Electronic Fisheries Monitoring Workshop Proceedings
Alaska Fisheries Science Center
Seattle Washington
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1 Introduction

A number of electronic monitoring (EM) technologies have been applied in fisheries monitoring as various technologies have evolved. The North Pacific Fishery Management Council (Council) assessed the range of EM tools being used in fisheries in 2004.[1] Since then, the use of video technologies in particular has seen considerable interest, and several different video applications have been developed in the North Pacific and elsewhere. Many of these applications have been in experimental settings, where their ability to meet identified monitoring objectives were tested and evaluated. Other applications, specific to particular monitoring issues, are currently in operation. Video appears to have high potential to meet some, but not all, fisheries monitoring needs. Within the fisheries management community, there is a range of perceptions about what is possible using video. For example, within the North Pacific, video technology has been discussed as a potential way to supplement or replace existing observer coverage, enhance the value of the data NMFS currently receives, and/or fill data gaps that have proven difficult to meet with industry reporting or human observers.

Given the range of interest in video applications and the various perceptions of its potential use, the National Marine Fisheries Service (NMFS), the Council, and the North Pacific Research Board (NPRB) collectively identified the need to assess the state of the current technology on both national and international fronts, with an eye toward its future use in the North Pacific. Their combined efforts culminated in a July 2008 public workshop with broad participation and attendance from various management agencies, the fishing industry, the environmental community and the industry developing monitoring technologies. This workshop considered video within the broader EM and information system context, recognizing its potential for integration with other data and data acquisition systems.

The steering committee also contracted with Howard McElderry (Archipelago Marine Research Ltd.) to develop a report that provides background information for delegates in advance of the workshop in order to help facilitate workshop discussion. This report is entitled, “At-Sea Observing Using Video-Based Electronic Monitoring,” and is appended to these proceedings (Appendix 1).

The workshop was structured with a keynote address and discussion, followed by panel presentations and discussion. Lastly, the discussions were synthesized in a concise summary. The first day of the workshop was structured to bring all participants to a general understanding as to the state of current knowledge (Keynote and Panel 1), to pull in perspectives from industry (Panel 2), and to understand the challenges NMFS faces in implementing video systems (Panel 3). The second day of the workshop looked to the future by identifying current video projects and the questions they are addressing (Panel 4), and then assessing research and development needs and the potential of video for the future (Panel 5). The final synthesis pulls all of the pieces together. MRAG Americas, Inc. (Bob Trumble and Jennie Harrington) provided rapporteuring services and were the primary authors of these proceedings.

Following are summaries of the workshop sessions.

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[1] Appendix I to the EA/RIR/IRFA for BSAI Amendment 86/GOA Amendment 76: Extension or Modification of the Program for Observer Procurement and Deployment in the North Pacific, public review draft, May 12, 2006. *Appendix I: Fisheries Monitoring Technologies* is a report prepared for the NPFMC by MRAG Americas, Inc., April 2004. The entire EA/RIR/IRFA is provided at: http://www.fakr.noaa.gov/npfmc/current_issues/observer/OPO606.pdf.

2 Session Presentations

2.1 Introduction and Keynote

2.1.1 Abstract

Current assessment of the state of video applications in fisheries in the United States and internationally

Presented by: Howard McElderry, Archipelago Marine Research Ltd, Victoria BC

The NPFMC, NMFS, the NPRB, other management agencies, and the fishing industry, are all interested in advancing the potential use of EM in North Pacific fisheries. The notion of technology-based at-sea monitoring has emerged because monitoring needs are growing and observer programs have shortcomings that limit their use. Over the past decade, Archipelago Marine Research Ltd. has pioneered video-based electronic monitoring (EM) technology, carrying out a number of pilot studies and fully implementing EM in three fisheries. Collectively across all projects, EM is now used on ~500 fishing vessels for a total of ~25,000 seadays. EM systems, consisting of up to four closed circuit television cameras, a GPS receiver, a hydraulic pressure sensor, a winch sensor, and a system control box, can be deployed on fishing vessels to monitor a range of fisheries issues including fishing location, catch, catch handling, fishing methods, protected species interactions, and mitigation measures. The efficacy of EM for monitoring issues varies according to fishing methods and other factors. In comparison with observer programs, EM has a number of advantages including suitability across a broad range of vessels, creation of a permanent data record, lower cost, higher scalability, and the ability to engage industry self-reporting processes. Observer programs are more suited as a tool for industry outreach, complex catch sampling operations, and collection of biological samples. A key weakness of EM is a design inability to prevent tampering because of the exposed cameras, sensors and wires throughout the vessel. Instead, EM systems are tamper evident and EM programs must be designed with measures to discourage tampering. Efforts to operationalize EM involve pilot studies, detailed program specifications and an operations plan. Important considerations in this process include infrastructure needs for EM programs, service delivery models, governance mechanisms, timelines and data policies. Currently, infrastructure to support EM programs is very limited and careful planning is needed to build capacity, and create a climate that encourages research and development of EM technology.

2.1.2 Discussion

After Howard McElderry's keynote address, a short discussion ensued. There were several logistical questions about lighting and radio-frequency identification (RFID) systems and a brief discussion of management, EM and observer responsibilities, but the bulk of the discussion focused on the costs of EM systems. The first question addressed Howard's closing thought: "Electronic monitoring enables a new paradigm in fisheries management," and asked whether it would be more appropriate to rephrase as "Electronic monitoring enables a new paradigm in observer coverage." Howard responded that he referred to a paradigm shift in management because it is NMFS' responsibility to ensure and enforce cooperation with observer and monitoring requirements. Additionally, one participant commented that it might be counter productive to use observers as "punishment" for poor or missing EM data. Howard responded that we must be careful not to label additional observer coverage as such, as observers cannot be replaced by EM for such tasks as biological sampling and in many cases, species identification; thus, they should not be viewed only as back up and verification for EM systems.

The discussion then shifted to reasons for cost differentials between EM programs. Howard explained that owning EM equipment and streamlining the data analysis (e.g., British Columbia Area A Crab) significantly lowers cost. Renting equipment and the need for increased data retrieval and analysis time increases the costs (e.g., BC longline fishery). Further increasing costs is the bi-monthly installation and removal of equipment, along with additional complexities in data analysis (e.g., U.S. Northwest hake program). When asked for a further breakdown of costs, Howard requested that the question be diverted until Panel 5 (his response during his presentation in Panel 5 was that Equipment Supply comprised roughly 25% of the cost, Field Services, 40% and Data Analysis Services, 35%). Howard also reported the total costs for implementing an EM program in dollars per sea day and as percent of catch value ($80 CAD or 2% of catch value for the Area A Crab fishery; $150 CAD or 3% of catch value for the BC groundfish longline fishery; and $250 USD or 1% of catch value for the Northwest shoreside hake fishery). He clarified that this represented cost as a percentage of the overall ex-vessel value, and reminded everyone to keep in mind that for the two BC fisheries (BC longline and Area A crab); there is a subsidy from the Canadian government (Department of Fisheries and Oceans) which is also included in the value of the fisheries.

2.2 Panel 1. Lessons Learned from Past Applications

2.2.1 Abstracts

Lessons learned through the application of Electronic Monitoring technology by the International Pacific Halibut Commission: regulatory compliance, bycatch monitoring, and comparison between EM and observer catch composition estimates.

Presented by: Bruce M. Leaman, Executive Director, International Pacific Halibut Commission

The International Pacific Halibut Commission (IPHC) has completed three studies evaluating the use of electronic monitoring (EM) technology. These studies were completed in cooperation with Archipelago Marine Research (AMR) and involved issues of regulatory compliance, bycatch monitoring, and species composition of longline catch. The first two studies were also conducted jointly with the U.S. National Marine Fisheries Service (NMFS).

The first study examined the ability of EM systems to provide images that would allow an analyst to monitor deployment of seabird avoidance devices (BADs) on longline vessels for compliance with NMFS regulations, as well as to detect and identify incidentally-caught seabirds. The EM system successfully monitored BAD deployment and relative position on 106 setting events. Wide and narrow focus cameras were required to accurately monitor relative position and regulatory compliance. Enhanced marking of the BADs would facilitate monitoring. Sixty-three frozen seabird specimens were seeded onto longline gear during setting to assess detection capabilities at retrieval. Detection rate ranged from 91-96% on retrieval and correct species identification was related to analysts' experience and the EM frame recording rate. Correct seabird identification ranged from 64-79%.

The second study involved multiple cameras aboard a Bering Sea trawl catcher-processor. Cameras monitored halibut and other fish from the trawl deck, through the factory, to sorting and discard. Individual halibut with visible tail tags were seeded into the fish holding bins and detection probability tracked through subsequent processing. Post-cruise analysis showed that halibut were visible throughout the processing operation but video was insufficient for species composition monitoring of the catch. Multiple EM cameras aboard factory trawlers would enhance an observer's ability to monitor catch progress and processing during normal observer deployments. Data from EM systems could provide a significant deterrent for illegal activities such as presorting and discarding. However, the use of such data for prosecution in fisheries cases has not been explored, although they have been used regularly in other judicial processes.

The third study compared species composition from EM systems with that from on-board observers, in a two-part study. The first component used technology available in 2002 and provided similar data from observers and EM. However, the EM analyst recorded fewer individuals for 7 of 17 species categories. The second component (in 2004) enacted recommendations from the first component concerning improved camera configurations, video recording and compression rates. The enhancements increased EM and observer agreement but also showed increased numbers of some species categories through EM compared with observers, generally due to the EM analysts' ability to spot drop-offs via a wide-angle camera. The study highlighted the fact that human observers have their own suite of errors and that there is no absolute standard of reference for either human or EM species composition data.

Electronic Monitoring in the Central Gulf of Alaska Rockfish Fishery

Presented by: Jennifer Watson, Resource Management Specialist, Sustainable Fisheries Division, National Marine Fisheries Service, Alaska Region

Amendment 68 to the Fishery Management Plan for the Groundfish of the Gulf of Alaska established a rockfish pilot program (RPP) for quota-based management of the rockfish fisheries in the Central Gulf of Alaska (CGOA). Under the program, each catcher vessel cooperative is allocated a share of various rockfish species, sablefish and Pacific cod. Additionally, the cooperatives are allocated halibut prohibited species catch (PSC) to allow the prosecution of the fishery. Halibut PSC must be discarded at-sea and, at this time, can only be effectively accounted against the cooperative's PSC quota if there is an observer onboard to estimate the halibut catch in each haul. However, North Pacific Groundfish Observer Program sampling methods were not designed for haul specific catch accounting on individual vessels.

In 2005, a pilot study was conducted to evaluate the use of electronic monitoring (EM) to monitor discards in the CGOA rockfish fishery (McElderry et al. 2005). The study evaluated EM to observe fish handling aboard the trawl catcher vessels. Overall, the study concluded that EM can be very useful in accomplishing some monitoring needed for the RPP. The report stressed that if discard was restricted to a single location and discard species were limited to only halibut PSC, the effectiveness of EM would increase.

In 2007, an exempted fishery permit study was conducted to determine whether EM could quantify halibut discard if the 2005 study recommendations were followed. In the study, one catcher vessel made six trips in a rockfish target. All catch other than halibut was retained and halibut were discarded through a single discard chute. All halibut were measured by project staff prior to being discarded. The results showed the EM estimates of halibut had a high level of precision and were not biased relative to the at-sea census of halibut. The study supported the use of EM to obtain estimates of halibut PSC catch at the haul level. Questions related to infrastructure needed to support an EM program, costs associated with an EM program, the viability of such a program under real world fishing conditions and the feasibility of using EM for near real time quota accounting have not been addressed. These questions need to be answered prior to large scale implementation of a comprehensive electronic monitoring for the Central Gulf of Alaska rockfish pilot program.

The U.S. West Coast Shore-based Pacific Hake Fishery

Presented by: Jonathan Cusick, NOAA, Northwest Fisheries Science Center

Pacific hake (*Merluccius productus*) is a semi-pelagic species with a large biomass found along the continental shelf in the northeastern Pacific Ocean. It is targeted commercially in the U.S. by a combination of catcher-processor, mothership and shore-based catcher vessels using mid-water trawl nets. In addition to managing the total catch of the target species, other management concerns include bycatch of endangered fish species such as salmon, overfished/rebuilding groundfish stocks (including widow and canary rockfish (*Sebastes spp.*)), marine mammals and other protected species. A special management concern is the extremely low bycatch limits for overfished rockfish species. For example, the bycatch limit of canary rockfish (*Sebastes pinniger*) was 4.7 mt in 2007 for all commercial sectors. In order to catch the quota of over 208,000 mt OY of hake, the canary bycatch rate had to be .0023%. As rockfish school, a large amount of an overfished stock can occur in one haul, necessitating the need for a higher level of monitoring.

Every catcher-processor and mothership vessel is equipped with certified flow scales and carries two observers. Total catch of all species is tracked using observer data in these two sectors. The shore-based fleet, operating predominantly out of Oregon ports, has no observer coverage and the landings, monitored by shore-based samplers, are tracked with fish tickets. As the total catch of this sector is based on the fish ticket (or landed catch) weights, it is important to confirm if the total catch recorded at the plants accurately represents total catch in the fishery, including bycatch. The shore-based catch sampling strategy relies upon maximized retention of catch at sea.

In 2002, working with Archipelago Marine Research, Ltd, the Northwest Fisheries Science Center began to test the feasibility of deploying electronic monitoring (EM) systems aboard the shore-based hake fleet to monitor for any at-sea discard. The primary goal of at-sea monitoring was to confirm maximized retention especially for any rare, high-bycatch events (documenting discard if it took place) in an independently verifiable and cost-effective manner. Electronic monitoring systems were deployed on all shore-based hake vessels during the 2004-2007 seasons to conduct further testing. In addition to providing information on EM advantages, limitations and costs, the shore-based hake EM project provided baseline information about this technology's application to industry members, fishery managers, enforcement agents and general counsel. EM systems are now part of a larger landings monitoring program that was put into place for the current shore-based hake season.

Video monitoring of commercial fishing operations in relation to observer programs in the Northeastern United States

Presented by: Amy Sierra Van Atten, Operations Coordinator, Northeast Fisheries Observer Program, Acting Branch Chief for the Fisheries Sampling Branch, National Marine Fisheries Service, Northeast Fisheries Science Center

The Northeast Fisheries Observer Program does not currently utilize any video monitoring aboard commercial fishing vessels. There have been several pilot projects to test the applicability, utility, and efficiency of using video to supplement observer coverage in the Northeast. However, due to the multi-purpose, scientific-collections oriented goals of the NEFOP, video monitoring is not currently considered as a suitable surrogate for observer coverage in the fisheries that are required to be observed. The NEFOP observes approximately 8,000 seadays per year from Maine through North Carolina, in inshore state waters to offshore Federal waters out to the 200 mile limit (Exclusive Economic Zone). Over half of the observed trips (56%) are less than 24 hours long, and longer trips may be out for two-weeks or more. Most of the NEFOP coverage is on vessels less than 60 feet (58%), and rarely on vessels over 200 feet. Some years the NEFOP observes on approximately 1,000 different vessels, with new vessels continually being observed.

The benefits of using video monitoring in our area would be that space is limited on the small vessel, personal liability is reduced using videos rather than observers, and the training resources (trainees time, trainers time, materials, training trips, sample collection, etc.) needed are less for video rather than observers. The disadvantages are that NEFOP coverage requirements are far ranging (in geographic area, gear types, vessel size, and trip length). The coverage requirements for individual vessels are not predictable since the coverage rates are assigned to fleet sectors, based on confidence intervals of certain bycatch analyses, with quarterly random stratified vessel selection and the coverage is spread out widely over the participating vessels.

The role of the NEFOP observer can not be replaced with a video camera at this time. The NEFOP data support numerous research projects, meet multiple mandates under several Federal Acts, are used to test bycatch reduction methods, are needed in developing Fisheries Management Plans, and contribute to the accuracy of stock assessments. NEFOP observers collect economic information, gear characteristics, environmental data, positional data, catch species composition and weights, discard reasons, sightings information, and tag recapture data. Biological sampling is conducted on fish (such as groundfish, herring, monkfish, scup, black seabass, sturgeon, redfish, etc.), crustaceans, marine mammals, sea turtles, birds, and sharks. The biological samples have been and continue to be used to test the overall health of the marine environment, determine basic life histories of rare specimens, examine animal diets, describe new species, explain animal ranges and migratory patterns, and contribute to understanding of interactions and entanglements at sea.

The NEFOP is interested in learning more about video monitoring technology to perhaps supplement some coverage, primarily to monitor discarding at sea. From our limited experience with video monitoring on hook, gillnet, and trawl vessels, possible applications may be in monitoring catch in the sector fisheries in the Northeast, and in particular the longline fishery. At this time however, due to the nature of the fisheries (gillnet, trawl, purse seine, and dredge gears), it does not seem that video technology would be sufficient to identify to species, estimate catch volume, and quantify discarding at sea (including upgrading, shoveling, and bag releases).

At-Sea Observing Using Video-based Electronic Monitoring: An Audit Tool for Fishing Logbooks: Some downstream complications

Presented by: Rick Stanley, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, British Columbia, Canada

British Columbia's 350-vessel groundfish hook and line, and trap line fleet is moving toward management reforms that, in turn, require an at-sea monitoring program to account for all retained and discarded catch. The traditional approaches of using observers or using video-based electronic monitoring (EM) systems, as an observer replacement, were dismissed for cost and timeliness issues. Instead, an audit-based monitoring approach was developed using data from EM systems to audit fishing logbooks. Under this plan, at-sea activities would be fully monitored using EM but only a random portion of data would be reviewed and compared with logbooks. Thus, the fisher logbooks remain the key data source for retained and discarded catch and the EM imagery provides the "radar trap" threat to encourage accurate catch accounting and offers fishers the opportunity to demonstrate that their logbooks provide accurate accounting.

However, the consequences of an "unsatisfactory" report status can include 100% review of all video at the fisher's expense, a notice of a "compliance failure" and/or, possibly having to take an observer on the next trip. As these consequences can be quite expensive, actual implementation of "punitive" consequences turned out to be more problematic than originally envisioned. This presentation will summarize the scoring methodology and some elements of the decision process that had to be invented as the "rubber-met-the road".

2.2.2 Session Discussion

Martin Loefflad moderated the first panel (Lessons Learned from Past Applications), and the ensuing discussion responded to presentations given by Bruce Leaman, Jennifer Watson, Jon Cusick, Amy Van Atten, and Rick Stanley. Many of the questions and comments focused on cooperation, responsibilities, and data ownership. Several others compared EM systems to observer programs. The discussion opened with questions and comments for upcoming panelists to consider when presenting. Questions for consideration were: "How can we make sure that cooperation will occur between management and industry?" and "What does management need to ensure a video monitoring program is enforceable?" Comments highlighted the opinion that industry, law enforcement, and management need to be involved from the start, and that attitudes within the industry change when they must bear some responsibility. The discussion then shifted to the topic of the federal Freedom of Information Act (FOIA). There was some concern that data collected via EM systems would fall under the FOIA, and potentially become publicly available. However, in the U.S., EM data are collected under the authority of the Magnuson Stevens Act (MSA) which protects the confidentiality of observer information, including video imagery. Additionally, it was noted that there could be other mechanisms to protect confidentiality, such as third-party retention and possession of all data, with disposal after a certain amount of time.

There was considerable discussion about the shoreside hake fishery on the west coast, as the video system used in that fishery monitors for illegal discards. It was noted that the potential for discard may be reduced if the fishery was under a different management model (Individual Fishing Quotas) as opposed to open access). Regardless, a video monitoring system, as is in place currently, would be needed to assess whether discard occurred. It was noted that there is a potential loss of biological data should one use video instead of observers for at-sea monitoring. This was not a problem in the shoreside hake fishery, owing to a mandatory retention requirement whereby biological collections are made at the dock. The discussion then considered the potential use of EM for species identification; video has some limitations in this case, depending on the gear type and handling of the fish on the vessel. In some cases, video monitoring has potential to produce a superior estimate to observers, but it is simply not feasible for all fisheries. Some fisheries have potential for EM systems to be combined with some level of observer coverage to meet multiple monitoring objectives. The rockfish fishery in the Gulf of Alaska was discussed as a fishery with such potential. Cost comparisons between observer and EM programs were revisited specific to the Gulf of Alaska rockfish fishery; the EM costs in the test project were high due to extraneous circumstances and the experimental situation. The need to evaluate cost tradeoffs in operational systems was noted, as was the need to assess the timeliness of data availability. With observers in the Gulf of Alaska rockfish fishery, 2 to 3 days were needed to make data available to managers, but timing for EM data is not yet known and is currently being evaluated. The discussion of timeliness of data appears in several of the later panel discussions as well.

The final questions involved dockside monitoring and retention of qualified EM technicians. Some perceived that 100% coverage at the dock would be an integral part of the EM data collection system. The question was deferred to a later panel presentation (Panel 4), but it was noted that Alaska requires 100% coverage at the plant for rockfish (but no required EM yet), as does the Department of Fisheries and Oceans in Canada. The final question inquired as to how to obtain and retain qualified EM technicians who would review the video. While there was no clear answer to that question, current practices try to limit review time (4 to 6 hours per day maximum), and rotate teams of reviewers every few weeks.

2.3 Panel 2. Industry Perspective

2.3.1 Abstracts

Application of Video Monitoring Technology On-board the Pollock Catcher Processor Fleet in the Bering Sea

Presented by: Paul MacGregor, General Counsel, At-sea Processors Association

The use of video technology to enhance data collection and fishing vessel monitoring is a promising new tool for fishery managers and others engaged in the commercial fisheries off Alaska. The efficacy of such technology and the degree to which it can be utilized in the North Pacific fisheries turn to a great extent on a number of important variables. Those variables include the following: the fishery involved, the regulatory regime under which the fishery operates, the size and configuration of the fleet(s) and vessel(s) engaged in the fishery, the fishing gear deployed, the level of at-sea processing (if any) involved, and a variety of logistical and cost considerations that must be considered in determining the extent to which electronic monitoring can compliment, supplement or perhaps replace, deployment of experienced on-board observers.

Using the at-sea pollock processing fleet as an example, Mr. MacGregor will discuss the nature of the Bering Sea pollock fishery, the size and configuration of the fishing/processing vessels involved, the harvesting co-operative under which those vessels operate, the monitoring requirements imposed by law and other characteristics of the fleet that determine the extent to which video monitoring might be used to compliment the comprehensive observer program under which our vessels currently operate.

As a final issue, Mr. MacGregor will discuss an important legal issue that must be resolved before fishermen and fishing vessel owners will be fully comfortable with the placement of video equipment onboard their vessels: the confidentiality of the video images and other data that may be collected by video monitoring equipment installed on their vessels.

How much will Electronic Monitoring Cost Industry?

Presented by: Julie Bonney, Alaska Groundfish Data Bank, Kodiak, Alaska

Managers and industry tout electronic monitoring (EM) as the monitoring tool of the future. EM is seen as a means of monitoring the small boat fleets that presently are exempt from human observer coverage requirements in Alaska. For vessels that presently carry human observers, EM may either enhance/improve monitoring or may replace human observers on board vessels entirely.

How does the industry and the agency move from the discussion phase of the utility of EM to the implementation phase? Several tests of EM have been performed, and EM has proven to provide quality data. However, industry is reluctant to embrace EM as a monitoring tool until cost tradeoffs are understood. From a catcher vessel perspective, the following issues need to be resolved so costs can be defined:

(1) Can EM replace human observers on catcher vessels or will some level of human observer coverage still be required?
(2) Can vessel reports be used for the needed data to manage the fishery with EM used as an auditing tool or will instantaneous EM review be required for fishery management needs?
(3) What would be the division of costs for EM between the government and industry?
(4) What are the economies of scale for developing an EM program in Alaska?

