well during the test. So, although NMFS has not thoroughly investigated the use of EM in freezer longline fisheries off Alaska, it offers promise. NMFS would be interested in working with the industry to further investigate the potential for EM in monitoring this cooperative.

Small boat fleet

Another possible application of EM is on small vessels as an alternative to an observer. The previous work on hook and line vessels in the Pacific halibut fleet has demonstrated the potential for EM to provide some helpful information on bycatch. In October 2010, the NPFMC passed a motion to restructure the observer program (BSAI Amendment 86 and GOA Amendment 76) whereby all vessels and processors in the groundfish and halibut fisheries off Alaska, regardless of size, would be placed into one of two observer coverage categories. Once implemented, NMFS will have the authority to place observers on small boats and halibut vessels that were previously not covered under the observer program. However, NMFS recognizes that some smaller vessels will not be suitable for observer coverage but could potentially carry EM as an alternative. The Council has asked its Observer Advisory Committee to consider EM and we suggest the small hook and line fleet should be their initial focus. NMFS staff have also been working with several industry members who have expressed an interest in EM on smaller vessels and are seeking funds for further pilot work.

Conclusion

EM is one of many tools that may be used to help accomplish specific objectives. Clarity in the desired objectives is essential. Decisions related to costs, feasibility, and effectiveness will help to determine the right mix of tools needed to achieve them. NMFS is encouraged by the rapid development of EM technologies and believes that they will play an important future role in the routine monitoring of fishing and fish processing activities in Alaska. We will continue to monitor the development of EM and implement EM systems when appropriate and cost effective for the monitoring objectives. All of the projects conducted to date in Alaska have been done with industry participation and collaboration. We believe that continued industry involvement in the development of EM systems will be essential to their future success.

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