Vessels that have a choice between human observer coverage and EM coverage to meet monitoring requirements need to be able to compare the differences between data quality and costs.

Electronic Monitoring Issues in the Alaska Longline Fleet

Robert Alverson, Fishing Vessel Owners' Association

The focus of EM issues for the smaller boat fleet that operates off Alaska is as follows:

1. Quantifying the need for coverage and monitoring.
2. Understanding options for monitoring and the respective costs to the harvester.
3. Reliability of EM systems vs. observers and the relative cost of data retrieval, including local maintenance of systems.
4. Integration of a monitoring alternative that would compliment the existing observer program off Alaska.
5. Compatibility of EM systems for small vessels with between one and six months of fishing time at sea.

Possible solutions that would be appropriate for the small boat fleet might be to require logbooks as benchmark (30,000 lbs is 1-2 trips) and to reallocate funds provided to the NPFMC for the observer program to EM, assigning observer coverage only where necessary.

Electronic Monitoring Perspectives from an Amendment 80 Vessel

Presented by: Todd M. Loomis, Cascade Fishing, Inc.

In the past decade, NMFS has prescribed the use of various technologies to assist fisheries managers, enforcement, and observers. Examples include motion compensated flow scales for weighing total catch; vessel monitoring systems for enforcing boundaries; and the use of electronic monitoring (EM) on certain trawl catcher/processors (C/Ps) to ensure catch remains unsorted prior to sampling by an observer. Each of these tools underwent various degrees of testing prior to implementation and the full potential of EM, especially video, has yet to be realized.

Electronic monitoring of catch on C/Ps was tested in 2005 and 2007. Use of EM became a requirement for certain vessels in the Amendment 80 sector (Bering Sea/Aleutian Islands non-pollock trawl C/Ps) in 2008. The two pilot tests and implementation of the bin monitoring program are excellent examples of how industry, the private sector, and government can work together to create an effective monitoring program. The use of EM in the Amendment 80 sector has been a success, and as more applications of the technology are tested, we hope they provide viable options that will benefit all stake holders.

Industry Perspective on Electronic Monitoring in Alaska Groundfish Fisheries

Presented by: John Gauvin, Best Use Coalition

My vision for electronic monitoring in Alaska groundfish fisheries is that it should be used to provide regulatory compliance monitoring in areas where EM can be effective and where human observer coverage would be tedious and not the best use of a trained biologist on a commercial fishing vessel. In my view, wherever possible human observers should be assigned duties that utilize their scientific training such as identifying species in the catch (taxonomy), collecting and analyzing biological data, making observations that help to ensure that we understand the effects of fishing on fish stocks and the ecosystem. For the day to day regulatory compliance monitoring issues, using human observers for anything more than making sure that EM systems are working or spot checking compliance is really not a good use of human assets in the field.

Examples of areas where I see EM as a potentially more appropriate means of monitoring compliance are such things as bin monitoring on A. 80 catcher processors (to ensure compliance with fish handling rules), monitoring fish handling and discard protocols on deck and in the factory for CVs and CPs, and verification of closed area or marine protected area enforcement via VMS (I view VMS as a form of EM). While a human observer could be used for any of the above tasks, such use would be very tedious and hardly a good use of someone who spent four years learning about fish biology as well as enduring the practical training in fish species identification and applied species composition sampling methods. The use of an observer’s time for mundane monitoring tasks begs the question of opportunity costs in terms of the additional fish lengths, stomach contents data, or gonads that could have been collected if the observer’s time had been dedicated to those tasks instead of monitoring. Additionally, I see benefits to using EM for these compliance issues in terms of removing the observer from these issues which would actually improve the observer’s ability to do biological data collection and sampling duties and extract the observer from being placed in the breech for difficult regulatory compliance issues.

My belief that EM should be preferred for most day to day compliance monitoring tasks is based on a list of assumptions regarding successful practical application of EM in Alaska. One of these assumptions is that the EM systems to collect video can be made robust and reliable enough for the conditions on commercial fishing boats over the entire course of each fishing season. Another is that technologies to review of the digital video data allow the data to be electronically processed efficiently such that review by shoreside reviewers is cost effective. A third assumption is that legal issues surrounding the potential use of the video images for purposes other than the ones they were intended can be circumvented. Fourth is that in developing regulations for EM applications, performance standards rather than specific equipment (brand and model) requirements will be used to allow improvements in technology to be adopted in this rapidly developing area of technology application. In addition to these expectations, I am also assuming that regulators can craft regulations where system breakdowns do not create extraordinary costs such as requiring a vessel to return to port immediately if an EM system failure occurs under normal fishing conditions. Likewise, I feel that the eventual cost-effectiveness of EM will depend on fairly wide applications in Alaska which will allow for sufficient economies of scale for one or more private sector companies to develop cost effective EM systems and review technologies.

For the remainder of my talk, I will briefly outline my experiences with EM in several projects when I served as cooperative research coordinator at the Marine Conservation Alliance Foundation. These experiences have helped me consider how EM can be beneficial in Alaska groundfish fisheries. An application of specific interest to me is to use EM for monitoring a different way to handle and account for halibut bycatch on Amendment 80 coop vessels fishing for flatfish and cod. The current requirement that halibut be placed into below-deck tanks and removed only as the catch enters the processing area effectively increases mortality. An alternative approach may be to remove as many halibut as possible on deck and monitor this activity with EM to ensure that only halibut are removed and track the amount of halibut being removed. Accounting for how much halibut is removed on deck would be done by measuring individual halibut via a specially designed EM system similar to what was successfully done in Kodiak in the rockfish pilot EFP. Using EM for this purpose instead of human observers on deck may allow for better accounting of halibut catches relative to current observer sampling, may allow for a significant reduction in bycatch mortality of halibut, and may increase safety for observers compared to placing human observers on deck.

2.3.2 Session Discussion

The second panel (Industry Perspective on Electronic Monitoring) included presentations from Paul MacGregor, Julie Bonney, Bob Alverson, Todd Loomis and John Gauvin; the session was moderated by Nicole Kimball. The questions and comments mainly focused on differences between Canada and the U.S., and issues that the U.S. may encounter moving forward from pilot programs to full implementation. The panelists first noted that the U.S. is lagging behind Canada, but moving in a positive direction by testing the application of EM in specific North Pacific fisheries. There is a large suite of questions that need answering. Panelists emphasized that EM programs should be built from the bottom up, as past attempts have been largely top down in their approach. In that respect, many agreed that NMFS should hold a working group with industry and agencies before attempting to regulate EM systems. The fleet needs motivation and funding issues must be addressed before embarking on a new endeavor.

Additionally, some in the industry feel that fleets must have the option to choose between observer coverage and EM, as costs remain a primary issue and concerns remain that fleets will be required to carry observers and EM systems. Related questions focused on trying to assess the economies of scale for developing an EM program in Alaska – meaning, what scope of EM would need to be implemented in Alaska in order to make it worth providing the infrastructure and staff resources on a local level? Building on comments about economies of scale and potential failure of EM equipment, the panel discussed sharing expenses within industry cooperatives, such as the cost of fixing an EM system on an individual boat. However, the main technical cost has not been associated with repair and maintenance; rather it is associated with the initial start-up. For remote locations, it makes sense to have a port technician onsite for the duration of the start-up, so that s/he can address technical issues as they arise.

The group then discussed issues encountered moving from a pilot project to full implementation and their effect on industry support. In the Amendment 80 fleet, initial implementation was stressful because of the looming deadlines. However, the fleet now enjoys greater flexibility and they have time to add enhancements. The industry also finds EM cameras useful for their own purposes, and when the industry's needs coincide with those of the government, there is the greatest amount of cooperation. The question of local resources being used for video analysis came up, and this depends on the data needs. If tally sheets (e.g., observer data, logbooks, landing reports, or other vessel reported data) are used in conjunction with the EM system data (i.e., EM is used as an audit system for other data collection methods), timely video review may not be necessary. However, if the data are used for in-season management or need to be summarized daily, local review will be required. The panelists identified the shoreside pollock fishery as another potential candidate for EM.

2.4 Panel 3. NMFS Legal, Management, and Enforcement Considerations

2.4.1 Abstracts

NMFS Legal, Management and Enforcement Considerations – Management Perspective

Presented by: Susan Salveson, Assistant Regional Administrator, Sustainable Fisheries, National Marine Fisheries Service, Alaska Region

The application of potentially cost effective electronic monitoring (EM) systems to augment or supplement observer data on catch, sorting or discard activity onboard a vessel or in a processing facility has been assessed in numerous fisheries. From a management perspective, the application of this technology should be considered within the context of program specific goals and objectives and in a manner that recognizes the limitations of EM technology and data management while taking advantage of its potential flexibility to document specific activities.

Whether or not managers can integrate EM into a fishery monitoring and enforcement program depends on numerous considerations. For example, can a program be designed to prohibit discard of all or a limited number of species so the activity being monitored by EM can be tailored to limitations of available and reliable technology? What EM data will be captured and where; what is the proper technology to meet those needs? Will the EM data be used in season to manage fisheries or post season to verify a reported activity? How flexible must the equipment and its use be to accommodate vessel or plant specific layout and operation; can enforceable regulatory performance measures governing this flexibility be developed? What are the costs of integrating EM into a monitoring and enforcement program and who will pay these costs?

If managers determine a monitoring and enforcement program may benefit from EM technology, integration of EM data into the program will require an assessment and balance of several and likely opposing considerations. For example, how quickly is EM data needed to support a management or enforcement function? The faster data must be reviewed and integrated into a monitoring and enforcement program, the more expensive it may be to support expeditious shipment of hard drives and pay for experienced personnel to review the video data. How accurate is EM data and its review required to be to support a management or enforcement function? Experienced personnel who can provide a timely review can be expensive. Is cost a prohibitive factor? If the costs of timely and accurate review are prohibitive, can the management program forsake timeliness and perhaps data quality? The question of who pays for an EM program is important as well. Who pays for equipment and servicing? For transportation of hard drives? For contract or personnel costs necessary to review digital data? Finally, how will storage of data be accomplished while maintaining chain of custody for enforcement purposes?

In summary, use of EM can be an attractive alternative to the costs of observer data, but whether or not it is an appropriate or feasible alternative must be carefully assessed on a program by program basis.

Legal, Management and Enforcement Considerations: The Prosecutor's Perspective

Presented by: Susan Auer, National Oceanic and Atmospheric Administration, Office of the General Counsel for Enforcement & Litigation, Alaska Region

When electronic monitoring (EM) is proposed as an option for addressing specific program goals, it is important that it be carefully assessed from the perspective of investigation and prosecution of violations to ensure that the EM system requirements are integrated into the management program and can be effectively enforced.

The practical and legal enforcement constraints should be addressed by the managers and enforcement personnel before an EM system is determined to be a viable monitoring option. Assuming that the administrative record contains sufficient justification for the EM requirements and their costs, the legal concerns are relatively simple: If proving the violation will require reliance upon a recording generated by the EM system, then there must be a legally acceptable "chain of custody" (i.e. so that it can be shown who had possession of the recording at all times). In addition, the EM method must have sufficient scientific and statistical support so that it can be used to prove that it is more likely than not that the violation occurred. (A good example of this is VMS, where the Agency has not been able to bring a "fishing signature" case because there is insufficient statistical data and analysis that would support use of VMS for that purpose.)

The practical concerns are much more numerous. For example, the EM recording or image must be of a quality that it can be understood by and persuade a judge; the EM system must be actually appropriate for proving the violation (e.g., it would be difficult to prove retention of a prohibited species using a video image designed to detect human movement rather than to identify species of fish); there must be knowledgeable, qualified and available persons to provide testimony about the specific EM system and how it functioned in that particular enforcement action; there must be knowledgeable, qualified and available persons willing to serve as expert witnesses (both for the hardware and software) so that the Agency can withstand a challenge to the effectiveness, accuracy or reliability of the EM system; and there must be an adequate method to promptly and consistently review the video or other EM recordings.

Most importantly, however, since any EM system will require ongoing interactions between the Agency and individual vessels or facilities, and will require ongoing staff support in order for the Agency to effectively implement the EM system and to stay abreast with technical developments, the Agency must be able to maintain its commitment – both in staff and expenses – to using that EM system.

In summary, although EM may appear as an attractive alternative to the costs of observer data, it is important that each program where EM is being considered be thoroughly assessed and analyzed to determine the necessary and appropriate level of monitoring. Then, once that level of monitoring is identified, the various monitoring alternatives, including EM, must be considered objectively.

Legal, Management and Enforcement Considerations: Management Attorney's Perspective

Presented by: Thomas Meyer, Attorney Advisor, National Oceanic and Atmospheric Administration, Office of the General Counsel, Alaska Region

As is the case with any proposed Council or agency action, the administrative record supporting a Secretarial decision implementing an electronic monitoring action must reflect reasoning and an adequate factual basis. The action cannot overlook or disregard a material fact, or it could be found to be arbitrary and capricious by a court. NOAA General Counsel will carefully review the administrative record at both the Council and agency level and determine whether it substantiates a fishery management plan amendment and issuance of related regulations.

NOAA General Counsel will determine whether an electronic monitoring action conforms to explicit statutory guidance. Further, that the measures are necessary and appropriate for fisheries conservation and management. Guidance and authorities include the Magnuson-Steven Fishery Conservation and Management Act (MSA), the Regulatory Flexibility Act (RFA), the Halibut Act, the Administrative Procedure Act, and the National Environmental Policy Act (NEPA). In particular, an electronic monitoring action must comply with several MSA guidelines, including those implementing the national standards. The RFA requires that the agency assess economic impacts on small businesses and consider cost-reducing alternatives before it imposes electronic monitoring. NEPA ensures that the agency weigh electronic monitoring's environmental impacts before it decides what path to choose.

NOAA General Counsel can provide advice in the early stages of any electronic monitoring proposal. There are a variety of potential issues that can be spotted and resolved early. NOAA General Counsel Alaska Region has previously reviewed two programs establishing electronic monitoring: Amendment 80 and the Rockfish Pilot Project fish holding bin monitoring. In these programs, fisheries observers use video to monitor crew activity in fish bins. The enabling regulations specify technical and equipment requirements. Video monitoring helped observers identify whether catch was pre-sorted, which would bias their samples. In this context, the programs are a justified fisheries management tool.

Among the legal issues is whether electronic monitoring data would be deemed confidential information under the Freedom of Information Act. Electronic monitoring proposals should identify persons who must or will have access to the monitoring data. Who has access will answer questions about the data's vulnerability to FOIA requests or other public disclosures. Memoranda of Understandings that permit data-sharing with other agencies or entities should be reviewed to ensure they are adequate and enforceable.

Video monitoring requirements are subject to certain geographical or other legal limitations. For example, NMFS may be limited in requiring video monitoring on fishing vessels not fishing in the EEZ, or imposing it on vessels not required to hold a federal fishing permit. Other fisheries or vessels might be excluded from video monitoring requirements if there isn't a sufficient rationale justifying its imposition. Recently, the Council decided to exempt dinglebar gear vessels from carrying VMS because, among other concerns, the facts showed these vessels did not represent a threat to closed federal water habitat.

Video monitoring proponents may wish to designate particular video equipment brands or sources for system installation. Designating particular brands, such as Sony, or a particular business entity for system installation may catch DOC GC and OMB's attention. While there is no particular applicable guidance, video monitoring proponents will have to build a strong record to justify a particular equipment brand or system provider.

Legal, Management and Enforcement Considerations of EM: Enforcement Perspective

Presented by: Kenneth Hansen and Dayna Matthews, National Oceanic and Atmospheric Administration, Office of Law Enforcement

The NOAA Office of Law Enforcement (OLE) supports the consideration of appropriate technologies, including electronic monitoring systems (EM), to more effectively manage and enforce fisheries regulations under NOAA jurisdictions. EM may also provide economies of scale for better allocating enforcement resources.

Electronic monitoring by cameras has been used in the West Coast shoreside Pacific Whiting fishery for the past four years. During this time, the program has been conducted by the Northwest Science Center under an Experimental Fishing Permit (EFP). The original goal of the program was to determine if speciation of bycatch could be determined using video cameras. During the first year, the experiment demonstrated this goal could not be achieved, but the video systems did show potential for monitoring maximum retention requirements.

Now in its fifth year, the EM EFP is being conducted through a partnership with OLE and Sustainable Fisheries Division in the Northwest. It is anticipated this will be the last year EM is conducted through an EFP, with Amendment 10 moving the program to a regulatory regime in 2009. Also, for 2009, the EM program will be expanded to include the at-sea catcher vessel fleet supporting the mothership sector.

Still unproven, cameras are subject to four variables which will ultimately determine the utility of this management and enforcement tool: equipment reliability, timeliness and quality of the data analysis, enforceability of the regulations supporting the program, and fleet behavior. While equipment reliability, data analysis, and enforceability are within the purview of the NMFS, fleet behavior is the outlier. Cameras can be beat if that is the intent of the vessel operator. Fleet cooperation, or lack thereof, will ultimately determine the future of EM as a management and enforcement tool.

In the North Pacific, video is currently being utilized on catcher processor vessels to assist embarked observers in monitoring compliance with prohibitions on catch sorting by vessel crew in fish holding tanks. This limited use of video appears to be working well for this compliance monitoring purpose, and OLE has not had any opportunities to use this data in a prosecution.

OLE is collaborating with agency and industry partners in studying potential compliance uses of EM, specifically video monitoring. Currently, video monitoring is being analyzed in the context of augmenting or replacing observer generated data, and potentially monitoring for compliance with full retention or limited discard requirements in quota fisheries, where catch composition information is principally determined shoreside.

As with the NWD whiting program, effectively utilizing EM data for compliance monitoring and/or enforcement purposes in Alaska programs will involve addressing several similar issues. These issues include type approval of system. Who will pay for the program, including hardware purchase, installation, and support, and is support infrastructure available in remote ports/areas where the regulated fishery occurs?

Depending upon the management program goals, NOAA must address what amount of data review is needed to achieve desired compliance results; who will conduct this data review, and how will this review be paid for? Do written descriptions of procedures and standards used to collect, and analyze potential digital evidence exist? Are procedures in place to insure that any action that has the potential to alter, damage or destroy any aspect of digital evidence be performed by qualified persons in a forensically sound manner?

2.4.2 Session Discussion

The third panel (Legal, Management and Enforcement Considerations), included Sue Salveson, Susan Auer, Tom Meyer, Ken Hansen, and Dayna Matthews; Chris Oliver served as moderator. The discussion after this panel's presentations centered on legal constraints with data obtained through EM, but the audience raised other topics such as discarding and supply/demand issues as well. There was a discussion about the development of standards for uses of federal equipment. NMFS is working to develop case law in regards to the use of VMS in legal proceedings. VMS systems have been in place on vessels for some years and the information obtained from VMS is currently being used in prosecutions. There was some discussion about the potential U.S. applicability of the EM model used in Canada whereby video is used as a compliance/quality control audit on the logbooks. It is a model worth evaluating, but it is not clear if a comparable system would work within the U.S. legal and fishery management systems.

The discussion shifted to discard events, and panelists noted that current EM systems would not likely inform regulators about discards and other events in time for in-season monitoring. The potential lack of observers compared to growing information needs was also discussed in the context of demands for new EM technology. Panelists agreed that technology advances were required, but also reminded workshop participants that we are ever more reliant on observers for haul-by-haul catch composition and biological data. Many questions regarding management and enforcement of an EM program remain unanswered, though experience is being gained through the developments noted in the presentations. Until more experience is gained and outstanding questions are addressed, we are a ways off from developing a comprehensive regulatory EM program in the North Pacific.

2.5 Panel 4. What New Video Work Is Underway For Use In Fisheries Management?

2.5.1 Abstracts

By-catch characterization in the Pacific halibut fishery: A field-test of electronic monitoring

Presented by: Gregg H. Williams, International Pacific Halibut Commission

This study compares and evaluates the effectiveness of electronic monitoring (EM) and the currently utilized North Pacific Groundfish Observer Program monitoring methods to operate effectively on commercial longline vessels targeting Pacific halibut. The study is dependent on cooperation with industry, and as a result, data collection is aboard fishing vessels which volunteer to participate in the study. This has resulted in some unexpected departures from our original study design due to fishing schedules and weather issues limiting the number of trips, and vessel size limiting the number of observers deployed. However, we have been successful in deploying observers on vessels that generally are not required to carry observers due to their small size, and have been effective in collecting observer-based catch censuses. We have identified the operational issues surrounding the EM data collection, and expect to collect EM data through the fall of this year. We will be able to test the effectiveness of EM to collect data in a commercial fishery.

Electronic Monitoring in the Alaska Rockfish Pilot Program

Presented by: Alan Kinsolving, National Marine Fisheries Service, Alaska Region

Research conducted during 2007 indicated that EM could be used to credibly quantify the amount of halibut discarded at-sea by trawl vessels participating in the rockfish pilot program off Kodiak Alaska. Phase II of this project continues that research on an additional four vessels fishing in the actual fishery. Though it appears that EM is a viable technology for this application, numerous issues related to cost, infrastructure and an appropriate regulatory framework remain to be addressed before fleet wide implementation would be possible. Thus, while Phase I of this project was designed to assess the technical feasibility of EM in this application; Phase II is designed to provide additional information on what cost, regulatory and infrastructural issues must be addressed before EM can be implemented. This presentation will focus on what some of those administrative issues are and describe how Phase II of the Kodiak research is designed to provide information to assist NMFS, the fishing industry and the NPFMC in developing an effective EM program.

Future Monitoring Efforts in the Pacific Whiting Fishery

Presented by: Frank Lockhart, Assistant Regional Administrator, Sustainable Fisheries, National Marine Fisheries Service, Northwest Region

The Pacific Whiting Fishery is one of the most valuable fisheries on the west coast. The fishery is composed of three sectors: at-sea catcher processors, at-sea mothership processors and associated shore based catcher vessels, and a shore-based sector which lands fish at coastal processors. The at-sea sectors are monitored by on-board observers, with the caveat that the mothership catcher vessels are unmonitored. However, until recent years the shoreside sector was largely unmonitored while fishing. Beginning 3 years ago, the Northwest Science Center started an experiment to see if cameras on board could effectively monitor the fishery. My talk will focus on the future monitoring efforts in this fishery, which will include cameras, VMS, and potentially electronic logbooks on boards, with Catch Monitors in the plants to ensure that landed fish are accounted for.

Use of a Video Electronic Monitoring System on Bottom Longline Vessels in the Gulf of Mexico

Presented by: John C. McGovern, Sustainable Fisheries Division, NOAA Fisheries Service, Southeast Region

In partnership with industry, the NOAA Fisheries Service Southeast Fisheries Science Center (SEFSC) and Southeast Regional Office (SERO) are conducting a pilot study to determine the feasibility of developing a cost-effective and reliable system of monitoring bycatch, release mortality, handling of fishes, and other shipboard practices aboard bottom longline vessels in the Gulf of Mexico.

The project includes four components: 1) Outreach to the fishing industry to describe the project and the benefits of video monitoring; 2) Deployment of systems on 6 vessels; 3) Data analysis; and 4) Evaluation of the feasibility of using video monitoring in the Gulf of Mexico longline fleet. During December 2007, an outreach meeting was conducted with the fishing industry to describe the project and obtain volunteers. Fishermen from six vessels agreed to participate in the pilot study. During early March 2008, vessels were equipped with electronic monitoring systems consisting of three cameras placed on the back deck of each boat in tamper-proof housings, plus a global positioning system, all connected to a digital video recorder locked inside a tamper-proof case. Sampling was conducted during March 15 to April 30, 2008. Pertinent data collected by the video electronic monitoring systems included species caught, number of hooks, location, depth, date, time, and disposition of released organisms. An observer was placed on each vessel for at least one trip that monitored fishing operations with video hardware. Data are being analyzed and a final report will be completed in September 2008. Video monitoring systems have the potential to enhance information used for assessment and management of reef fish species and could prove to be a valuable data collection tool for the Gulf of Mexico longline fleet.

2.5.2 Session Discussion

The fourth panel of the workshop (New Video Work Underway for use in Fisheries Management) was moderated by Jennifer Watson and included presentations from four panelists: Gregg Williams, Alan Kinsolving, Frank Lockhart, and Jack McGovern. The discussion afterwards was lengthy and varied, but revisited the discussions from previous panels, and focused on the turnaround of data, comparisons between observers and EM, alternate EM methodologies and supplemental data sources, moving from testing systems to regulating systems, and data privacy and reliability.

To begin, panelists discussed the logistics of EM in the Northwest shoreside hake fishery. Data are typically available within 3 weeks, which is not sufficient for in-season monitoring. In the future, there might be an immediate initial data review at least to determine the number of discard events and NMFS would be able to identify non-cooperative vessels in a more timely fashion. OLE will have advance notice of vessel landings and can send out an enforcement agent to meet the boat if necessary. Additionally, panelists noted that currently EM in the shoreside hake fishery functions mainly as a data collection tool documenting both the number of discard events and an estimate of the quantity of those discards. However, EM also has an enforcement component as the agency cannot ignore direct violations of regulations which are caught on film.

It was noted that there have been comparisons of EM and observer data and the panel was asked if there was any common thinking on approaches to the two methods regarding what we should be looking for, and how we should move forward. While there have been some studies making discrete observer to EM comparisons, in many instances the data are lacking to make those comparisons. In other cases, observer and EM data collections have different objectives so we could be comparing apples and oranges. For example, observers can provide estimates of both size and composition of individual discard events, whereas video can provide a census of total discard events. The complexity of comparing the two approaches to data collection varies from project to project and depends on the specific data collection goals. It was also noted that many small boat fisheries are unobserved, so data do not exist to make comparisons between the two methods. Given the challenges to observing small boat fleets, EM may be a more viable alternative than observers to meet some data collection needs. All panelists agreed that it is difficult to make direct comparisons between observer and EM systems, noting that EM is better thought of as a completely new, separate way of gathering data.

Discussion shifted to addressing the potential for EM applications in processing plants, where a great deal of catch accounting occurs. A potential example was given whereby EM could monitor the general sorting and observers could focus on rare species. The panel noted that there is potential for applications in processing plants and that several possibilities have been discussed but that practically they are still some time out in the future. It was noted that installations in plants would potentially be easier than on boats.

Two points were addressed specific to the Pacific halibut fishery. One point was specific to the use of survey data to supplement fisheries landings data in lieu of observers or EM. While it could be used, it would be a proxy, at best, as the survey also operates in areas not fished commercially. The second point was specific to the ongoing project using EM in this fishery as it was pointed out that it has been challenging to get voluntary participation in the project. This highlighted the importance of including fishermen’s needs in program development. As the commercial halibut fleet in Alaska is not currently subject to observer coverage requirements, it is likely that the halibut fleet did not see how EM would aid their operations, and thus it was not a fleet priority.

Noting there is a gradual shift occurring from pilot studies to regulated operational EM systems, there was considerable discussion about how best to set up regulated systems. In general, the use of performance standards and/or type approval appears to be a good approach, noting that “hard wired” specifications do not work because the regulations do not keep pace with technological changes. Additionally, it was suggested that the end product should be determined upfront (i.e., what data do you want?), and approaches that stimulate regulatory workarounds should be avoided. An example of a regulatory workaround was given whereby some owners have shortened their vessels to avoid observer coverage requirements based on length. Placing the responsibility on industry to come up with the best approaches to solving problems and meeting agency requirements was encouraged. As well, regulators were advised to seek input from other fleets that have already implemented EM, in order to take advantage of their expertise. Further experience with the Bering Sea/Aleutian Islands Amendment 80 vessels was discussed, identifying the need for power protection (for brownouts and surges) and the potential for some advanced technologies to aid in data collection, as well as some simple practices such as shapes rather than letters or numbers to aid in obtaining measurements from video. Additionally, if it is necessary to ship hard drives for data retrieval, it was suggested that regulations address packaging since hard drives are extremely fragile. Within the Amendment 80 fleet, a combination of type approval for scale technology and performance standards for video was used in regulating the fleet.

Data privacy was revisited, and it was a common theme throughout the workshop. In the NMFS Southeast Region, data confidentiality was discussed at an outreach meeting so the fleet was assured, in advance, that data would be private and not distributed to anyone. The fishermen then felt confident that others would not see their catch numbers and fishing locations.

Discussion expanded from data privacy to questions about data reliability. Data reliability is challenging on small boats, and it was pointed out that missing data may represent a source of real bias in small fleets. The solution to this problem depends on how much funding is available to create comprehensive systems, the impacts on fishery participants, and how open the fleet is to electronic monitoring. The closing point was that strong industry buy-in is required for good EM monitoring, especially of a small fleet.

2.6 Panel 5. Research and Development Advancements and Future Needs

2.6.1 Abstracts

Review of the State of Video in Other Fishery Research Applications

Presented by: Dave Somerton, Resource Assessment and Conservation Engineering Division, NOAA Fisheries Service, Alaska Fisheries Science Center

Methodology for the collection and analysis of video observation in fisheries research has advanced rapidly in the last 5 years in two areas that may be of particular importance for monitoring the fish catching activities of commercial vessels, that is, stereo video and automatic pattern recognition. Stereo video, because of its ability to measure the distance to every pixel in the image, is used to estimate the lengths of fish. In normal, single-view, video fish length can only be determined if the fish is oriented perpendicular to the lens and if some reference dimension is also in the field of view. Automatic pattern recognition holds the promise of recognizing distinct objects (for example, individual fish) in the field of view, identifying them to species and potentially measuring them all without operator intervention. Such a system has been developed to identify, count and measure scallops on Georges' Bank video taken on towed camera sleds.

Integrated Fisheries Monitoring

Presented by: William A. Karp, Deputy Director for Science and Research, NOAA Fisheries Service, Alaska Fisheries Science Center

In the North Pacific and elsewhere, information requirements for fisheries science, management and enforcement can be expected to increase in the future. As we further embrace the ecosystem approach and increase our attention to the ecosystem impact of fishing, we will require more detailed information on catch and bycatch characteristics and associated environmental conditions. As we implement more limited access privilege programs, managers will require more timely and comprehensive information on retained and discarded catch. Spatial characteristics of fishing operations and catch will become increasingly important and compliance monitoring requirements can also be expected to increase. In the late 1990s the concept of integrated fisheries monitoring emerged as agencies struggled to reconcile differing and sometimes competing needs for fishery dependent information. While sophisticated multi-objective observer programs were well established in some regions, the use of electronic monitoring technologies was in its infancy. Following initial implementations of VMS, the value of this technology as a source of scientific as well as compliance data was becoming apparent and possibilities for linking VMS with sensors that could be used to better define fishing effort had been demonstrated. We continue to depend on observers to collect data in support of many of our current fishery dependent data needs but the definition of “electronic monitoring” has expanded to include video, electronic logbooks, and sensors of many types. An integrated approach is necessary to assure effectiveness and efficiency of most current and future monitoring programs. This approach may require reconciliation of competing information needs, and will almost certainly necessitate selection of the appropriate combination of human and electronic monitoring resources, and the design and implementation of information systems that facilitate synchronization of disparate information and support requirements for timeliness, spatial resolution, and accuracy as defined by scientists, managers, and enforcement personnel.

How to Operationalize Electronic Monitoring in Commercial Fisheries

Presented by: Howard McElderry, Archipelago Marine Research Ltd, Victoria, BC Canada

Moving toward the use of electronic monitoring as an operational part of a fishery involves a number of considerations. Initially, pilot tests are useful to assess the overall feasibility of the technology for the fishery application, and to gain an understanding of EM suitability for the fishery. Moving from a pilot program to a fully implemented program requires the development of specific monitoring specifications in order to plan project operations and costs. The specifications will require a lot of discussion among various fishery stakeholders and must identify the specific components of the program and how they will operate. The specifications should include detailed information on critical issues that drive cost such as fleet activity, coverage levels, landing ports, timelines, reporting requirements, and project deliverables. Once the specifications have been completed, a plan for program delivery must be developed. Program delivery issues include service delivery model (who is providing the service), monitoring program oversight, funding arrangements and the responsibilities of the parties involved. If possible, the program should be phased in over a period of 2-3 years, allowing for a smoother transition for all parties, and enabling the new monitoring infrastructure to become established. The phased approach also allows for management of start up costs which can elevate monitoring program cost by 10 - 30% in the first few years after program start up.

Catch Meter in U.S. Fisheries Monitoring

Presented by: Helge Hammersland, Managing Director, Scantrol AS, Bergen, Norway

The CatchMeter is a vision based system for automatic classification of individual fish for monitoring and quality control purposes. The CatchMeter is a result of a research and development project that was initiated by IMR in Bergen in 2003, with Aberdeen University and Scantrol as project partners.

The main function of the CatchMeter is classification of individual fish by specie and length. It can be trained to recognize a large number of species, and the training procedures are easy to carry out. The capacity of the model that is available today is up to around 6000 fish per hour, but this will increase on future models.

Test results have shown that it is possible to classify species with an accuracy of up to 99%, and measure the length of the fish with a resolution of 1 mm.

A possible application of CatchMeter in U.S. fisheries has been discussed with both commercial fishing companies and the authorities:

A percentage of the catch will be extracted from the main production stream, and fed to the CatchMeter for classification. The CatchMeter will include functionality for extracting the fish to be sampled, and will generate reports for the skipper and for the observer immediately after the sampling is finished. This will be a good management tool for the skipper, and help the observer to provide accurate measurement of a randomly selected percentage off the catch.

The Electronic Catch Monitoring Option - Economic Dimensions

Presented by: Gordon Gislason, GSGislason & Associates Ltd., Vancouver Canada

The economics of EM for a particular fishery are dependent upon specifying: 1) what is the monitoring objective, and 2) what is the alternative to EM in meeting this objective (e.g., observers)? These precursor issues are discussed before analyzing differences in cost structures between EM and observer programs. Additionally, I identify the attributes of fisheries for which large EM cost savings are expected. Typically, when observer requirements are 50% coverage or more, EM will have a cost advantage, but this may still vary depending on fishery. When the monitoring focus is on TEP species or single species fisheries, these will benefit more from EM than observer coverage. Another thought to consider is the potential for public funding of observer programs, but this may raise data confidentiality issues. As a closing thought, the demand for third party monitoring is constantly increasing, and it is expected that the EM cost advantage will increase over time relative to observer program cost.

2.6.2 Session Discussion

The last panel discussion (Research and Development Advancements and Future Needs) included presentations by David Somerton, Bill Karp, Howard McElderry, Helge Hammersland, and Gordon Gislason, and was moderated by Clarence Pautzke. The discussion began when the panelists were asked to list two or three future research needs that they felt were a priority for 2009. The first comment, while not a research priority, cautioned that when creating new regulations to govern electronic monitoring, we must review past regulations and amendments to see if they will benefit or conflict with proposed EM requirements. Additionally, panelists reminded us that industry support is not typically a problem as vessel owners and captains are often excited about EM potential; however, they often can not necessarily fund EM, which is why using EM for auditing purposes is a viable alternative. Observers and technology are both invaluable for providing monitoring data. In the future, panelists would like to see further development for real-time analysis of EM data and tying EM data in with electronic logbook data and communication systems. Other research needs are the development and evaluation of technology for species identification, automating the process for removing samples from the entire catch, reaching unsampled sectors, increasing the capability to collect different kinds of data, incorporating performance sensors in EM systems and testing the CatchMeter technology in Alaska. Cost analysis should also be an integral part of each EM project, including the cost of changing onboard handling processes or other vessel operations (if required). Collaboration with the effected representatives of the fishing industry to develop a straw man monitoring system was also suggested.

The rest of the discussion centered on the size of the observer pool, cost (a recurring theme of the workshop), and service delivery. It was noted that observer availability appears to be a function of the state of the economy. There are currently ~500 Alaska groundfish observers, but the number fluctuates depending on temporal demands. The cost of the CatchMeter was of keen interest to several participants, but cost can very widely depending on the complexity and size of the implementation. Also, even though the CatchMeter can handle 8,000 fish/hour (each fish must be viewed separately), it is not enough to characterize entire loads on large trawlers. For Alaska, the CatchMeter would be useful for sampling, but not censusing, catch. The idea of utilizing several EM companies to provide various components of an EM system (equipment, field services, data analysis, etc) was suggested, but the most logical service delivery for EM appears to be a single service provider for a particular fleet grouping.

3 Workshop Synthesis and Discussion

3.1 Synthesis

The goals of the workshop were to assess:

- the current state of the art/science of video monitoring technology in fisheries,
- its applicability to research and management of the North Pacific fisheries,
- its future potential, and
- research and development needs.

The synthesis of the workshop sessions addresses each of the four goals.

3.1.1 Assess the current state of technology

The presentations demonstrated that EM consists of the proven technologies of closed circuit TV (CCTV), Global Positioning System (GPS)/Vessel Monitoring System (VMS) which could stand alone, and sensors on winches and hydraulics. The key components of the system have successfully provided data in a number of fisheries. In the case of some vessels in the British Columbia Area A crab fishery, eight year old systems still function on board the vessels that initially entered the Area A crab fishery management system with EM. The systems have worked successfully on a number of vessel types representing various fisheries, from factory trawlers fishing for groundfish, to halibut and sablefish longline vessels, to pot vessels fishing for Dungeness crab.

These technologies have been successful in pilot programs and have entered the management and enforcement tool box with proven applications. The EM systems have successfully monitored, and in some cases modified, behavior of fishermen during fishing operations. The original EM example of the British Columbia Area A crab fishery restored order to the fishery by monitoring gear use, eliminating vandalism, and controlling gear loss through tracking pot lifts with radio-frequency identification (RFID) combined with closed circuit television and GPS for each pot. EM utilized in the Northwest Pacific whiting fishery monitors and confirms retention in the fishery to allow for management of other species, e.g., catch limits for Pacific region rockfish. EM proved adequate for determining whether fishermen followed requirements to use bird avoidance devices on halibut longline vessels that are not required to carry observers.

EM systems have proven successful in making counts of individual activities. The RFID system counted and identified individual pots in the Area A crab fishery, and technicians counted hooks utilized by longline fishermen and counted fish on the hooks. In some cases, EM technicians could identify individual species. Comparisons of EM data with observer data often showed satisfactory similarity between the two data sets; neither can serve as an absolute standard as each method has inherent errors.

EM systems do some things well, but other things not as well. The research to date has been about understanding the potential uses of EM, and what type of data the technology can provide. High potential exists, for example, to use video in hook-and-line fisheries where individual fish can be imaged. Research shows the potential to obtain an accurate length from the image. In contrast, receiving comparable data from trawl vessels is challenging because of the bulk fish handing practices where individual images are not possible. Video can monitor for discard events (e.g., at-sea hake) but is much less effective for species composition, given existing fish handling practices. In all cases, the specific objective for EM should be identified and assessed to see if it will work to meet the management objective in the specific fishery context.

EM has entered the management system in the form of regulations, with more management applications under evaluation. Canada incorporates EM in the management plans for a number of fisheries. Regulations are now in development for the Northwest Pacific whiting fishery and the fishery has been successfully prosecuted under an EFP for many years. While originally intended to monitor full retention, analysis of the data showed that 100% retention was not practicable, and the Pacific whiting management system evolved to a much more complex requirement to demonstrate an adequate level of retention.

In spite of the proven technology and successful applications, the presentations demonstrated that widespread application of EM will need to address a series of issues. These issues reoccurred throughout the workshop. The issues break into two main categories, 1) administrative: cost and funding, regulatory environment, and confidentiality; and 2) practical: incentives for industry to participate, delay between data collection and analysis, system reliability, and tampering. Overarching these categories is the issue of data quality – can video provide information of a sufficient quality to meet fishery managers' needs.

Costs and funding were also common themes discussed during the workshop. Experiences in Canada and with the Northwest Pacific whiting fishery provide some rough guidelines for costs, but the costs for a system in any potential fishery depend on the details of the configuration. A primary issue is the amount of cost borne by the industry versus government. In Canada, industry funds EM, often a less expensive alternative to on-board observers. Currently, the industry in Alaska pays for the direct costs of observers on groundfish vessels. Because the role of EM in Alaska is likely going to be significantly different among fisheries, the overall cost and funding requirements are not clear. Application of EM to a management system in a U.S. regulatory environment will require a substantial amount of consultation among managers, general counsel, law enforcement, and industry. Among the regulatory issues is assuring an unbroken chain of custody from the collection of data to analysis and use of the results. While the reauthorization of the MSA confirms that observer data are confidential, and defines observer data to include electronic monitoring, questions still exist on the legal uses of the data and who may access them.

Considerable discussion revolved around incentives for industry to participate. In general, industry will participate in EM programs when EM provides superior benefits than the alternatives available. Both industry and non-industry participants at the workshop encouraged outreach activities to inform the industry and receive industry feedback.

The impact of delays between EM data collection and analysis depends on the timing of management needs. There will be tradeoffs between cost, timeliness, and quality in any video application. Each of the three variables may affect the other two.

While many EM systems have worked well for long periods on vessels, most pilot programs discussed at the workshop experienced EM system failures during the project. Reliability seems to increase with the duration of the project, as technical problems with systems are overcome. No system can be made tamperproof, but all systems should be made tamper evident, to the extent possible. Without some means of detecting tampering, enforcement capabilities are diminished.

These issues of concern identified in the current state of the technology resonate through discussion of the applicability of EM to the North Pacific and of the future use of this technology.

3.1.2 Assess applicability to North Pacific

EM has many potential applications for North Pacific fisheries. However, incorporating EM into a monitoring program will depend heavily on the objectives of the particular program. Numerous discussions pointed out that observers and EM may do different things well, and the program must identify the objectives clearly enough that program design can incorporate the most appropriate data collection program, whether EM or observers or both. Although the workshop focused on EM, and video monitoring in particular, several presentations and discussions pointed out that EM is part of an overall *monitoring* system and should be used as a component to enhance the overall system.

The regulatory and legal environment in the North Pacific will affect the application of EM to fishery monitoring. Sufficient reviews of the management, regulations, and enforcement requirements have not occurred to provide clear guidance for development of programs involving EM. Substantial differences exist between U.S. and Canadian law, such that the U.S. will not likely be able to directly track the Canadian experience. Experience with contractual arrangements related to compliance requirements with U.S. fishery cooperatives suggests that cooperatives may offer an efficient means of regulating some aspects of monitoring requirements. Close coordination among program developers, fishery managers, NOAA General Counsel, Office of Law Enforcement, and fishermen will enhance development of a suitable program.

Experience has shown that industry participation and support is critical to the success of an EM program. In general, the support will increase as the benefits that a vessel owner or operator receives increase. Many participants spoke of the need to bring industry representatives into discussions early in the process to build a monitoring program, but especially when EM forms a component of the monitoring program. Fishermen will have different incentives whether to support incorporation of EM depending on their share of the monitoring costs.

Fishermen and managers may determine that EM offers a high degree of applicability within a suitable regulatory mechanism, but the costs of the program and a decision on funding may drive the decision whether to fully develop and implement EM in the North Pacific. While Canada has devolved most direct costs of monitoring to industry, including observers and EM, the U.S. government pays for most observer programs, with the notable exception of the North Pacific. The costs of monitoring must be made in the context of the overall monitoring program, with a view of the costs compared to the alternatives. For example, different costs and different data result from a full implementation of EM compared to an audit, or whether EM would replace or supplement observers. In the Canadian experience, the requirement to pay management costs provides an incentive to fishermen to develop the most cost effective program that meets the management requirements.

EM systems are very data intensive, and Information Technology(IT)/database considerations for storage and analysis of data must be addressed early in the development of the programs. Database considerations are often postponed to the end of program development, and the resulting IT system may be inadequate for the program needs.

3.1.3 Assess future potential in the North Pacific

Two programs that rely on EM to various extents, the shoreside Northwest Pacific whiting fishery and specific catcher processors in the Amendment 80 sector in the Bering Sea/Aleutian Islands off Alaska, demonstrate the future potential for EM in the U.S. North Pacific. Both programs are integral to management. Regulations are in place in Alaska and in development in the Pacific Northwest. Comparison of the programs gives insights to future development of EM in other U.S. fisheries. Shoreside Pacific whiting monitoring began as a series of pilot projects under an exempted fishing permit (EFP), with each new phase building on the prior. Through consultation with the industry, the objectives evolved, shifting from monitoring full retention to monitoring for maximum retention. The regulations are developing with consultation between the government and industry. The Amendment 80 bin monitoring program received industry support, but regulations developed quickly in an environment with little previous experience. In retrospect, the regulations would have benefited from additional consultation, experimentation, and refinement of the performance standards to improve vessels' ability to comply with the program.

In both cases, the programs successfully addressed issues of concern identified in Section 3.1.1. The future of other projects will depend on how well developing programs address these same issues and other issues not yet identified. A number of presentations identified key concerns, such as enhanced industry participation, resolving regulatory and legal issues, and resolving cost issues.

Developers of monitoring programs that use EM should consider the full sampling needs of the program, and combine technology and observers in a way that takes advantage of what observers and EM do best. For example, several presentations mentioned the inability of VMS to identify fishing activity. However, the addition of video to VMS could conclusively demonstrate when fishing occurs and monitor the fishing event, as linked with location.

Most current EM programs have minimal biological data collection components. Rather, EM monitors fishermen behavior (e.g., discarding or not discarding fish; using or not using bird avoidance devices; ownership or non-ownership of hauled pots). Counts of individuals and, sometimes, identification of species, can occur when fish are brought on board individually (e.g. hook-and-line gear). As the ability of EM expands to incorporate more biological data, its use will increase. The recent Gulf of Alaska rockfish pilot program demonstrated that EM can obtain fish lengths under specific parameters, which would greatly increase the applicability of EM data.

3.1.4 Assess research and development needs

At the conclusion of the panel session on research and development advancements and future needs, the moderator requested that each panel member provide several key research topics that could be considered by the North Pacific Research Board when developing future requests for proposals. The panel suggestions captured many ideas from workshop presentations and discussions, and are presented below:

- Business center for vessels. EM has the potential to serve as an information center for vessels, for example, through an electronic logbook (ELB) integrated with EM sensors that contains information required by the management system and desired by the fisherman. By making an integrated ELB essential to fishermen, managers, scientists, and enforcement also receive high quality information.

- Cost analysis. Analysis must evaluate not just the cost of EM systems, but the cost relative to alternatives to EM. Data required by monitoring systems may be obtained in a variety of ways, often either EM, observers, or a combination. Cost of EM systems may also include changes in operations of vessels, for example, by rearranging discard chutes to pass discards by a camera. Many regulations are currently based on observer data; implementing EM may require major revisions to the regulations, at a cost often overlooked.

- Automatic fish identification and measurement. Early attempts to use digital image recognition to identify fish to species failed in the field, but new work shows high potential for identifying individual fish on board vessels and underwater. Length measurements of individual fish also seem promising. Continued development and field testing are necessary.

- Automatic system for sample collection. If automatic fish species recognition proves feasible and cost effective, a system that automatically collects a subsample from large quantities of fish (e.g., a trawl haul) would prove invaluable for identification of species composition.

- Crew sampling. On several occasions, the idea surfaced to have vessel crew members conduct biological sampling, with video cameras monitoring the collection and processing of samples to confirm proper procedures. Evaluation of appropriate biological data, development of training, and field testing would determine if the concept has potential for application.

- Environmental data. Application of ecosystem-based fishery management often requires more environmental data than are currently collected. Use of existing sensors on fishing gear and fishing vessels, development of new sensors, and integration into on-board data storage devices could provide new data.

Two additional ideas for research and development surfaced several times during the workshop:

- Develop standards, do not specify equipment. Specifying equipment for EM systems restricts improvements and may run afoul of regulations. Specifying performance standards avoids these issues.

- Rapid transmittal of large data packets. Video, sensor, and GPS data represent very large data packets. Technology that allows for wireless transmittal of these data from vessels to the database will shorten the delay between data collection and data analysis, and provide much more flexibility for managers to use the data.

3.2 Discussion

Toward the end of the workshop, Bob Trumble of MRAG Americas, Inc. provided a preliminary synthesis of the presentations and discussions heard thus far. Martin Loefflad led the wrap-up discussion by asking the audience if Bob accurately captured the thoughts and ideas of the workshop. There were a few general thoughts on the wrap-up presentation, a discussion on observer responses to EM, dialogue on the importance of local infrastructure, some discussion of future direction and Council response, and finally, closing remarks. A few people had comments on the wrap-up presentation. First, we must make a distinction between tamper-evident and tamper-proof design. Additionally, the use of EM in measuring fish length must be captured, and we should be aware that adding EM as a monitoring tool may necessitate redefining observer protocols. We also need to highlight the potential for implementing EM in fisheries or fleets in which shoreside monitoring is suitable, with EM used as a tool primarily to monitor discard events. Finally, emphasis was placed on the fact that observer coverage and EM should be considered tools in the toolbox; sometimes one is better, and sometimes they can work together; EM is simply a subset of integrated monitoring.

The discussion then shifted to observer responses to EM. So far, feedback from observers in the BSAI Amendment 80 fleet has been positive; they like having another “set of eyes.” Additionally, this fleet could consider installing cameras on deck to enhance what an observer can monitor. Australian observers are extremely supportive of EM, because a single haul can last for upward of 15 hours. As such, EM allows observers time to sample the catch, and increases the safety of observers on board. EM could also provide observers more comfort in reporting violations because there would be an electronic record. Regardless of the response, however, one thing was agreed upon: obtaining regular feedback from observers on the integration of EM systems onboard should be a priority.

Participants discussed EM system infrastructure next, and clearly, we cannot underestimate the importance of the information technology (IT) systems that enable EM to function properly. IT must be part of the design from the very beginning, but in reality this is not often the case. There was a lot of discussion about equipment standards, but we also need data standards, so that the related IT systems develop accordingly. Finally, it was noted that infrastructure is very important for ongoing support, but that technology and monitoring need to be developed on a fishery-by-fishery basis.

Towards the end of the discussion, participants talked about future steps, specifically for the North Pacific Council. Should we continue to utilize EFPs or regulations like Amendment 80, or use some other mechanism entirely? Should we hold workshops focused on individual fisheries? Participants responded that for individual fisheries, a small group should develop a core baseline model and then bring it to discussion with a larger group. However, a word of caution was given that if you let EM grow up organically, it is very hard to step back at a given point and get a broader view – we then risk not addressing the economies of scale issue. Additionally, it was mentioned that we spend a lot of regulatory time and effort finding solutions to problems, when some broadly written rules should provide incentives and allow industry to do research on their own. As for the North Pacific Council, it is well aware of the issue of electronic monitoring, and the quality and cost of monitoring programs is a continued priority. More focus on the integration of EM with the existing observer program is likely in the future. At its December 2008 meeting, the Council will again consider whether and how to attempt to restructure the groundfish observer program in the North Pacific, recognizing that EM can potentially play a future role. The Council will proceed with further workshops, Council meetings, committee meetings, and smaller group discussions, etc., with a likely first step to focus on a specific issue or individual fishery first.

As some final take home points, participants reiterated that the industry must be involved in the early development of an EM design, that we must start small, and that we should allow the fleet to drive technological improvements. National and international experience has shown that performance standards and type approval are the preferred approach. Additionally, more flexibility (afforded when using EFPs to test EM) will result in more options and faster growth. Transparency and getting the right parties involved to speak freely and openly is imperative. The goal of this workshop was to obtain a common knowledge, language, and understanding of the challenges that we face in implementing EM. We now must look more carefully at how technology can advance fisheries monitoring in general, and perhaps we can move EM in parallel with observer coverage – this is a paradigm shift and the challenge for the future.

4 List of steering committee and speakers

Steering Committee

Nicole Kimball, North Pacific Fishery Management Council
Martin Loefflad, National Marine Fisheries Service
Chris Oliver, North Pacific Fishery Management Council
Jennifer Watson, National Marine Fisheries Service
Francis Wiese, North Pacific Research Board

Keynote Speaker

Howard McElderry, Archipelago Marine Research, Ltd. *Current assessment of the state of video applications in fisheries in the United States and internationally*

> Howard McElderry is a founding member of Archipelago Marine Research, Ltd. with twenty-five years of experience in the field of commercial fisheries monitoring and analysis. Mr. McElderry is vice president of Archipelago and director of the electronic monitoring division.

Panel 1: Lessons Learned from Past Applications

Bruce Leaman, IPHC. *Lessons learned through the application of Electronic Monitoring technology by the International Pacific Halibut Commission: regulatory compliance, bycatch monitoring, and comparison between EM and observer catch composition estimates*

> Bruce Michael Leaman is the Executive Director of the International Pacific Halibut Commission (IPHC), located in Seattle, WA. Established in 1923, the IPHC is a joint Canada-United States commission responsible for research, assessment, and management of the Pacific halibut resource from California through the Bering Sea. Dr. Leaman was the Canadian Scientific Advisor to the IPHC from 1985-1997 and was appointed as its Executive Director in 1997.
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> Prior to joining the IPHC, he was employed for 21 years as a researcher with the Canadian Department of Fisheries and Oceans at the Pacific Biological Station in Nanaimo, B.C., where his primary responsibilities were as Head of the Stock Assessment and Recruitment Biology Program concentrating on biology, stock assessment, and population dynamics of rockfishes, sablefish, and lingcod.
>
> Educated at Simon Fraser University (B.Sc.) and the University of British Columbia (M.Sc., Ph.D.), Dr. Leaman publishes in the fields of fishery management, stock assessment, and reproductive biology. He is also an Affiliate Professor in the School of Aquatic and Fishery Sciences at the University of Washington.
>
> Research Interests: Reproductive and evolutionary biology of long-lived fishes; stock assessment; fisheries governance, management, and harvest policy.

Jennifer Watson, NMFS Alaska Region. *Electronic Monitoring in the Central Gulf of Alaska Rockfish Fishery*

> Jennifer Watson is a Resource Management Specialist for NMFS Alaska Region, in the Sustainable Fisheries Division. Jennifer received a Bachelor of Science in Marine Fisheries from the Texas A&M University at Galveston. Her current work is focused on developing appropriate monitoring tools to ensure accurate catch accounting including testing electronic monitoring for its use in fisheries management.

Jon Cusick, NMFS Northwest Region. *The U.S. West Coast Shore-based Pacific Hake Fishery*

> Jonathan Cusick manages the NOAA Northwest Fisheries Science Center's observer programs that collect data on U.S. West Coast groundfish. He joined NOAA in 2001 to establish the West Coast Groundfish Observer Program after working for five years as an observer aboard vessels in the North Pacific, the Indian Ocean and along the West Coast. While there, he has been responsible for testing electronic monitoring systems for fishery monitoring applications, specifically the shore-based hake fishery.

Amy Van Atten, NMFS Northeast Region. *Video monitoring of commercial fishing operations in relation to observer programs in the Northeastern United States*

> Amy Sierra Van Atten has worked for the National Marine Fisheries Service for 17 years or so. Most of that time has been spent with the Northeast Fisheries Science Center. Amy is the Fisheries Sampling Branch Acting Branch Chief which manages and directs the Northeast Fisheries Observer Program (NEFOP). Amy has also spent several years in Alaska and Antarctica developing and conducting data collection programs at sea. Amy has a Master of Science Degree from the University of Maine, Orono in Wildlife Management. Her research was on aging and food habits of seals that were bycaught during commercial fishing activities.
>
> Amy is currently serving on the National Observer Program Advisory Team, the National Electronic Monitoring Team, the Herring Plan Development Team, and is working with the groundfish fishery as it develops monitoring programs for sector management. Amy is also involved on the International Fisheries Observing and Monitoring Conference Steering Committee, with concentrations on data collection tools, the values of fishermen using observer data, observer training and accreditation, and observer professionalism.

Rick Stanley, DFO Canada. *At-Sea Observing Using Video-based Electronic Monitoring: An Audit Tool for Fishing Logbooks: Some downstream complications*

> Rick Stanley is a research biologist with the Science Branch of Fisheries and Oceans Canada. He works at the Pacific Biological Station, Nanaimo, BC. His work focuses on stock assessment of rockfish (Sebastes spp), commercial catch monitoring, and survey design.

Panel 2: Industry Perspective

Paul MacGregor, At-sea Processors Association. *Application of Video Monitoring Technology On-board the Pollock Catcher Processor Fleet in the Bering Sea*

> Paul MacGregor is a senior partner in the Mundt MacGregor law firm, a Seattle-based law firm that specializes in U.S. and international fisheries issues. He is also General Counsel to the At-sea Processors Association (APA), a trade organization that represents the owners and operators of the nineteen vessel fleet of catcher processors that operate in the Bering Sea pollock fishery. He has been actively involved in the North Pacific

Fishery Management Council process for thirty years and has served on the Council's Observer Advisory Committee since the early 1990s.

Julie Bonney, Alaska Groundfish Data Bank. *How much will Electronic Monitoring Cost Industry?*

Julie Bonney is the Executive Director of Alaska Groundfish Data Bank and the cooperative manager for all five Kodiak shorebased rockfish cooperatives. She has been involved in development of electronic monitoring for use in the Rockfish Pilot Program as the exempted fishery permit holder for two different projects that examine the utility of EM in the rockfish fishery. Julie has a Master's degree in Environmental Science from Drexel University and a Bachelor's degree in Biology from the University of Puget Sound.

Robert Alverson, Fishing Vessel Owners' Association. *Electronic Monitoring Issues in the Alaska Longline Fleet*

Robert D. Alverson has been Manager of the Fishing Vessel Owners' Association (FVOA) since 1976. The FVOA members operate vessels from mid-40 foot to 85-foot in length and are crewed with three to six persons. Mr. Alverson has served on both the North Pacific and the Pacific Council and the Conference Board to the Halibut Commission.

Todd Loomis, Cascade Fishing, Inc. *Electronic Monitoring Perspectives from an Amendment 80 Vessel*

Todd Loomis is employed by Cascade Fishing, Inc. He is a former North Pacific groundfish observer and was a fisheries biologist with the Observer Program from 1998 – 2006. While with NMFS, Todd was involved in several EM projects on small and large vessels. Cascade Fishing has one Amendment 80 vessel that uses an electronic bin monitoring system.

John Gauvin, Best Use Coalition. *Industry Perspective on Electronic Monitoring in Alaska Groundfish Fisheries*

John Gauvin is a fishery economist who has worked both in government on the east coast and in the fishing industry in Alaska. He has extensive work with the Amendment 80 sector and other sectors of the Alaska fishing industry on development of solutions to fishery management problems such as bycatch, effects of fishing on habitat, incorporating ecosystem considerations into fishery management, and modification of fishing practices to improve sustainability.

Panel 3: NMFS Legal, Management, and Enforcement Considerations

Sue Salveson, NMFS Alaska Region. *NMFS Legal, Management and Enforcement Considerations – Management Perspective*

Susan Salveson has worked with the National Marine Fisheries Marine Fisheries Service (NMFS) since 1975. She currently is the Assistant Regional Administrator for Sustainable Fisheries in the NMFS Alaska Region. The Sustainable Fisheries Division is responsible for implementing North Pacific fishery management programs and regulations developed in coordination with the North Pacific Fishery Management Council and as authorized under the Magnuson-Stevens Fishery Conservation and Management Act. Prior to her work with the Alaska Region, Ms. Salveson worked with the Alaska Fisheries Science Center in Seattle and the Center's Auke Bay Laboratory conducting research and other activities supporting North Pacific groundfish stock assessments. Ms. Salveson received her BS degree in Biology from Western Washington University and her MS degree in Fisheries from the University of Alaska.

Susan Auer, NOAA GC EL/AK. *Legal, Management and Enforcement Considerations: The Prosecutor's Perspective*

Susan Auer has worked in the National Oceanic and Atmospheric Administration (NOAA), Office of the General Counsel since 1988. She currently is the Senior Enforcement Attorney in the Alaska Region for the NOAA General Counsel's Office of Enforcement and Litigation (GCEL). GCEL is responsible for enforcing regulations promulgated pursuant to statutes administered by NOAA. Most of Ms. Auer's work in the Alaska Region involves enforcement of regulations developed by the Sustainable Fisheries Division in coordination with the North Pacific Fishery Management Council and promulgated pursuant to authority provided by the Magnuson-Stevens Fishery Conservation and Management Act. Ms. Auer also spends a significant amount of time reviewing regional and national regulations for legal and practical enforceability. Before she came to Alaska in 1992, Ms. Auer worked in NOAA General Counsel for Fisheries and NOAA General Counsel for Ocean Services in Washington, D.C. She received a Bachelor of Arts in Political Science and German from Willamette University in Oregon, and she received her JD degree from Lewis and Clark Law School.

Thomas Meyer, NOAA GC AK. *Legal, Management and Enforcement Considerations: Management Attorney's Perspective*

Thomas Meyer has worked in the National Oceanic and Atmospheric Administration (NOAA), Office of the General Counsel since 2000. He is currently an attorney advisor in the Alaska Region office. This office is responsible for reviewing regulations promulgated pursuant to statutes administered by NOAA. Mr. Meyer's responsibilities include providing daily legal advice to the Alaska Region Sustainable Fisheries, Habitat Conservation, and Protected Resources Divisions. He also is the lead attorney who provides daily advice to the Alaska Fisheries Science Center Fisheries Management Analysis Division and its groundfish observer program.

Ken Hansen & Dayna Matthews, NOAA OLE Northwest Region. *Legal, Management and Enforcement Considerations of EM: Enforcement Perspective*

Ken Hansen has served NOAA/Office of Law Enforcement in Kodiak AK since 1987. He is the Assistant Special Agent in Charge, where he supervises federal field enforcement activities and program areas in the Western Gulf of Alaska and Bering Sea. Prior to NOAA, he was employed by Oregon Dept. of Fish and Wildlife and California Dept. of Fish and Game. He spent a season as a crewman aboard a salmon troller off of Oregon and Washington. He served as a Foreign Fisheries Observer aboard Soviet and Japanese processor vessels in the foreign directed and joint venture fisheries in the early 80s. Mr. Hansen attended Humboldt State University, where he earned a BS Degree in Natural Resources Planning and Interpretation.

Dayna Matthews has served NOAA/Office of Law Enforcement in Lacey, WA since 1996. He is the West Coast Enforcement Coordinator, where he works as a program and policy analysis for both the Northwest and Southwest Division of the Office of Law Enforcement. As a 28 year natural resource law enforcement professional, Mr. Matthews began his career with the Washington Department of Fisheries and later, the Washington Department of Fish and Wildlife, where he rose through the ranks to serve as Chief of Enforcement. Mr. Matthews holds a BS in Fisheries Science from the University of Washington and an MPA from The Evergreen State College.

Panel 4: What New Video Work is Underway for Use in Fisheries Management?

Gregg Williams, IPHC. *By-catch characterization in the Pacific halibut fishery: A field-test of electronic monitoring*

> Gregg Williams is currently employed by IPHC as Research Program head, where he is responsible for the direction, supervision, and evaluation of the research program. He is also responsible for most issues of interaction with other fisheries management agencies, including coordination of the Commission interaction with U.S. fishery management councils, and state and federal agencies. He also has primary responsibility for dealing with most halibut bycatch issues, including monitoring and evaluating halibut bycatch reporting by U.S. and Canadian agencies. Gregg has been with IPHC since 1977.

Alan Kinsolving, NMFS Alaska Region. *Electronic Monitoring in the Alaska Rockfish Pilot Program*

> Alan Kinsolving received his MS in stream ecology and statistics from Auburn University. He has been with NMFS for 11 years and runs the at-sea scale program. He has been involved in the development and implementation of several electronic monitoring projects for NMFS. Prior to coming to work for NMFS, he spent three years in American Samoa where he assisted in the development of the conservation law enforcement program and investigated issues associated with the small boat tuna fishery. He has also worked on issues associated with hydroelectric development on downstream resources in Arizona and Alabama; the impacts of grazing on the composition of stream invertebrate communities.

Frank Lockhart, NMFS Northwest Region. *Future Monitoring Efforts in the Pacific Whiting Fishery*

> Frank Lockhart is the Assistant Regional Administrator for Sustainable Fisheries in the Northwest Region. He has worked for NOAA in various roles for over 10 years. In other positions, he has worked as a biologist, as staff for a multi-state fisheries organization, worked for both houses of Congress, and was staff for the U.S. Commission on Ocean Policy.

Jack McGovern, NMFS Southeast Region. *Use of a Video Electronic Monitoring System on Bottom Longline Vessels in the Gulf of Mexico*

> John C. McGovern (Jack) is a Fishery Biologist with the Sustainable Fisheries Division at the Southeast Regional Office. He has been involved in the field of marine science since 1981, primarily in the areas of larval fish taxonomy, reef fish biology, and fisheries management. Jack has been working at the Southeast Regional Office since 2003 on aspects of snapper grouper stocks in the South Atlantic.

Panel 5: Research & Development Advancements and Future Needs

David Somerton, NMFS AFSC. *Review of the State of Video in Other Fishery Research Applications*

> David Somerton is the Leader of the Groundfish Assessment Group, RACE Division, Alaska Fisheries Science Center. His personal research interests include the sampling performance of survey trawls and the seasonal migration pattern of fish and crabs determined from archival tags. Dave is a member of the NMFS Advanced Sampling Technology Working Group and led a 3 day workshop sponsored by the ASTWG on the use of video analysis in fisheries research.

Bill Karp, NMFS AFSC. *Integrated Fisheries Monitoring*

Dr. Bill Karp is the Deputy Director for Science and Research for the NOAA Fisheries Service Alaska Fisheries Science Center. He was born in the UK and earned his undergraduate degree at Liverpool John Moores University in 1972. Bill was awarded MS and Ph.D. degrees by the University of Washington in 1975 and 1983. He worked for several years in the private sector before joining the federal service in 1986. During his 22 years with the fisheries service, he has worked extensively in the fields of fisheries acoustics, and fishery-dependent monitoring. He directed the Center's Fisheries Monitoring and Analysis Division before taking on his current position. Bill also chairs the ICES Fisheries Technology Committee, and the steering committee for the (NMFS) National Bycatch Report.

Howard McElderry, Archipelago Marine Research Ltd., Canada. *How to Operationalize Electronic Monitoring in Commercial Fisheries*

Howard McElderry is a founding member of Archipelago Marine Research Ltd with twenty-five years of experience in the field of commercial fisheries monitoring and analysis. Mr. McElderry is vice president of Archipelago and director of the electronic monitoring division.

Helge Hammersland, Scantrol, Norway. *CatchMeter in U.S. Fisheries Monitoring*

Helge Hammersland is managing director of Scantrol. Scantrol, established in 1988, is based in Bergen, Norway. The company’s objectives are to supply efficient control systems for fishing vessels, marine research institutions and the offshore industry. They combine a scientific approach with practical solutions within this area. This expertise is the platform for a state of the art product range within autotrawl systems and databased fish sampling tools.

Gordon Gislason, GSGislason & Associates Ltd., Canada. *The Electronic Catch Monitoring Option - Economic Dimensions*

Gordon Gislason MSc (Statistics) is an economist, statistician, and financial analyst with over 35 years experience analyzing fisheries issues (commercial, recreational, aboriginal, aquaculture). His work has led to several important policy initiatives such as a $200 million salmon license buyback program and a commercial-recreational allocation policy for salmon. His recent work demonstrates that effective third party monitoring of total catch - landings plus discards - provides needed transparency in sustainable fishing practices and this in turn instills public confidence. He has analyzed the costs of Electronic Monitoring (EM) versus on-board observer programs for Australian fisheries.

5 List of Participants

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Appendix 1

At-Sea Observing Using Video-Based Electronic Monitoring

Prepared For:
Electronic Monitoring Workshop
29-30 July 2008

Workshop Sponsored By:
The North Pacific Fishery Management Council
The National Marine Fisheries Service and
The North Pacific Research Board

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ABSTRACT

This background paper was prepared for a workshop on electronic monitoring in Seattle, WA on July 29-30, 2008, sponsored by the North Pacific Fishery Management Council, the National Marine Fisheries Service, and the North Pacific Research Board. The NPFMC, NMFS, the NPRB, other management agencies, and the fishing industry, are all interested in advancing the potential use of EM in North Pacific fisheries. The notion of technology-based at-sea monitoring has emerged because monitoring needs are growing and observer programs have shortcomings that limit their use. Over the past decade, Archipelago Marine Research Ltd. has pioneered video-based electronic monitoring (EM) technology, carrying out a number of pilot studies and fully implementing EM in three fisheries. Collectively across all projects, EM is now used on ~500 fishing vessels for a total of ~25,000 seadays. EM systems, consisting of up to four closed circuit television cameras, a GPS receiver, a hydraulic pressure sensor, a winch sensor, and a system control box, can be deployed on fishing vessels to monitor a range of fisheries issues including fishing location, catch, catch handling, fishing methods, protected species interactions, and mitigation measures. The efficacy of EM for monitoring issues varies according to fishing methods and other factors. In comparison with observer programs, EM has a number of advantages including suitability across a broad range of vessels, creation of a permanent data record, lower cost, higher scalability, and the ability to engage industry self-reporting processes. Observer programs are more suited as a tool for industry outreach, complex catch sampling operations, and collection of biological samples. A key weakness of EM is a design inability to prevent tampering because of the exposed cameras, sensors and wires throughout the vessel. Instead, EM systems are tamper evident and EM programs must be designed with measures to discourage tampering. Efforts to operationalize EM involve pilot studies, detailed program specifications and an operations plan. Important considerations in this process include infrastructure needs for EM programs, service delivery models, governance mechanisms, timelines and data policies. Currently, infrastructure to support EM programs is very limited and careful planning is needed to build capacity, and create a climate that encourages research and development of EM technology.

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INTRODUCTION

Independent collection of at-sea data is essential to support a range of fishery-dependent information requirements associated with science, management, and compliance monitoring objectives. Over the past two decades the level of at-sea monitoring of commercial fisheries has grown, with human based observer programs being the traditional and primary method available. The notion of technology-based at-sea monitoring has emerged because monitoring needs are growing and observer programs have several shortcomings that limit their use. Over the past decade, Archipelago Marine Research Ltd. has pioneered the development of video based electronic monitoring (EM) technology and a number of pilot studies have been carried out to test the efficacy of this technology. Table 1 provides a listing of over 25 studies spanning diverse geographies, fisheries, fishing vessels and gears, and fishery monitoring issues. In some instances, an outcome from the pilot projects has resulted in EM being implemented in the fishery to address monitoring and information requirements. The level of EM-based monitoring is becoming significant in size. In 2008, EM is projected to provide at-sea monitoring on over 500 vessels and about 25,000 fishing vessel days at sea. While these numbers are small in relation to the magnitude of commercial fishing effort where at-sea monitoring is needed, the level clearly demonstrates that EM based monitoring has utility in a variety of ways and is much more than an experiment. Moreover, EM has become an enabler for monitoring of some commercial fisheries that could not otherwise be monitored. Without diminishing the important contributions of at-sea observers, EM technology will increasing become part of the fishery monitoring ‘toolbox’, both in terms of providing monitoring on vessels where the technology makes more sense and in placements on vessels with observers, recognizing that it is impossible for an observer to monitor different parts of a large ship simultaneously. Uniquely, EM can be used as an audit tool where the accuracy of fishing vessel logbook data is verified. Jurisdictions seeking cooperative or other alternatives to ‘command and control’ forms of resource management will benefit with direct involvement of the industry in the supply of verified fisheries data.

NMFS, the NPFMC, the NPRB, other management agencies, and the fishing industry, are all interested in advancing the potential use of EM in North Pacific fisheries. The use of video based monitoring approaches is relatively new to Alaskan fisheries and the technology provides the potential to improve at-sea monitoring on many fleets, NMFS and the Council need to assess this potential comprehensively as we move forward. Accordingly, a two-day workshop (July 29-30, 2008) has been organized to allow agency personnel, members of the fishing industry, and others to learn more about the state of the technology, successes and failures in various fishery applications, considerations for implementation, and opportunities where EM could be usefully applied. The purpose of this paper is to provide background information for delegates in advance of the workshop in order to help facilitate workshop discussion.

This paper mostly chronicles the experiences of Archipelago Marine Research Ltd. with the development and use of EM based monitoring. The focus toward Archipelago’s work is not just a bias of the author; no other organizations that we are aware of have published work in this field and the work of Archipelago is certainly the most extensive and comprehensive. The paper starts with overview of EM technology and how it can be applied to address particular fishery monitoring issues. Three cases where EM has been fully integrated into a fishery monitoring regime are described in order to distinguish the difference between the technology, a pilot project and a fully implemented project. A variety of operational considerations are presented to illustrate some special characteristics of these programs. The paper also comments on future technology developments that are likely in the next few years.

Table 1. Summary of Electronic Monitoring Studies.

Year	Project Location	Target Species	Gear	Monitoring Issue	Project Type*	Project Size**	Reference
2005	SA, Australia	Shark	Gillnet	Catch Monitoring	PS	1 / 16	McElderry et al., 2005c
2005	Antarctic, Australia	Toothfish	Longline	Catch Monitoring	PS	1 / 48	McElderry, 2005a
2005	TA, Australia	Redbait	Midwater Trawl	Protected Species	PS	1 / 42	McElderry, 2005b
2002	BC, Canada	Salmon	Seine	Catch Handling Discard Monitoring	PS	1 / 19	McElderry, 2002
2003	BC, Canada	Halibut	Longline	Catch Monitoring	PS	19 / 459	McElderry et al., 2003b
2003	BC, Canada	Salmon	Troll	Catch	PS	4 / 60	Riley et al., 2003
2003	BC, Canada	Prawn	Trap	Catch/Gear	PS	1 / 60	No report produced
1999-2008	BC, Canada	Crab	Trap	Gear	FI	50 / 4,000	No report produced
2005-2008	BC, Canada	Groundfish	Longline	Catch	FI	230 / 12,000	No report produced
2007-2008	BC, Canada	Inshore Groundfish	Trawl	Catch Monitoring	FI	9 / 840	No report produced
2006-2008	BC, Canada	Hake	Trawl	Discard Monitoring	FI	34 / 2,100	No report produced
2007	New Zealand	Groundfish/Pelagics	Longline	Protected Species	PS	4 / 100	McElderry et al., 2008c
2007	New Zealand	Groundfish	Gillnet	Protected Species	PS	5 / 82	McElderry et al., 2007a
2003	New Zealand	Hoki	Midwater Trawl	Protected Species	PS	1 / 31	McElderry et al., 2004c
2002	AK, USA	Halibut	Longline	Catch Monitoring	PS	2 / 120	Ames et al., 2007; Ames, 2005; Ames et al., 2005
2003	AK, USA	Groundfish	Trawl	Protected Species	PS	5 / 22	McElderry et al., 2003a
2005	AK, USA	Rockfish	Trawl	Discard Monitoring	PS	10 / 38	McElderry et al., 2005b
2006	AK, USA	Groundfish	Factory Trawl	Bin Monitoring	PS	1 / 14	McElderry et al., 2008b
2007	AK, USA	Rockfish	Trawl	Discard Monitoring	PS	1 / 14	Bonney and McGauley, 2008
2006	CA, USA	Swordfish	Drift Gillnet	Protected Species	PS	5 / 58	McElderry et al., 2007b
2007	CA, USA	Swordfish	Drift Gillnet	Protected Species	PS	1 / 3	McElderry et al., 2008a
2004	New England, USA	Cod/Haddock	Longline	Discard Monitoring	PS	4 / 10	McElderry et al., 2004a
2007	New England, USA	Groundfish	Longline/Gillnet	Catch Monitoring	PS	7 / 59	McElderry et al., 2007c
2007	New England, USA	Herring	Small Mesh Trawl	Catch Monitoring	PS	1 / 10	McElderry, 2007
2002	West Coast, USA	Hake	Midwater Trawl	Discard Monitoring	PS	1 / 13	McElderry et al., 2002
2004	West Coast, USA	Hake	Midwater Trawl	Discard Monitoring	FI	26 / 823	McElderry et al., 2004b
2005	West Coast, USA	Hake	Midwater Trawl	Discard Monitoring	FI	28 / 982	McElderry et al., 2005a
2006	West Coast, USA	Hake	Midwater Trawl	Discard Monitoring	FI	37/ 1,043	McElderry et al., 2006
2007	West Coast, USA	Hake	Midwater Trawl	Discard Monitoring	FI	36 / 878	No report produced

* Project Type: PS, Pilot Study; FI, Fully Implemented EM Program

** Project Size: # Vessels Monitored / # Seadays (per project or per annum

EM TECHNOLOGY OVERVIEW

EM System Description

EM systems have been in use in various monitoring applications since about 1992. The earliest systems were single camera, VHS tape based video recorders with a GPS text overlay on time lapsed images. With the commercial availability of inexpensive, high capacity hard drives in 1999, a number of digital video recording devices became available in the security industry. The high data storage capacity made the technology more practical for fishery monitoring as multiple cameras could record imagery for extended durations while the vessel was at sea. It was recognized early on that the hundreds of hours of recorded imagery would be difficult to work with without ancillary sensor data to simplify identification of vessel activity and enable direct access to imagery of interest. Earlier EM systems simply integrated a commercial video recording system with a separate computer to record sensor data. Later systems coupled these two functions within a single computing platform in order to achieve greater reliability and performance. With this change EM system control software evolved to provide greater system control, error trapping and data integration. The EM system currently used by Archipelago, shown schematically in Figure 1, is termed V4 (version 4), reflecting this development chronology.

An important development guiding principle has been to keep equipment costs low to enable cost effective EM-based monitoring. EM systems use standard, commercially available components and the overall design is as simple as possible. Sensors, cameras and control box components come from the security or electronics industry. The control box is manufactured by Archipelago because there is nothing commercially available that meets the cost and specification requirements. Archipelago has also developed control box software for EM systems.

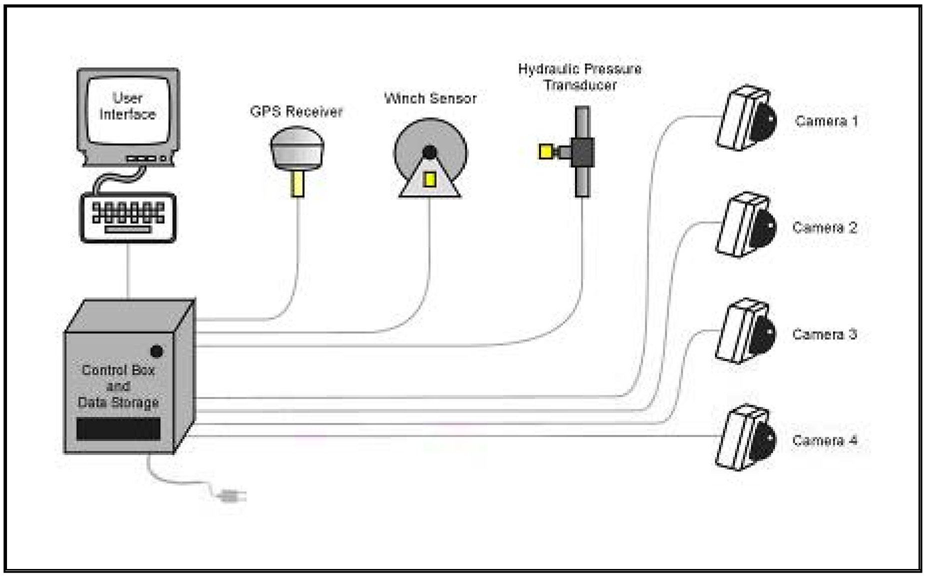

Figure 1. Schematic of V4 Electronic Monitoring system.

The EM system consists of up to four closed circuit television cameras, a GPS receiver, a hydraulic pressure sensor, winch sensors, a system control box and a user interface (keyboard and monitor). Ancillary sensors used in some applications include radio frequency identification (RFID) tag readers and net pinger hydrophones. The control box is usually located on the bridge with wiring to all sensors, cameras and to the ship's electrical power (DC or AC). The control box monitors system performance, records data and provides a continuous display of EM system status. All data are recorded on high capacity hard drive that is retrieved when the fishing vessel returns to port. Wireless transmission of EM data has not been employed because data volumes are very large, transmission costs are high, and reporting timelines have not necessitated such urgency. Detailed information about the EM system is provided in Appendix I.

The EM system can use either AC or DC electrical power. In the case of AC power, the control box is generally fitted with a UPS, to ensure continuous power supply. The recommended circuit capacity for an EM system is 400 watts if using 110-volts AC, or 20 amps with 12-volts DC. The EM system amperage requirements vary from about 6 amps (at 12-volts DC) when all cameras are active, to less than 3 amps without cameras (sensors only), and about 20 milliamps during the 'sleep cycle'.

The EM system's GPS receiver mounts in the vessel rigging or on a cabin ceiling away from other electronics, and provides independent information on vessel position, speed, heading and time. The electronic pressure transducer installs on the supply side of the hydraulic system and provides an indication when hydraulic equipment (winches, pumps, lifts, etc.) is operating. An optical sensor is mounted on winches to detect their activity. CCTV cameras are mounted to the vessel standing structure, in locations that provide unobstructed views of catch and fishing operations. Camera placements are aided with universal mounting brackets that enable quick attachment to masts, booms and other standing structures. In order to effectively monitor fishing operations, camera placement strategies often involve multiple camera views, using both wide angle and close up lenses as shown in Figure 2.

First time installation of an EM system can take 6-hours or more, depending upon the vessel layout, monitoring system specifications, and amount of advance preparation made by vessel personnel. Key issues with the installation of an EM system include control box location, placement of sensors, wire routing, establishing a dedicated electrical supply circuit, and setting up an access point for hydraulic pressure monitoring. The EM system configuration adjustments may be required after evaluating EM data from the first monitored fishing trip.

Figure 2. Example camera views from trawl vessel showing the aft portion of the fishing deck (upper) and port and starboard discard chute areas (lower). (McElderry et al., 2005b).

EM Operating Specifications

The EM system is designed to operate continuously throughout the fishing trip. The control box software starts up automatically when powered, resumes functions following power interruptions, and restarts when a software lockup is detected. EM sensor data is recorded continuously for the entire fishing trip, with a frequency of one data line per 10-second interval. The data storage requirement for sensor data is about 0.5 MB per day. Image data are generally recording according to various selectable criteria. Common configurations include continuous recording while the vessel is not in port, recording only during fishing operations (as sensed by hydraulic or winch sensor activity), or recording from the start of first fishing event until the vessel returns to port. The EM system records imagery from up to four cameras at selectable frame rates (i.e., images or frames per second), ranging from 1 to 30 fps (motion picture quality). All recorded images include a text overlay showing vessel name, date, time, and position. Using a common recording rate of 5 fps the data storage requirement is about 60-100 MB per camera per hour. An EM system equipped with a 500 GB hard drive can record continuous imagery from four cameras for up to three months.

EM Data Interpretation Procedures

The EM system provides a comprehensive sensor and image data record for the fishing trip. As well, a series of system files are generated to record EM performance data. Raw sensor and image data are interpreted using specialized analytical tools for generation of fishery data. The goals of sensor data analysis usually including determining overall data quality and distinguishing key vessel activities including transit, gear setting, and gear retrieval, and interpreting the geographic position of vessel operations. The objectives of the image interpretation process include completing an inventory to ensure that all imagery is present, making an assessment of image data quality, and finally, interpreting imagery to make specific fishery observations such as catch events or fishing behavior.

Sensor Data

As a result of recording at a frequency of one record per 10-second interval, sensor data provide very fine scale resolution of vessel activity during the fishing trip. The complete sensor data record for a fishing trip can easily exceed 150,000 records and specialized software tools are used to manage and interpret the data efficiently. Raw sensor data are generally imported into a Sequel Server database environment for storage and performing a variety of data integrity processes such as identification of missing or nonsensical values, poor GPS data quality, incomplete data, etc. One of the more important data quality assessments is characterizing the data set by the total number and size of gaps in the data set timeline. Time gaps are usually the result of system power interruptions and represent intervals when no data were recorded. Overall data set integrity can be compromised by time gaps, particularly when the data loss is during critical operations such as hauling gear or sorting catch on deck.

The next step in the sensor data interpretation process is to present the data in a way to enable identification specific fishing trip activities. A custom software tool provides simultaneous display of raw data, graphical time series of selected values, and a spatial plot. The time series presentation of vessel speed, hydraulic pressure and winch sensor (Figure 3) reveal unique data patterns or ‘signatures’ for specific vessel activity such as vessel transit, gear setting, gear hauling, and other operations. The spatial plot (Figure 4) provides a different perspective on these events, showing the location and enabling the association of events such as longline setting and retrievals combined with other information such as a coastal map, fishery statistical areas and closed areas. These tools provide an efficient way to event mark the sensor data record with specific activity categories. These events are later summarized to build a detailed fishing trip timeline, showing all the major events by time and location.

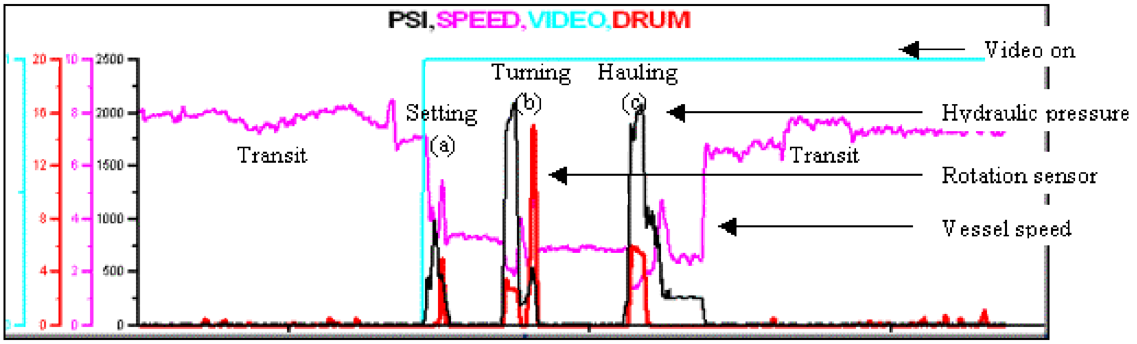

Figure 3. EM time series graph of sensor values showing a typical trawl fishing event: transit to grounds, setting gear (a), turning the vessel (b), hauling gear (c), and transit back to port. Shown are net drum rotation sensor (red), hydraulic pressure (black), vessel speed (purple), and image recording (turquoise) (data from McElderry et al., 2005a).

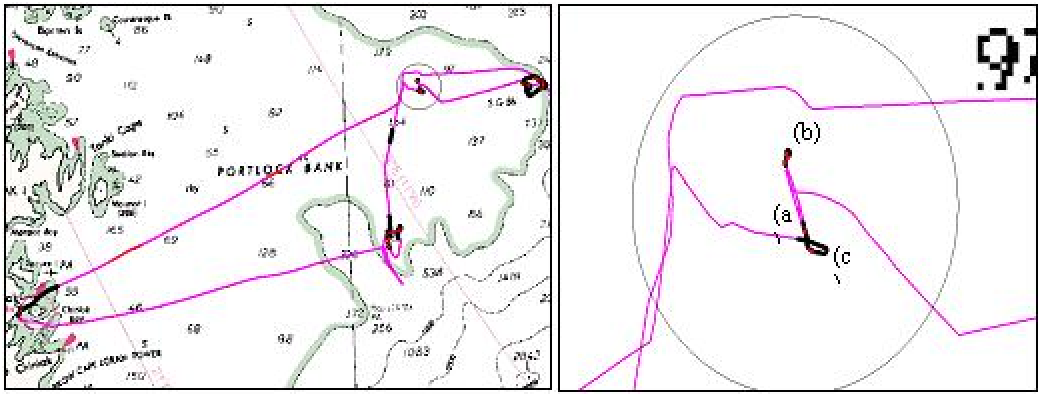

Figure 4. Spatial plot showing cruise track of a vessel for an entire trip with an EM system. Insert shows cruise track for the fishing event corresponding to time series data shown in Figure 4. Black indicates hydraulics on for setting (a), turning (b), and hauling (c) of gear. (McElderry et al., 2005a).

Image Data

Image interpretation generally follows the sensor interpretation process and is more time consuming. The first step is making an inventory by comparison with the sensor data record to ensure that image data files are complete. In addition to the time gap issue previously mentioned, breaks in the image data set can occur when sensors fail to trigger event recording. Once the inventory is completed, the next step involves making an assessment of image data quality. Image files are quickly reviewed to determine if imagery is usable for making interpretations. A variety of issues such as camera position, glare, water droplets, and poor lighting can erode image quality such that there may be little point in investing effort in making image interpretations.

EM image files can be readily played on most standard MS Windows based media player software products. The complexity lies with multiple camera views that must be played simultaneously for a reviewer to fully interpret vessel activities. These types of multimedia players are less common, more expensive and generally not suited to the purposes of image interpretation. Consequently, Archipelago has developed an image analysis software tool providing synchronous views of all recorded imagery, with selectable viewing rates from frame by frame to 16 times real time (Figure 5). The software tool also enables direct data entry of interpretations into the viewer program. Much like the interpretation process described for sensor data, image interpretation is essentially a process of event marking the fishing trip timeline with specific observations made from the imagery. These events can later be summarized for a variety of purposes such as catch by species (or species group) per fishing event.

The time requirement for viewers to complete image interpretation varies according to the information objectives, image quality and the number of cameras in use. Often, imagery is interpreted at or well below the real elapsed time. Catch census for longline fishing occurs at about 60% of real time while monitoring deployment of seabird mitigation devices can occur at less than 10% of real time. As well, the imagery of interest may make up only a small portion of the total fishing trip such that image viewing requirements may be relatively low. For example, a typical demersal longline fishing trip in BC will complete 25 fishing events over an 8-day period, with about 25 hours of recorded retrieval imagery. Interpretations of this imagery for catch monitoring purposes would require about 15 hours for a full census of all fishing events.

Figure 5. Image analysis workstation showing synchronous camera views from a demersal longline vessel.

CAPABILITIES OF EM

EM has been tested in a wide variety of geographies, fisheries, fishing gears, and fishing monitoring issues. The capabilities of the technology can be assessed in terms of general suitability of the technology for use on fishing vessels, and in terms of the capabilities to address specific fishery monitoring issues. The former assessment tends to be a comparison of EM capabilities in relation to observers, while the latter (fishery monitoring issues) is simply a capability assessment. The following sections provide examples where EM has been used for these monitoring issues. The examples are intended to show a range of situations and also provide an assessment of strengths and weaknesses.

General Issues

Vessel Suitability

Observer programs are limited to monitoring vessels with ample accommodation and workspace for an observer. As information needs have grown monitoring has become problematic for smaller vessel fleets where vessels have only enough crew capacity for the intended fishing activity. The process to decide when a vessel is suitable to host an observer is complex and fisheries agencies, observer providers, and industry have not been able to prepare specific guidelines (Cusick et al., 2003). Small vessels are not intrinsically unsafe, however as compared with larger vessels, adding an observer to the crew complement on a small vessel is more likely to impact observer duties, workspace, accommodations, safety equipment, fishing operations, and the safety of the observer and crew. Observer employers are reluctant to deploy observers on vessels where these issues come to play. Many fisheries jurisdictions struggle with this problem and data from monitored fisheries can contain biases due to vessel size. Cooperation with industry is also affected because those with the vessels most suited to observers bear the brunt of a fleet's at-sea monitoring requirement while the small vessels escape the monitoring burden.

In many instances, EM has eliminated the problem of monitoring small vessels because the vessel specification requirements are much lower than what is needed to deploy an observer. The minimal requirements are a dry location for the control box and adequate electrical power to operate the EM system. The space requirements for the equipment are small and can be fitted on most fishing vessels. As an example, EM systems have been successfully installed aboard open outboard-powered skiffs that use hook and line gear to catch live rockfish in BC. The control box was mounted in a waterproof compartment and cameras and GPS sensors mounted on custom mounting brackets. The EM system was powered by a 12-volt battery and from the outboard engine.

Another consequence of vessel size is the extent to which weather influences fishing patterns. Small vessels tend to adjust fishing plans based on weather conditions, often making decisions on short notice. Uncertain fishing schedules are problematic for observer programs as a result of the more complicated deployment logistics, higher costs, and less efficient use of observer resources. EM is better suited to these fleets because equipment is generally installed for a period of time and the program is not dependent on the specific fishing schedule of the vessel.

A common comment among fishers of monitored fleets is their preference for EM over observers because it is less intrusive. Living and working space on many fishing vessels is limited and crew dynamics are important to create a productive, safe work environment. As opposed to the unknown element of which observer and how well they will fit in, EM is much more benign and most crew quickly begin to ignore to the presence of cameras. The level of support can also improve by limiting image recording only to areas and times on the vessel when fishery monitoring is needed.

Multiple Camera Images

Multiple CCTV cameras provide the ability to monitor several areas of the vessel at once. This approach was tested on a large factory trawler using nine cameras, monitoring the trawl deck and several areas of the factory (see Figure 15; McElderry et al., 2008b). The multiple views were of great assistance to the observer in reducing the potential for presorting and enabling unbiased catch samples.

Permanent Data Record

A key advantage of EM is the permanent data record created for the fishing trip. The data record provides a great deal of flexibility in how it can be analyzed and by whom. For example, fishing event imagery can be sampled or reviewed in full, and reviewers have a range of playback controls (e.g., speed, replay, frame capture, etc.) to optimize viewing conditions. In contrast, observers view fishing operations directly, without breaks, at the speed at which operations occur, without the ability to replay or stop. Missed observations are lost data. Without multiple observers the ability to compare observations and measure accuracy is limited.

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Another key advantage of an EM system is to record data continuously throughout the fishing trip without breaks. Monitoring continuous operations for observers are difficult to sustain because of the need for breaks.

EM Equipment Reliability

EM systems are designed to be fault tolerant, operating continuously for long periods of time with little interruption or downtime. In a fishing vessel setting, the reliability of EM equipment is a function of several factors. The stability of the electrical power supply is key. Many vessels have good electrical systems but there are many with unstable power, or a poor ability to supply power when the engine is not running. Also important are the positions of cables to cameras and sensors. The work deck on a fishing vessel is a rugged environment where unprotected cables can easily be damaged. Given the right incentive structures, the reliability of EM equipment can be very high. For example, the fully monitored 50 vessel Area A crab fleet collectively has less than 200 hours of lost data out of a season total of about 55,000 hours. In other applications with less strict incentive structures, data capture may be lower as less attention is given to supporting power requirements, or the skipper will simply turn the system off.

A key weakness of EM is a design inability to prevent tampering. Unlike VMS, which is an entirely enclosed solid-state monitoring device, EM system has exposed cameras, sensors and wires throughout the vessel. There is little one can do to the physical design of an EM system to prevent vessel operators from tampering with sensors, camera angles and the electrical power supply to render an incomplete data set. Efforts to make EM equipment tamperproof are not likely to succeed, as there are too many uncontrollable ways to fault the system. The more appropriate development strategy has been to incorporate tamper evident design, making it easier to detect sensor interference, and to program incentive structures that discourage tampering. The latter point will be revisited in the Program Governance section.

Industry Engagement

Involving industry in data collection processes helps build a better understanding on the state of the resource and improves decision-making processes. Self-reported data systems such as vessel logbooks are used extensively but are criticised because data may be of poor quality or questionable credibility. EM supports industry data collection activities by providing a tool to audit self-reported data. An audit involves comparing a sample of vessel logbook data with the EM data set. Given proper incentive structures, an EM audit functions as a 'radar trap' and can improve the quality of self reported data. The audit results provide several products: a measure of logbook data quality, an independent sample of the fishery, and an avenue for providing feedback on logbook data quality. Observer programs, while valuable for many reasons, generally undermine self-reporting processes as observer and industry data are not independent and the former are generally preferred.

Outreach

A key element of an observer program is the creation of a communications link between the fishery participants and the agency. Observers provide a great deal of useful information both ways and invaluably inform the fisheries management process. EM programs offer little in this respect as the human is replaced with a machine. EM technicians may be present on the vessel before and after a fishing trip however these people will be skilled at electronics and may know little about issues in the fishery.

Fisheries Monitoring Issues

Monitoring issues in fisheries generally relate to gathering information about fishing location, catch, catch handling, biological sampling, fishing methods, protected species interactions, or mitigation measures. Compliance monitoring is not one of the monitoring categories as it relates more with how the monitoring information is used. However, it has been included as a category because of the specific interests of EM for MCS purposes.

Fishing Location

The location of fishing operations is important for a wide range of fishery management goals including monitoring the spatial distribution of effort, assigning catch to area, and monitoring compliance with area closures, marine protected areas and other area restrictions. A key strength of EM is in the ability to efficiently monitor the time and location of fishing operations. The use of GPS and placement of sensors on hydraulic equipment and winches enables clear definition of most fishing activities.

Salmon Seine Fishing – Salmon seiners deploy nets in a circular arc, closing the circle, then pursing the net into a progressively smaller size. The setting pattern is readily evident as shown in Figure 6.

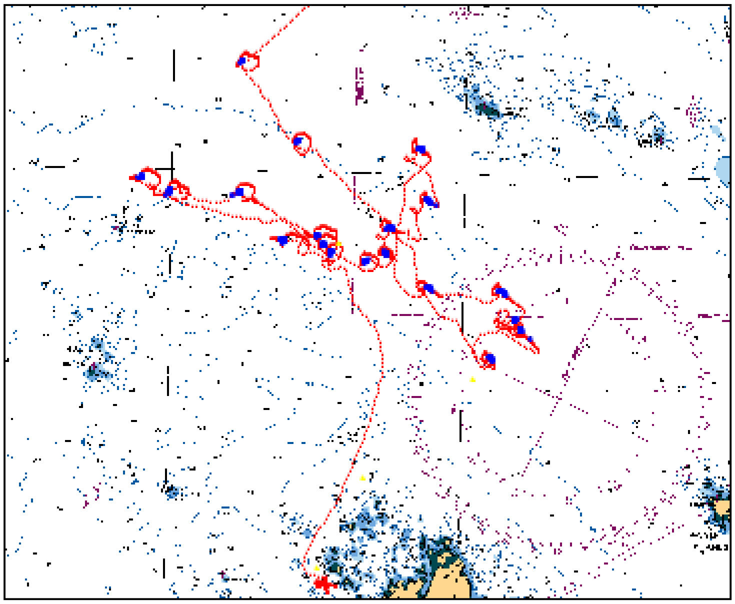

Figure 6. Spatial plot showing vessel cruise track from salmon seine fishing trip. Cruise track shown in red and blue color denotes hydraulic pressure spikes corresponding with net retrieval. (McElderry, 2002)

Crab Trap Fishing – EM has been used extensively with single buoyed trap fishing for crabs. Trap hauls are readily evident from the hydraulic pressure spike when the trap is hauled and the particular cruise track pattern. Crab traps are marked with RFID tags that also serve to specifically denote a trap hauling event. RFID tags are uniquely numbered, enabling a simple means to identify vessel trap inventories. An example of trap hauling is shown in Figure 7.

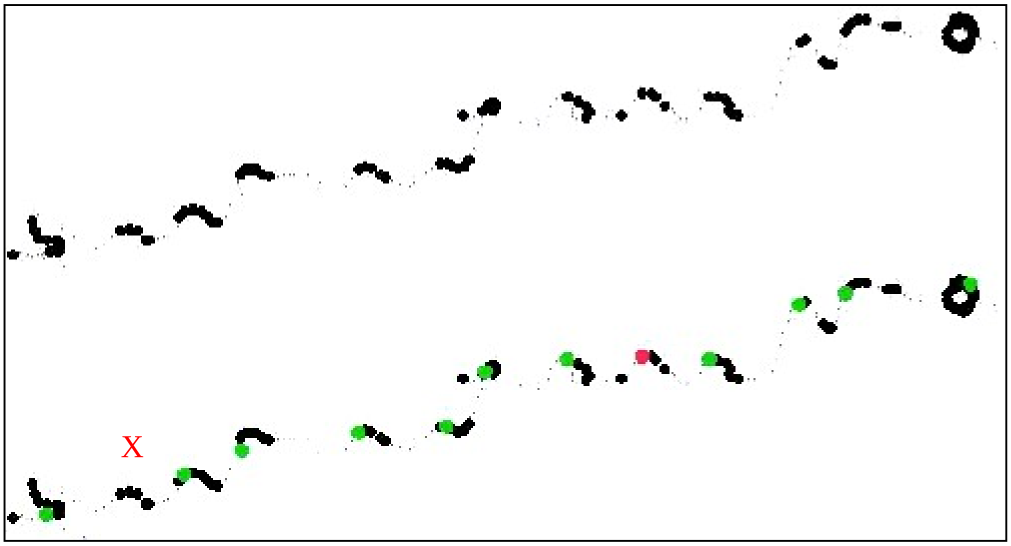

Figure 7. Spatial plot showing two examples of the same trap hauling sequence. Upper track shows GPS position (gray) and hydraulic pressure spikes (black). Lower plot includes RFID scanning events, green dots reflecting traps belonging to vessel inventory and red dot denoting other vessel trap. Trap haul without RFID scan denoted by 'x'.

Demersal Longline and Gillnet Fishing – EM has been used with both longline and gillnet fishing. The sensor data pattern for the two methods is quite similar. The setting process is evident as gear is generally deployed at a constant vessel speed and heading. Many vessels use a line or net drum and gear is set by freewheeling the drum without active hydraulic work. The gear retrieval process is quite different from setting as the vessel maintains orientation over the gear as it is hauled aboard. During retrieval, vessel speed is slower than during setting and both speed and heading are quite variable. Hydraulic pressure is evident but also quite variable, corresponding to the constantly changing rate of gear retrieval. An example of longline fishing is shown in Figure 8.

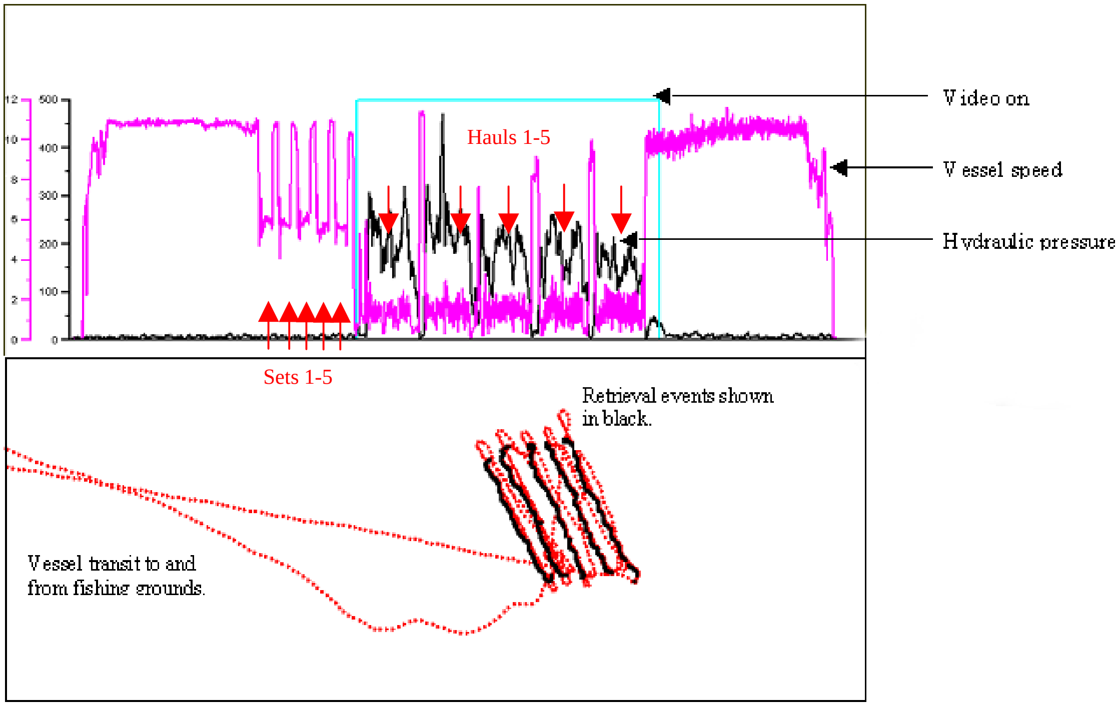

Figure 8. Plot showing setting and hauling activities on a groundfish longline vessel. Top is time series graph of sensor values and bottom shows GIS plot of setting and hauling (from McElderry et al., 2004a).

Trawl Fishing – Activities associated with trawling include searching for fish, net deployment, net towing, net retrieval and catch stowage. These events are often very distinctive from the sensor and spatial plot (Figures 3 and 4). Trawlers have multiple winches (e.g., warp, Gilson and others) and there may be more than one hydraulic system in use. The single hydraulic pressure and winch sensor is generally adequate to distinguish fishing activity.

Strengths and Weaknesses of EM for Fishing Location – EM is a very powerful tool for distinguishing fishing events in most fisheries. The shortcomings are with fishing methods that do not involve the use of vessel machinery (e.g., hand line fishing). In such cases vessel and speed can be used to identify likely episodes of fishing and examination of visual imagery is needed to confirm activity. Another problem area is with associating specific gear during set and retrieval events. A vessel may not haul their gear in the same order as set and linking the two events can be problematic. The link is important as information from both the set and retrieval parts of the fishing event are used in fishery data sets. Set and haul events may not spatially overlay one another (See Figure 9), especially if the gear is tightly spaced, or set unanchored (e.g., pelagic gear), in deep water, strong currents, or high winds. The solution to this problem involves some form of gear identification, either using distinctive buoys, or RFID tags.

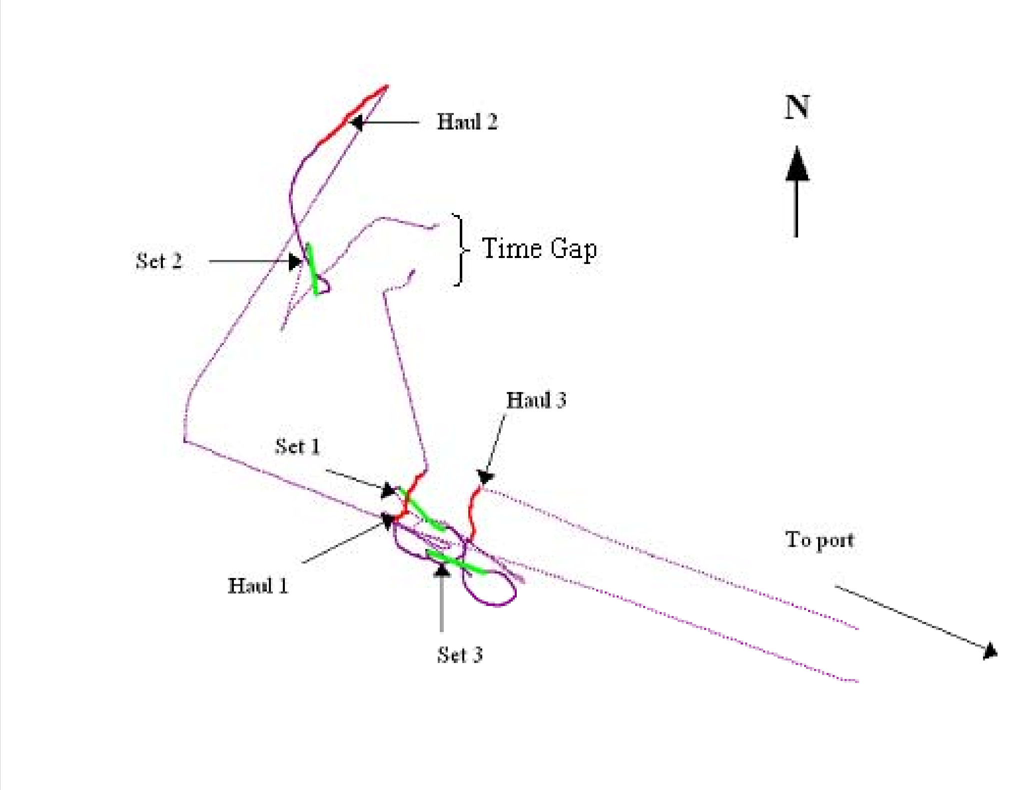

Figure 9. Spatial plot showing set and haul locations for pelagic drift gillnet gear (from McElderry et al., 2008a).

Catch Monitoring

Often catch monitoring is the most important information objective in a fishery monitoring program. At-sea monitoring programs generally attempt to document catch by species and quantity, including both retained and discarded catch. The use of EM for catch monitoring has been examined in a number of studies and its efficacy is dependent upon several factors. Catch quantities, species distinctiveness, fishing method and onboard handling practices figure strongly in whether catch can be reliably determined from EM image data. As well, the number of cameras and the quality of camera placements affect image resolution and complexity, and consequent ease with which the imagery can be interpreted.

Fishing gears such as longline and gillnet receive their catch aboard in a serial manner and cameras can be set up to observe retrieved catch as it moves through the view area. Retrieval rates are generally slow with crew removing catch items from the gear. Usually multiple cameras are placed outboard of the hauling station, providing a close up of where most catch items occur as well as a wider angle view of the entire retrieval area. The former provides detailed view for identification purposes while the latter provides context of fishing operations. An example of camera views is shown in Figure 10.

Demersal longline fishing generally uses very short (<0.5m) branch lines and nearly all catch items are brought to or over the rail. Pelagic longline fishing differs with much longer branch lines (3-5m) and a more involved landing process. Catch items are generally larger and a lot of effort may be required to manoeuvre the catch along side and through the sea door. Some catch species may not be brought aboard at all, either released with hook and branch line attached or brought alongside and cleared of as much of the terminal gear as possible. The ability for cameras to successfully capture this style of fishing is considerably more demanding than with demersal longline fishing. Whereas demersal longline catch observations would come from primarily one camera, catch observations from pelagic fishing would come from multiple cameras depending upon the type of catch encountered. Pelagic longline cameras must monitor the hauling station, the area where catch is boarded and a fairly large (5-6m) area around the sea door where catch is manoeuvred.

Figure 10. Example camera views from longline vessel.

The use of EM to monitor catch with trap fishing may also be complex. Trap contents may be emptied into a hopper from which it is sorted and processed. The hopper may not be cleared between trap hauls making it difficult to census catch contents on a trap-by-trap basis. The best option is for placement of a camera over the point where catch is removed from the hopper and census catch from this control point. This method may require a change to crew behavior to ensure that all trap contents are placed in the hopper and all catch pass by the control point. An example of trap fishing is shown in Figure 11.

Fishing gears such as seine and trawl fishing bring catch aboard en mass, making it difficult to determine catch composition unless the catch can be directed past a specific control point (e.g. fish chute or conveyor) where individual catch items can be discerned. However, in many instances the volumes are too large for this to be practical. Camera positions on trawl vessels generally provide both wide angle views of the entire fishing deck and therefore make it difficult to discern specific elements of the catch. EM is generally not used to fully census catch in trawl fisheries because of the large quantities associated with each fishing event.

Figure 11. Example camera views from a BC sablefish trap vessel showing trap hauling and fish hopper (upper left), census control point where crewmember removes fish from hopper (lower left), and close up view of the discard chute (right).

Strengths and Weaknesses of EM for Catch Monitoring – In serial catch fisheries where catch monitoring has been successfully used, EM has some clear differences as compared with observers. In terms of species recognition, observers are better able to distinguish species, particularly those that are uncommon or closely resemble one another. EM has been shown to provide high resolution for many common groundfish species but certain species of rockfish are difficult to distinguish consistently (McElderry et al., 2003b). In terms of catch quantification, EM probably does a better job as retrieval events are easier to observe from imagery where viewing speed can be adjusted as necessary, halted to provide viewer rest breaks, or replayed to double-check interpretations. The permanent data record also affords the opportunity to examine imagery from the same events more than once. Live event viewing by observers requires continuous attention over the rail toward the line being retrieved, which is often difficult on a busy work deck. The experience can be mesmerizing and briefly looking away (e.g., to write observations on a form) can make it easy to loose track and overlook or double count the catch. In terms of monitoring catch utilization, EM can be reliable provided that fish handling operations are conducive to detection by camera imagery. Receiving fish under camera but discarding over the other side of the vessel, or later when cameras are off, would not be detected while observers could more easily monitor these events. An important limitation with the use of EM for catch monitoring is the unit of measure: EM can only record catch in pieces, not weight. Observers have a better opportunity to weigh catch although they often estimate catch by applying an average piece weight to the piece count.

Catch Handling

Some fisheries prescribe particular methods for onboard catch handing in order to ensure bycatch viability, or proper catch accounting. EM has been successfully tested in a variety of instances.

BC Salmon Seine Fishery - In order to ensure viability of bycatch, salmon seiners in BC must brail small quantities of fish aboard instead of hauling the entire net aboard over the stern ramp. Brailed fish must be transferred to a sorting area where and bycatch such as Coho and Steelhead salmon can be removed and placed in a recovery tank prior to being returned to the sea. A single mast-mounted camera enabled monitoring of these activities. An example camera view is shown in Figure 12.

Figure 12. An example camera view from a salmon seine vessel showing view of the fishing deck and catch handling operations.

BC Groundfish Longline Fishery - BC's IQ groundfish longline fishery differentiates dogfish (*Squalus acanthias*), sablefish (*Anaplopoma fimbria*), halibut (*Hippoglossus stenolepis*) and lingcod (*Ophiodon elongatus*) by legal and undersize for quota accounting purposes. Undersize fish can be released without a penalty to the vessel's quota holdings while the vessel must carry quota for legal sized fish, even if they are released back into the water. To facilitate this accounting requirement, fish are measured against a simple color marked reference board. Retrieval camera imagery is used to confirm that fish are measured and accounted for correctly. An example is shown in Figure 13.

Figure 13. An example camera view from a groundfish longline vessel showing the process of fish measurement.

Groundfish Trawl Fishing - The Kodiak rockfish pilot program and the West Coast shore side hake fishery both monitor at-sea catch by sampling at offload stations and thus have full retention requirements while vessels are at sea. These fisheries require that, to the extent practical, all catch must be brought aboard and stowed unsorted. With a few exceptions discarding is not permitted. The EM system uses multiple overhead cameras of the fishing deck, fish hold hatch covers, and areas astern of the vessel (see Figure 2). Stowage operations are monitored in detail, as are the fish hold hatch covers for the entire duration while fish are aboard. The Kodiak rockfish pilot program carries an additional requirement, as all halibut must be censused and discarded at sea. This need is met by the modification of crew procedures to place all halibut on a special discard chute graduated to enable size determination. The camera set up includes a detailed view of the discard chute and stowage monitoring includes counting and measuring each halibut discarded. An example of camera views for this application is shown in Figure 14.

Figure 14. Example camera views from a trawl vessel showing complete view of the fishing deck and close up view of the discard chute.

Factory Trawl Fishing - Observers make catch estimates aboard Alaskan groundfish factory trawlers using a standardized sampling method. The method involves collection of basket samples of unsorted catch, collected from the conveyor at several points of the catch processing operation. Observer sampling has been hampered because of the potential for ‘presorting’, where crew essentially prevent certain species such as halibut from entering the observer sample. It has been hard for the observer to prevent presorting because of the inability to monitor the conveyor and crew operations upstream of the observer sampling station. EM consisted of the placement of several cameras in the fish holding areas with a monitor placed at the observer sampling station in order to enable unobstructed views of these areas while fish were sampled. An example of camera views is shown in Figure 15.

Figure 15. LCD screen available to crew in sorting area (left) and close up photograph of the LCD screen showing nine camera views simultaneously (right). (from McElderry et al., 2008b).

Strengths and Weaknesses of EM for Catch Handling – EM can be a very useful tool for monitoring a wide range of catch handling operations. EM provides multiple simultaneous views that make it easier to monitor large complex operations. The main shortcoming with EM is that it may be difficult to provide camera coverage for all areas on a fishing vessel where catch handling occurs. Also, some catch handling requirements may be very subtle and may be difficult or time consuming to detect.

Biological Sampling

Biological sampling is often a key goal of an at-sea monitoring program as this may be the only source for unsorted catch. Biological sampling consists of taking a variety of measures (length, weight), observations (sex, maturity) and collection of biological structures (otoliths, stomachs, etc.). EM is not a tool for biological sampling and observers may be the best option. In a few instances crew have been used to collect biological samples and EM has been used to verify sampling procedures.

Fishing Methods

Fisheries are often regulated by a range of measures concerning how gear is used including amount of gear, soak limits, time restrictions on when gear can be set or hauled, etc. The strength of EM for monitoring time and location issues has already been shown with several examples in the Fishing Location section. The example below is a database approach with RFID tag data.

BC Area A Crab Fishery - The crab fishery is regulated by effort controls with vessel trap limits ranging from 600 to 1,200 traps depending upon vessel length. In addition to trap limits by vessel, trap soak duration is also regulated not exceed 18 days as the potential for gear loss increases with time untended. Vessel trap inventories are managed by marking all crab trap buoys with RFID tags (see Appendix I, Figure A6), which provide individual serial numbers for each trap. Through database analysis of trap scans it is possible to determine trap soak intervals, active trap inventories and the identity and last known location of missing gear. Figure 16 provides output results from this analysis.

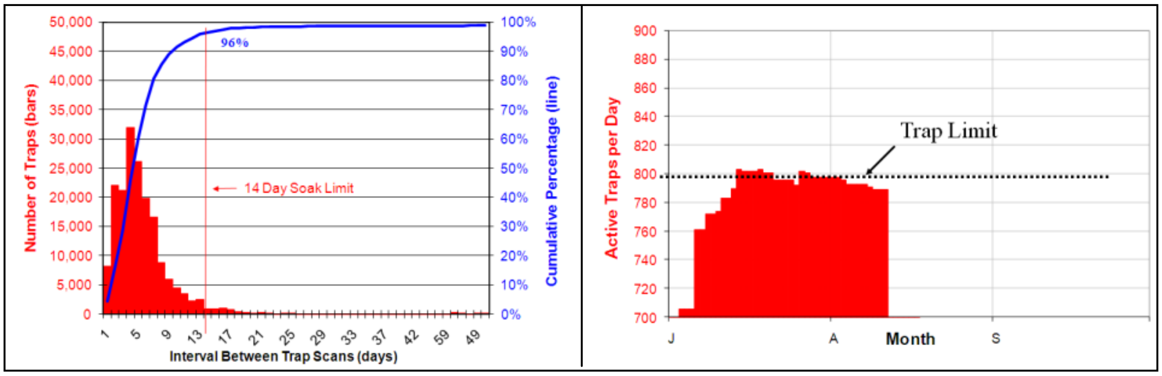

Figure 16. Area A crab fishery summary of trap soak durations for fleet (left) and summary of active trap inventory for a single vessel (right).

Strengths and Weaknesses of EM for Fishing Methods - The example with trap monitoring in the Area A crab fishery demonstrates the simplicity with which certain complex tasks can be monitored. Without automated trap detection, the task of monitoring trap soak duration and trap limits would be an enormously time consuming. The strength of the analysis is heavily dependent upon the quality data and measures are needed to ensure that all traps are scanned properly.

Protected Species Interactions

Protected species include threatened or endangered species of marine mammals, seabirds and sea turtles. Fisheries interact with protected species in a variety of ways including directly as catch, or simply being in the vicinity of fishing operations where they may be harmed. The main impetus for many at-sea monitoring programs is for monitoring protected species interactions and fishery coverage can be problematic because encounter rates are often very low. The usefulness of EM for protected species monitoring has been proposed as a more cost effective way of achieving desired coverage levels. A variety of pilot studies have been carried out to examine the capabilities of EM for monitoring protected species interactions.

Australian Redbait Fishery – A Tasmanian midwater trawl fishery for redbait, a small forage species used as a food source in blue fin tuna farming, has incidental encounters of porpoise. A trial study was carried out on a vessel with cameras trained at key points on and around the vessel (Figure 17) to monitor catch handling operations. Catch is generally pumped aboard the vessel while porpoise must be manually removed from the net, usually at the stern ramp. The imagery provided clear views of catch and net handling operations around the vessel and was felt to be successful in monitoring porpoise takes.

Figure 17. Example camera views from midwater trawl vessel showing net at stern (a), on the trawl deck (b) and forward starboard quarter where fish are pumped (c).

Groundfish Longline Fishing – Extensive use of EM for catch monitoring in the BC groundfish longline fishery has provided a lot of experience with seabirds catch monitoring. Other studies have been conducted in Alaska (Ames, 2005; Ames et al., 2007) and New Zealand (McElderry et al., 2008c) with similar outcomes. When the EM system is set up to monitor catch, seabirds can generally be detected very easily. Identifications can be problematic as the soaked birds are difficult to distinguish without close inspection. Exceptions to this are distinctive species such as black-footed albatross (*Phoebastria nigripes*).

Pelagic Longline Fishing – Pelagic longline fisheries have takes of both seabirds and sea turtles. As compared with demersal longline fishing, the ability for EM to monitor protected species interactions is more demanding because catch handling occurs in a large area near the vessel and most unwanted catch will not be brought aboard. Catches of sea turtles are noteworthy events because it may take the crew several minutes to bring the animal under control and remove the hook. Figure 18 provides imagery of a leatherback sea turtle (*Demochelys coriacea*) take. Crew catch handling procedures can play an important role in catch items being successfully monitored as unwanted catch items may avoid detection by release of the branch line before the catch item comes into camera view. This is an issue for catch detection by both EM and observers although more significantly the former.

Figure 18. Imagery of protected species encounters recorded by EM on pelagic longline vessels. Upper photographs show Black Petrel interaction and lower photographs show Leatherback sea turtle.

Trawl Third Wire – Many trawl vessels deploy a sonar cable ('third-wire') from the vessel to the trawl net monitoring device. Seabird mortality resulting from interactions with the third-wire has been documented, but groundfish observers do not directly monitor third-wire interactions. An EM study was conduced to evaluate the potential for monitoring interactions with trawl third wire (McElderry et al., 2003a). Results from the study demonstrated that EM could effectively monitor the presence, relative abundance, and general behaviour of seabirds in the vicinity of the third wire during most daylight fishing events. EM also detected entanglements of seabirds on the third-wire although it was not possible to determine the cause of these entanglements. EM imagery was not very useful for seabird enumeration and species identification. An example of third wire imagery is shown in Figure 19.

Figure 19. Example third wire imagery from Alaska factory trawler (McElderry et al., 2003a).

Strengths and Weaknesses of EM for Protected Species Interactions – Catch interactions of protected species can often be very easily detected using EM if the species are brought within camera view. As these items are often very distinctive from the target catch image review times may be very fast, particularly if the only purpose of catch monitoring is to look for protected species captures. The use of EM for other types of interactions is less clear. Seabird interactions with trawl warps can be characterized but difficult to quantify. More general monitoring of protected species presence in the vicinity of fishing vessels is difficult because image resolution is poor. The combined motion of the vessel and water, and the lack of a fixed visual reference (i.e., a horizon) make viewing conditions difficult to resolve animals. EM would also not be very useful to monitor deck landings of seabirds because of the number of cameras that would be required to monitor areas where seabirds could board.

Mitigation Measures

Mitigation measures are designed to limit protected species interactions with fishing vessels. These measures may include specific devices such as net pingers, seabird streamer lines, or escape panels, etc. Mitigation measures may also include procedures such as restrictions on when offal may be discharged, or where and when fishing gear may be operated. Mitigation through fishing restrictions has been covered in previous sections. A few different studies have been carried out to examine protected species interactions with the use of specific devices.

Streamer Lines for Seabirds – Streamer lines, also called tori lines, are commonly used as to exclude seabirds from certain areas around the vessel where the line is being deployed. On longline vessels, streamer lines are used to confine the air space immediately aft of the vessel, keeping seabirds from landing where the longline and bait are accessible. EM was trialed on halibut longline vessels in Alaska (Ames, 2005) and cameras were found to effectively monitor the presence and effectiveness of streamer lines (Figure 20) although streamer lines should be constructed with more visible materials to make the gear more distinctive on video. In another study, EM was tested to monitor the effectiveness of streamer lines placed ahead of trawl warps (McElderry et al., 2004c). Figure 20 provides a conceptual drawing of how trawl streamer lines work. Both studies showed that EM could be a useful too to monitor deployment and general performance of streamer lines but had limited value in quantifying interactions and identifying species involved. The limitation is due to the poor quality of camera images of water areas around the vessel.

Figure 20. Left- example of streamer line imagery from an Alaska halibut longline vessel (Ames et al., 2005). Right- conceptual drawing of seabird streamer line device used to reduce seabird interactions with trawl warps (from Crysell, 2002).

Net Pingers for Marine Mammals – Several gillnet fisheries require the use of pingers to reduce the incidental take of marine mammals. A net pinger is an acoustic deterrent device that broadcasts a 10kHz sound for 300 milliseconds at 132 dB, repeating every 4 seconds. The signal, which lies within the hearing range or marine mammals, acts to alert the animals to the gillnet position in the water column, therefore effectively reducing net entanglement. Two EM studies (McElderry et al., 2007a,b) examined the deployment of net pingers on gillnets and concluded that while these devices were evident in the imagery, they were difficult to accurately count their performance could not be established. A follow up study (McElderry et al., 2008a) was carried out to develop and test an EM system equipped with a pinger hydrophone (see Appendix I, Figure A7). The results from the test provided clear acoustic signals (Figure 21) but further work is needed to develop an efficient way to determine the number and placement of net pingers in use.

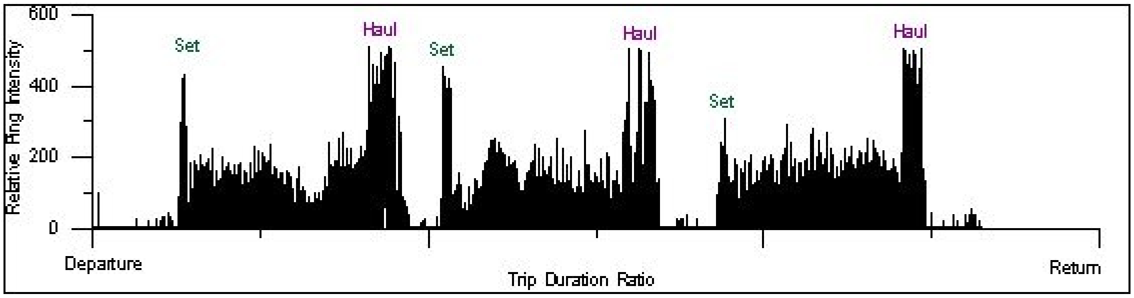

Figure 21. Continuous acoustic signal data from a three-day drift gillnet fishing trip shown in relation to net setting and hauling events. (From McElderry, et al., 2008a)

Strengths and Weaknesses of EM for Monitoring Mitigation Devices – There are a range of devices that are effective at reducing interactions with protected species when properly used. EM can be a valuable tool to confirm the presence of these devices and assess their general performance. Some measures such as trawl escape grids can be easy to confirm but difficult to assess performance. Where the purpose of the monitoring is to study the effectiveness of the mitigation device EM imagery may not provide enough resolution to discern individual species and their behaviour.

Compliance Monitoring

Compliance monitoring is an important focus of many monitoring programs. In many respects, the presence of monitoring (EM or observers) on a vessel creates compliance and fisheries enforcement actions may be relatively small. The deterrent effect of monitoring comes from both the effectiveness of the monitoring tool in detecting compliance issues, and the utility of the evidence to successfully prosecute charges. While EM is a strong tool for a range of monitoring issues discussed in the previous sections, the technology is relatively new and there are only a small number of cases where EM data has been introduced as evidence before the courts. The reason for this is a combination of both the small number of compliance issues identified and limited experience among enforcement community in working with EM data. The use of EM data for evidence and making prosecutions will increase with:

- More widespread use of EM,
- Increased knowledge of EM capabilities,
- More understanding of EM data products and their use, and
- Building EM case history with successful prosecutions.

The BC Area A crab fishery has over nine years using EM to fully monitor the fleet. There have been a number of administrative penalties, supported through contract law, on a range of issues such as trap vandalism. There was one large case brought forward against a fishing vessel on several charges including such as fishing in a closed area and falsification of data. The case was eventually settled out of court in favour of DFO.

In 2007 there was a successful court case brought against a BC groundfish longline vessel. A DFO patrol vessel caught the vessel fishing in a closed area. The vessel was monitored with an EM system that also showed the vessel fishing in the same closed area on previous days. DFO was successful with the court confiscating the catch for all fishing days, plus a fining the license holder for fishing in the closed area.

A key problem with using EM based monitoring for compliance is when the system is turned off. Logically, if someone wanted to commit a fisheries violation, the EM system would be shut off to prevent incriminating evidence from being recorded. In the summer of 2007, a fishing vessel participating in the West Coast shore side hake fishery chose to turn off the EM system before discarding a net full of rockfish. It was through other evidence, including an admission by the skipper, that a successful prosecution was achieved. Clearly, the design of the EM program needs to incorporate measures to discourage tampering with the EM system. This issue is returned to in the Program Governance section.

EXAMPLES OF FULLY OPERATIONAL EM PROGRAMS

The demonstrated capabilities of EM, coupled with lower cost and other issues, create a compelling argument for operationalizing EM. An operational EM program goes beyond pilot scale testing to be a key tool providing information to support the science, management and compliance objectives of the fishery. Over the past nine years, EM technology has become fully integrated in a few fisheries. This section summarizes these fisheries and some key outcomes.

The Area A Crab Fishery

Fishery Background

The Area 'A' crab fishery takes place in the shallow marine waters of Hecate Strait and Dixon Entrance in northern British Columbia. The 50-vessel fleet, ranging from 7 to 20 meters in length, is based out of the ports of Prince Rupert and Massett and uses single buoyed traps to fish for Dungeness crab (*Cancer magister*). The fleet collectively fishes about 4,000 days per year, fishing 32,000 traps and making about 500,000 trap hauls. The fishery operates most of the year except for a spring fishery closure during the crab molting phase. Catches vary from year to year and recent levels are around 1,400 metric tons (~3 million pounds), valued at about $10 million CDN.

Industry leadership is through the Area A Crab Association. Formed in 1997, with current membership of nearly all license holders, the Association's purpose is to advise and contribute to the management, monitoring, enforcement, and research activities through consultation with Fisheries and Oceans Canada (also referred to as 'DFO').

Monitoring Issues

There are a number of monitoring issues in the fishery:

- The fishery is primarily regulated by effort controls with vessel trap limits ranging from 600 to 1,200 traps depending upon vessel length.
- Vessels must also limit trap soak duration to not exceed 18 days as the potential for gear loss increases with time untended.
- The fishery is also regulated by seasonal area closures to protect molting crabs.
- In addition to DFO regulations, the Area A Crab Association enforces a code of practice with regard to gear handing. The code of practice prohibits theft, vandalism or removal of catch from another vessel's traps. In the past these were significant issues in this fishery where there may be areas of high gear congestion.

Monitoring Program Summary

The monitoring program developed out of a mutual requirement of DFO and industry to effectively address the monitoring issues. The Area 'A' Crab Association provided leadership in contracting with Archipelago to carry out pilot studies and establish an EM program. The fleet moved to 100% EM-based monitoring in 2000 and the program has remained in place every year since. All vessels carry an EM system that includes a control box, a single mast mounted camera, a GPS receiver, a hydraulic sensor and RFID tag reader. All vessels hail before and after a fishing trip and must keep the EM system powered continuously while the vessel is at sea. The EM system records sensor and camera imagery continuously during the fishing trip. Each vessel uses trap buoys with a distinctive color pattern and all buoys must carry an RFID tag (inserted into foam core). Trap buoys are scanned when a trap is hauled.

Analysis and Reporting

Data are retrieved from the EM system approximately monthly during the fishery. A multi step analysis approach was developed to address the major compliance issues in the fishery:

- Firstly, the sensor data stream is carefully examined to ensure that the EM system was operating continuously during the fishing trip. Failure to comply with keeping the system continuously operating was considered a serious compliance issue.
- Secondly, sensor data was examined to ensure that all traps hauled were properly scanned. This is achieved by associating hydraulic pressure oscillations and RFID scans on the vessel cruise track (Figure 7).
- The next step involves referencing RFID scan identities with the authorized vessel trap inventory to ensure the trap belongs to the vessel. As well, RFID scan events are compiled in a database to calculate trap soak durations and active trap inventories (Figure 16). Stray gear (i.e., traps that have not been recently hauled) is also actively monitored and reported to fishers to assist them in retrieval efforts for lost gear.
- Vessel cruise track information is examined for compliance with area restrictions and the identification of anomalous activity such as a delay in the hauling sequence to clear tangled buoy lines, and straying from the trap line to haul nearby gear. Analysis of imagery is primarily exception based. Events identified in the sensor data (e.g., haul event) may be referenced in the imagery for further confirmation.

Results from the EM analysis are compiled in a fishery data system. Incident reports (compliance issues) alert fisheries authorities and the Area A Crab Association to compliance issues in their fishery. Reports are provided to DFO, the Association and fishers to summarize EM data set analysis results and provide feedback on data quality. The monitoring program also provides other ad hoc reporting on activities in the fishery on a range of issues.

Governance and Service Delivery

DFO and the Area A Crab Association govern the EM program. Each fishing vessel is bound by DFO license conditions that specify the monitoring requirements. For a number of practical reasons, DFO has specified that there be only one monitoring service provider for the fishery; the selection of the service provider is made by industry. The Area A Association contracts with the service provider (Archipelago) on behalf of license holders, and in turn contracts with license holders to ensure compliance with the monitoring program. Failure to comply with the DFO or Association regulations results in potential action by DFO, the Association, or both. The dual governance provides for a range of remedies enforced under contract law or the federal Fisheries Act. The remedies available to the Association include warning notices, a requirement to post a performance bond, fines, or suspension of monitoring services. Remedies available to DFO follow a more lengthy process through the courts and may involve fines or loss of fishing privilege.

Program Costs

The EM program has been in place for nine years under the same independent third party contractor structure. The program is entirely funded by the fishing industry and it is estimated that the cost is about 2% of the value of the fishery, or about $80 CDN per vessel day at sea (McElderry and Turris, 2008).

Program Outcomes

The main outcomes of the Area A Crab EM Program were as follows:

- DFO Effort Controls Met – The EM program provides an accurate way to monitor vessel trap limits, soak durations, and area restrictions.
- Industry Compliance Controls Met – Issues concerning trap theft and vandalism, and catch theft declined precipitously. License holders benefited with a reduction in lost gear and more catch.
- Reduced Conflict –100% fleet monitoring provided a common standard across the fishery, improving compliance and reducing tensions between vessels.

The Groundfish Longline Fishery

Fishery Background

BC's groundfish longline fishery collectively comprises a fleet of about 250 vessels, 1,600 trips, 12,000 days at sea, catches about 30 million pounds, and is valued at about $85 million CDN. There are six separately licensed fishery components including halibut, sablefish, lingcod, dogfish, inshore rockfish, and offshore rockfish. While each fishery has a specific species focus, there is a high species overlap between fisheries, they collectively catch about 140 species, and there are 61 separately managed stocks, delineated by both species and area. The groundfish longline fishery is part of an overall integrated management plan that encompasses the entire groundfish fishery. License holders are allocated individual quota on an annual basis and there is a significant level of trading between different license holders to establish quota portfolios that meet specific fishing plans and expected bycatch levels.

Industry is represented through several organizations. Each license group has advisory boards that DFO consults with on a variety of fishery issues. In 2003, the Canadian Groundfish Integrated Advisory Committee (CGIAC) was formed to establish a strategic approach toward integration of BC groundfish fisheries. Membership is very broad and includes provincial and federal governments, commercial fisheries sectors, coastal communities, marine conservation, recreational fishing, and the B.C. Aboriginal Fisheries Commission. A subcommittee of the CGIAC, the Commercial Industry Caucus (CIC), was established to provide advice on management and monitoring for the integrated groundfish fishery.

Monitoring Issues

DFO's groundfish management policies are guided by three objectives:

- 100% of all catch, including fish discarded at sea, must be accounted for.
- Catch levels for the 61 managed groundfish stocks must remain within established quotas.

- Licence holders must be individually accountable for their fishing practices.

In addition to meeting these needs, industry requires accurate catch accounting in order to support quota trading needs.

Monitoring Program Summary

Groundfish fisheries have a comprehensive monitoring program that includes vessel logbooks, a hail system, 100% dockside monitoring, and 100% at-sea monitoring. All groundfish fisheries must hail at the beginning and end of a fishing trip. All landings are monitored to verify offload weights and proper species sorting. At sea monitoring involves an observer program for the trawl fishery and EM for the groundfish longline fishery. The EM program was developed through a series of pilot studies conducted from 2002 to 2005. EM became mandatory for the fleet in 2006 with compliance measures and other program complexity introduced in 2007 and 2008. All vessels carry an EM system consisting of two or more cameras mounted outboard of the hauling station and trained on the catch retrieval area (Figure 10), a GPS receiver, a winch sensor and a hydraulic pressure transducer. All vessels must keep the EM system powered continuously while at sea and must come to port if the system fails. The EM system records sensor data continuously during the fishing trip and imagery is recorded during gear retrieval operations, triggered by hydraulic and winch sensors. Vessel masters must keep accurate records of all catch, including size-based accounting for certain species (Figure 13). As rockfish species may be difficult to identify in EM imagery, they must be retained for census as part of the dockside monitoring program. Upon completion of the fishing trip an EM technician meets the vessel to remove data and prepare the EM system for the next fishing trip.

Analysis and Reporting

EM data are processed upon completion of each fishing trip in order to support the quota management needs of the fishery. The basic approach taken is to use the EM and dockside monitoring program data as tools to audit the quality of vessel logbook data. The analysis process occurs in multiple steps:

- Firstly, logbooks and offload data sources are processed, error checked and data entered.
- EM sensor data are examined to confirm that all fishing events recorded in the vessel logbook are accounted for and properly logged by time and location.
- A 10% sample (minimum of one per trip) of the fishing events is randomly selected for image interpretation. Image viewers examine the retrieval event, recording all catch by species, utilization (kept or discarded), and size (legal or sublegal, if relevant).
- The results of the image interpretation are compared with catch recorded in the vessel logbook and the level of agreement is evaluated.
- The final step of the analysis involves comparison of the offloaded catch (in pieces) to the retained catch as recorded in the logbook.

The EM program provides a number of data summary reports:

- The complied data from vessel logbooks, EM and dockside monitoring program are provided to DFO.
- The 10% random sample provides an independent data set for the fishery.
- The results of the audit comparison are provided to DFO and the license holders summarizing the results of the comparisons. An average audit report may contain 30-40 specific comparisons and a passing score requires meeting standards for specific tests as well as achieving overall averages across several tests.
- The EM program also provides regular reporting on a variety of issues including as fishery updates, program operations and equipment performance.

An audit report, showing the results of the EM vessel logbook comparison, is forwarded to both the fisher and DFO. A series of criteria have been developed to determine pass or fail. Failing an audit indicates that vessel logbook data are unreliable and may warrant further program consequences such as reviewing additional image data to construct an independent catch record, providing feedback to the skipper on areas of needed improvement, and possible punitive measures.

Governance and Service Delivery

The monitoring program has come together through a number of processes:

- DFO adopted the CIC-developed monitoring plan as part of the fishery management plan.
- DFO sets regulations (through license conditions) for licence holders that specify monitoring requirements of the fishery.
- The CIC decides service delivery and selects the service provider. The CIC has chosen an independent third party service delivery model with a single provider (Archipelago) for all monitoring services.
- Archipelago separately contracts with each license holder outlining the terms and conditions of service.

Program Cost

Industry and DFO co-fund the EM monitoring program with industry covering about 80% of the costs. Industry pays for all costs associated placement and operation of EM systems aboard the vessel, and the cost for initial interpretation of EM data. DFO pays for costs associated with overall program administration, data analysis, reporting and delivery of data to DFO. The total cost of the EM program, including equipment, is about $150 per sea day, or about 3% of the catch value.

Program Outcomes

The EM program, combined with dockside monitoring, created a number of significant changes:

- DFO Principles Were Met – Monitoring provided a fully documented fishery, with individual vessel accounting of catch and discards.
- Data Rich Platform – The monitoring system provides comprehensive fishery information that can be used for a variety of current and future issues.

- Industry Self-reporting – The audit system placed significant responsibilities on industry to account for catch properly. Catch accounting and feedback from audit reports increased industry involvement in data reporting.
- Industry Motivated to Reduce Bycatch – The monitoring system provides accountability for all catch. Licence holders must either acquire quota or find ways to reduce bycatch.
- Changed Fishery Behaviour ('Levelled the Playing Field') – The 100% monitoring approach provides a common monitoring standard across all elements of the fishery, effectively aligning the fleet with regard to compliance with fisheries regulations.
- Trusted Fishery Data – The independent third-party service delivery model results in the creation of data set that provides a credible, objective perspective of the fishery.
- Cost Efficient Monitoring System – The integrated monitoring system (observers, EM systems, dockside monitoring, etc.) for the entire BC groundfish fishery costs about 5% of the total catch value of the fishery. The industry-funded portion of this is about 80%.

West Coast Shore Side Hake Fishery

Fishery Background

The non-tribal, commercial Pacific hake fishery is a seasonally intense spring/summer fishery that operates off the coasts of Washington, Oregon and northern California, consisting of both an at-sea processor fleet and a shore-based fleet. The shore-based fleet comprises approximately 40 vessels that make day fishing trips and deliver their catch to six ports. There is usually an early season fishery in northern California, starting early April, where up to 5% of the coast wide quota is taken. The balance of quota is taken further north during the main season fishery, which generally begins mid June off the coast of Oregon and Washington. The Pacific Fishery Management Council regulates the quota for different components of the U.S. hake fishery, and the annual quota is about 100,000 metric tons, valued at about $25 million USD.

Monitoring Issues

At-sea monitoring for the West Coast shore side hake fishery is desirable for two reasons. Firstly, threatened bycatch species such as rockfish and salmon require accurate accounting to monitor overall take of these species by hake vessels. Moreover, owing to large volumes of hake caught relative to bycatch, and to a rapid parasitic degradation common to freshly caught hake, the most practical catch handling operation is to quickly transfer unsorted catch to refrigerated fish holds. Cold temperatures slow hake's degradation process, and attempting to sort bycatch at sea is both labour intensive and would lead to lower hake quality. Estimates of bycatch are thus made from offloaded catch and it is necessary to ensure that landed fish are not pre-sorted at sea.

Secondly, catch wastage is an important concern in the West Coast shore side hake fishery. The fast-paced nature of this fishery is coupled with a desire to deliver full loads. Fishing vessels occasionally catch more fish than they can carry and the excess fish are dumped at sea. Practices such as blow out panels and net monitors are currently in use to mitigate wastage. Discard monitoring has been useful both in estimating excess dumping and in developing individual vessel accountability measures to encourage maximized retention.

Monitoring Program Summary

A pilot study carried out in 2002 demonstrated the feasibility of EM for discard monitoring in this fishery (McElderry et al., 2002). The program was expanded to include the entire fishery in 2004 and has since been a permanent requirement. The EM program began as a science-based program to characterize the fishery and has recently transitioned to a management program with a stronger compliance focus. All vessels carry an EM system consisting of 2 or 3 mast-mounted cameras, a GPS receiver, a hydraulic pressure sensor and a winch sensor. EM systems are generally leased to the fleet and installed prior to commencement of the fishing season. The system must be powered continuously while the vessel is at sea and if an EM system fails the vessel is required to cease fishing and return to port. The user interface software has a functionality test program that fishers can use to continually monitor the operational status of the equipment. The EM system records sensor data continuously and imagery is recorded from the start of the first fishing event until the vessel returns to port. Vessel skippers are required to keep accurate vessel logs for comparison with EM data.

Analysis and Reporting

EM data are collected from fishing vessels on a biweekly schedule. The overall goal of the analysis is to verify accuracy of vessel logbook, create a detailed data summary for the fishery, assess vessel compliance with a number of fishery and monitoring program requirements, and provide feedback to NMFS and industry on a number of fishery issues. The analysis process consists of the following steps:

- Firstly, logbooks are reviewed, error checked and data entered.
- EM sensor data are examined to confirm that all fishing events recorded in the vessel logbook are accounted for and properly logged by time and location.
- The EM data record is examined to ensure the vessel was compliant with keeping the EM system running continuously.
- Image data from catch stowage operations are examined in detail and any discard events are categorized by type (e.g., bleeding, deck discard, etc.) and the quantity estimated.
- Imagery is also examined for the balance of the fishing trip to confirm that fish remain aboard.

The EM program provides a number of data summary reports:

- Compliance reporting includes an inventory of fishing activity by vessel and trip, a summary of fishing events, reports of missing EM data, and an assessment of compliance with full retention requirement.
- Vessel reports provide a summary of fishing activity, EM system performance, and full retention compliance, and a comparison between EM data and the vessel logbook.
- Fleet reports provide fishery summary on fishing activity EM system performance, and full retention compliance.

- The complied data from vessel logbooks and EM are provided to NMFS and provide a comprehensive data set for the fishery.

Governance and Service Delivery

The monitoring program has come together through a number of processes:

- The West Coast shore side hake fishery is managed under an Exempted Fishing Permit (EFP).
- NMFS specifies the EM program through the EFP.
- NMFS contracts with a single service provider (Archipelago) for provision of the EM program.
- Archipelago separately contracts with each EFP holder outlining the terms and conditions of service.

Program Cost

Industry and NMFS co-fund the EM program with industry covering about 75% of the costs. Industry pays for all costs associated placement and operation of EM systems aboard the vessel, and the cost for initial interpretation of EM data. NMFS pays for program outreach, training of NMFS staff, and data analysis, reporting and delivery of data to NMFS. The total cost of the EM program is about $250 per sea day, or about 1% of the catch value.

Program Outcomes

The outcomes of the West Coast shore side hake EM program were as follows:

- Improved Fishery Data – Monitoring provided a comprehensive understanding of the fishery and helped sensitize industry, fishery managers and others to key issues in the fishery. The EM program provided greater assurances on the reliability of landings data.
- Industry Motivated to Reduce Bycatch – Vessel and fleet specific discard information stimulated the few problem vessels to conform to the fleet norm.
- Changed Fishery Behaviour ('Levelled the Playing Field') – The 100% monitoring approach provides a common monitoring standard across all elements of the fishery, effectively aligning the fleet with regard to compliance with fisheries regulations.
- Trusted Fishery Data – The independent third-party service delivery model results in the creation of data set that provides a credible, objective perspective of the fishery.
- Cost Efficient Monitoring System – The EM program cost is a quarter or less the cost of an at-sea observer program.

OPERATIONALIZING EM PROGRAMS

The chronology for development of an EM program often begins with an initial pilot study to accomplish the following:

- Testing the use of the technology for the specific fishery monitoring issues,
- Calibrating EM and observer methodologies,
- Demonstrating EM to fishery stakeholders (fishermen, fisheries agency staff, and others) to foster education on EM and its capabilities,
- Measuring fleet suitability and acceptance levels for EM,
- Developing recommendations on how EM could successfully meet the fishery monitoring requirements, and
- Providing advice on steps needed to develop and EM program.

Advancing from a pilot to an operational EM program requires the development of monitoring objectives, program specifications and an operations plan. The process should involve a lot of discussion with fishery stakeholders to ensure the program meets their needs and achieves acceptability. Specifications should be sufficiently detailed to enable program planning and cost forecasting. Critical issues to consider include fishery characteristics, sample design, EM equipment specifications, infrastructure requirements, analysis and reporting requirements, timelines, and project deliverables. The operations plan addresses program delivery issues including the service delivery model (who is providing the service), program governance, responsibilities of the parties involved, funding arrangements.

This section provides an overview of different considerations involved with development of an operational EM program.

Operational Issues

Infrastructure Requirements

An EM program has three main components:

- Equipment supply,
- Provision of field services, and
- Data processing.

The supply of EM equipment for a program involves manufacturing, distribution, equipment repair, and research and development. EM equipment is not an off-the-shelf product and systems are generally built to order. Fishery participants may choose to purchase or lease an EM system, depending upon their needs. Owners of active vessels will lower their costs by purchasing equipment while leasing is a better option for less active vessels. Strategies to encourage purchasing reduce program costs as purchased equipment is generally cared for better than leased equipment. The supply of EM systems also carries a need to provide services to maintain the pool of leased equipment and to provide repair services for purchased equipment. The supply system must also include replacement parts and spare equipment to ensure continuous operation of EM equipment on the fishing vessels. The equipment supply also has an active research and development component to fix problems and expand the EM system capabilities. A new fishery monitoring application may require specific EM system customization or technology development requirement.

The field service component involves establishing a network of technicians to support the operation of EM equipment on the fishery. The basic functions of field technicians include:

- Installing EM systems,
- Providing routine service and repairs to EM equipment,
- Assisting fishers with the use of EM equipment,
- Supporting chain of custody requirements for the handling of EM data, and
- Providing a communication link between the fishermen and other elements of the program.

An EM program generally positions field technicians at various landing ports for efficient access to the fleet. Field staffing is a tradeoff between fewer, more centralized technicians but slower response time versus having more field technicians distributed for timelier access to the fleet. The specialized nature of an EM program has resulted in these persons being staffed from within the program rather than contracting with electronics firms in the ports. The support infrastructure for managing a network of field technicians involves training, tools and resource materials, as well as setting up processes for staff scheduling and performance monitoring.

The third component of an EM program involves data processing. EM data technicians use custom software tools to interpret sensor data and review imagery. As described earlier, summarized fishing data are then imported in fishery data system, analyzed for data quality issues, compiled to meet various reporting requirements, and transferred to client data systems. EM data processing functions should be centralized to promote more continuity between data technician staff and closely link the data outputs with the program operations.

While EM programs have complex infrastructure requirements, the labor requirements are much smaller than what is required for observer programs. Using the BC groundfish longline fishery as an example, the EM program (230 vessels, 12,000 seadays) requires 2.25 hours of program staff labor for every monitored vessel day at sea. In contrast, the BC groundfish trawl observer program (50 vessels, 5,000 seadays) requires about 14 hours per monitored day at sea. As every seaday requires a day of observer time, it is impossible to achieve the same scale of efficiency as an EM program. With large fisheries involving hundreds of vessels and tens of thousands of seadays, observer labor requirements would be enormous and EM may be the only way to achieve high coverage levels.

Service Delivery

The service delivery model specifies how the program will be delivered. Using US observer programs as a reference, monitoring services are often provided using a combination of resources provided by the fisheries agency and private contractors. The range of services varies among different programs but the agency more generally provides program specifications, observer training, and data management, while contractors generally employ observers and coordinate their deployment on fishing vessels. With government-funded programs the fisheries agency can specify the contractor. With industry-funded programs industry chooses a contractor that may need to be government certified. The number of service providers for a monitoring program varies between programs. Government-funded programs often have a single contractor for the monitoring program and industry-funded programs in Alaska and the US North East have more than one contractor.

In Canada observer programs are contracted by DFO with a single service provider selected for each region. Canadian observer programs receive a significant (~80%) level of funding from industry, the balance paid by DFO. Program services are distributed between DFO and the contractor in a similar fashion as in the US programs but contractors may provide fully stand-alone monitoring services while the agency provides little more than program specifications and contract oversight.

There is no ‘correct’ service delivery model for monitoring services and different fisheries and monitoring issues may prescribe different models. The distribution of monitoring program services among the agency and one or more contractors limits the degree to which a program can be centralized, and the capacity for each of the parties to specialize. When contractors are engaged as little more than an employment service there is limited opportunity for development of fishery expertise. The Canadian model where single contractors offer full service programs has created the opposite climate where contractors are motivated to specialize, invest in research, and develop monitoring solutions for particular fishery needs. The development of EM technology was a logical outcome from this service delivery setting.

The service delivery model for fully implemented EM programs follows the single contractor, fully stand-alone model. All program services (equipment, field services, and data processing) are fully integrated as a single stand-alone program. Alternatives to this model are limited because very little EM infrastructure and expertise currently exists outside Archipelago. Recently, some pilot projects have begun to experiment with a distributed service model where locally based personnel are trained to provide program services such as field services and image interpretation, while other project functions are centralized. This project design is less efficient than the single service model but provides a cost effective way to deliver EM services in areas where infrastructure is limited.

From the present where the capacity for delivery of EM services is limited, it seems inevitable that the future will involve a significant growth in capacity with multiple providers of EM equipment and services. Fisheries agencies, as the customary party responsible for fisheries monitoring functions, should try to foster EM capacity development and work with industry to develop an effective setting for service delivery. Some key issues are:

- What role(s) should fisheries agencies have with service delivery of EM programs?
- What role(s) should contractors have in the design and operation of EM programs?

- What are the pros and cons of centralized versus distributed service delivery?
- What is needed to encourage EM technology development?
- What standards should exist for EM technology?

Governance

Program governance must effectively address both fishery and monitoring program compliance issues. EM is only effective if it can deliver a clean data set and measures are needed to prevent tampering.

The traditional governance approach is to specify compliance requirements in fishery regulations. This is likely appropriate for major issues like fishing in a closed area. Sometimes regulations changes are necessary to support the EM program. For example, the BC groundfish longline fishery implemented regulations for onboard retention of all rockfish since EM imagery could not adequately resolve to the species level. The use of fisheries regulations may not be very effective for issues like turning the EM system off for 10 minutes. Fishery violations are prosecuted through a costly, time-consuming court process, and an avenue appropriate for serious issues. Even though 10 minutes of missing EM data record could be masking a serious fisheries offence, it would seem fruitless to seek court conviction for this offence.

Two of the fully integrated EM programs have developed other governance measures:

1) The Area A Crab Association regularly monitors fleet performance and uses a progressive discipline process, starting with warning letters and advancing to a requirement to place a performance bond that will be refunded after a year of compliant behaviour. In some cases, fines have been levied where the damages were quantifiable. Vessels with poor EM performance were also requested to take an observer for a period of time at their expense.

2) The governing body for the BC groundfish longline fishery (the CIC) lacked strong industry governance and there were fears that any actions like those carried out by the Area A Crab Association would cause an already fragile industry organization to unravel. The CIC worked closely with EM program staff to develop a series of administrative measures to promote compliance. Vessels providing a clean EM data set can expect quick service at minimal cost while those with poor data can expect a delay and more cost simply because the data set takes more time to process. Vessels with consistently poor data can expect to either pay the cost of 100% image viewing (poor vessel log data but a good EM data set), or loose the privilege of EM and carry an observer (consistently poor EM data) at more cost.

Another approach to achieve compliance is to seek mechanisms to build fleet acceptance for the program. In the case of the Area A Crab fishery, individual crab fishermen had a lot to gain by ensuring that other fishers were fully monitored so it was logical to cooperate as well. Similarly, in the BC groundfish longline fishery, many fishers came to understand that the future of the groundfish fishery depended upon an integrated fishery where quota could be traded among license holders of different fleet sectors. *"As soon as* *it became obvious that another sector needed "my fish", then it became clear that that sector required monitoring…and If everyone else required monitoring… So must I"* (Koolman et al., 2007).

Program acceptance can also be achieved through the provision of services to specifically address information interests of fishers. In the Area A crab fishery, tracking trap hauls and identifying traps that had not been hauled recently has proved to be a valuable tool in assisting with the recovery of lost gear. Placements of additional cameras providing deck views from the wheelhouse can improve vessel safety conditions. There are a number of other options such as fish hold and engine temperature monitoring that have not been implemented but would be of interest to industry.

Feedback is also a useful tool to achieve compliance. With many fishing regulations, the majority of the fleet will be compliant and a few will consistently disregard the regulations. Often a person's willingness to comply will be guided by perceptions of how compliant the rest of the fleet is. The isolated nature of fishing means that perceptions of fleet compliance are generally conjecture and not based on fact. The West Coast shore side hake EM program generates fleet reports that summarize individual vessel activity in relation to the rest of the fleet (Figure 22). These reports have improved compliance and assisted industry and agency in setting goals for key performance measures.

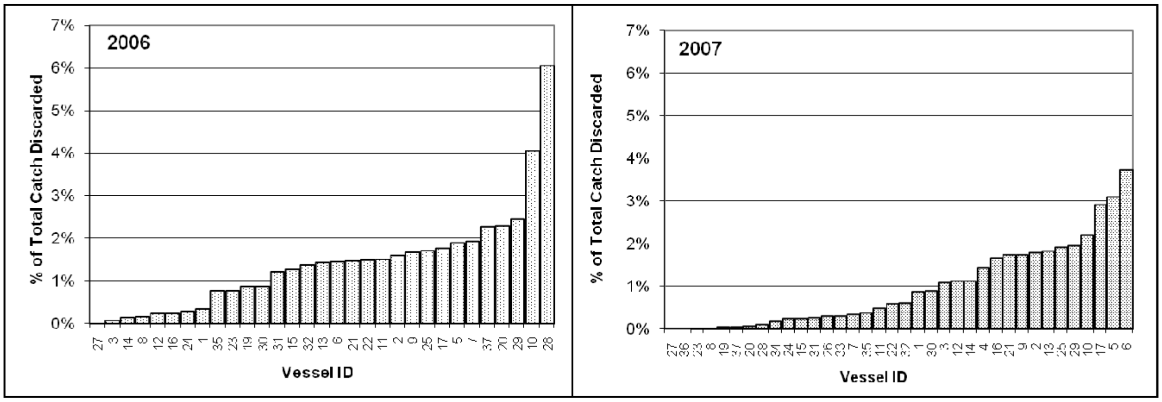

Figure 22. Histograms showing discard levels as a % of total catch by vessel for 2006 and 2007.

Timelines

Establishing an operational EM program in a fishery may require a period of 2-3 years, or more, for all elements of the program to be fully implemented. The period where EM is being phased in allows all parties to transition to the new program. The quality of EM data improves with the number of trips completed as vessels make adjustments to their operations and equipment settings. Similarly, agency staff and others gain experience over time working with EM program outputs and developing ways to make the program more operationally efficient. The phase-in also allows for EM program infrastructure to become established and fully operational. Even with all resources in place at the start of the program, it takes time for program staff to develop the knowledge and capability to work with the fleet effectively.

Data Policies

The comprehensive nature of data collected by EM systems results in issues that are not present with observer data. Image data, in particular is extensive and could compromise the privacy expectations of vessel crew or reveal various techniques, work practices, safety procedures, etc., which have little to do with the fishery monitoring objectives. As well, video imagery of catch events, particularly sensitive or charismatic species, has a different emotional sentiment than a data point. There are understandable sensitivities about the analysis of imagery for non-fishery purposes such as monitoring crew work patterns or activities of specific individuals.

Industry support for an EM program will be predicated on the rules concerning what information is collected and how it is used. Very likely, raw EM data will need to be protected from distribution in some manner. Strategies used in the BC crab and groundfish longline EM programs differ but both involve the image processing by an independent third party with strict contractual obligations concerning handling and use of EM imagery. Imagery are analysed for specific purposes with results compiled in a database environment. Raw imagery is generally deleted when analysis has been completed. Fisheries agencies do not receive raw imagery except for except for specific compliance events or other mutually agreed upon incidents.

Further issues come with data storage. Fisheries agencies typically own monitoring data and data policies may require archival of both raw and processed EM data for a period of several years. Industry will understandably be concerned about the prospect of image data from their operations being archived with the fisheries agency where their access and control over uses may be limited. Fisheries agencies my find archiving requirements problematic as data volumes are large. For example, an average BC groundfish longline EM data set may be about 50 GB. With all the trips combined, the data storage requirements are estimated to be about 75 TB (1 TB = 1,000GB) per year.

Data policies for an EM program need to be developed in advance and should address several key questions:

- Who owns the data?
- What are the chain-of-custody requirements?
- What are the archival requirements?
- Who has access to the data?
- What purposes can the data be used for?

Data policies for the three fully implemented EM programs have similarities and differences. Data ownership varies from agency (West Coast shore side hake), the license holder (BC groundfish) and industry organization (Area A Crab). In the case of the latter two, DFO has unfettered access to all raw and processed data. All programs have similar chain-of-custody procedures, limiting data handling to program staff and keeping data sets secure from unauthorized access. The data archival policies also vary. NMFS keeps all West Coast shore side hake fishery EM data for a period of one year, or longer with compliance issues. The two BC programs delete image data upon completion of analysis, provided that no compliance issues were identified and no further analysis purposes are required. all relevant information is delivered to fishery agency staff when compliance issues are identified in the EM data set.

Cost Issues

A key benefit for considering EM over observers is lower cost. Using the BC groundfish fisheries as an example, the observer program cost in the trawl fishery is about $560 per seaday, while the EM program cost in the longline fishery is about $150 per seaday (McElderry and Turris, 2008). These programs are different in many respects but achieve the same result of providing full documentation of a fishery. EM programs cost less primarily because the labor requirements are much lower. The up front cost for EM equipment is significant ($8-10k) but the daily cost over the lifespan of the equipment is low. The total cost of an EM program varies according to a number of factors and there are clearly situations where EM could cost more than an observer (deployment of EM equipment for a single, short duration fishing trip). Cost drivers for and EM program relate to the fishery and the monitoring program.

Fishery Influences

The cost for various monitoring options is strongly affected by a variety of inputs that determine program size:

- Fishery Activity – Monitoring program costs directly relate to the fishery characteristics such as the number of active vessels, total landings and vessel days at sea.
- Fishery Landing Patterns - The number and spatial distribution of vessel landing ports influences infrastructure requirements, staffing levels, and travel costs. Temporal activity patterns are also important.

Monitoring Program Influences

Program output requirements also directly influence monitoring costs:

- Coverage Levels for Partially Monitored Fisheries – Monitoring programs generally have a high ratio of labor that scales directly to coverage levels. Higher fishery coverage costs more, although on a cost per day basis, fisheries with low coverage cost more because of the cost of moving EM equipment to each vessel selected for monitoring. Fisheries with partial monitoring may also be more costly to monitor if there are no strong measures to compel fishers to comply.
- Labor Management – Monitoring systems are primarily service programs with high volumes of labor. Labor cost represents 65% or more of the program cost and operational systems that utilize labor efficiently create significant cost savings.
- Staffing Levels and Timelines – Staffing strategies for monitoring services are significantly affected by call up requirements. The requirement to meet all requests requires strategies to vary staffing levels for peak periods of activity (e.g., good weather, strong market conditions) and periods when activity is low. Response timelines also influence staff management strategies. Short response timelines become more difficult to manage than more steady state conditions.

Labor laws in most regions generally carry provisions for minimum call up and overtime for various industries or work settings. The labor cost for these can be significant if not managed carefully. Fishing activity is naturally variable and monitoring program flexibility is needed to best align with opportunities. Finding a balance will result in program cost savings and minimize incidents where fishers to wait for service.

- Program Reporting Requirements – Data analysis and program reporting requirements directly influence the volume of work carried out. Complexity of data, efficiency of data entry process, level of analysis and the number of different reports all contribute to the work volume.
- EM Equipment – EM equipment represents a significant part of the cost of an EM program. Ownership of equipment may make sense for active vessels, enabling the purchase cost ($8,000 to 10,000) to be amortized over several years and having a one-time technician cost for installation of the EM system. Less active vessels may not have enough activity to justify the capitol cost of purchasing and will pay daily lease costs and technician time for installation and removal. Other strategies are for fishers to share purchased systems. In the BC groundfish longline fishery, rental systems are used for about 20% of the 12,000 seadays in the fishery while purchased systems cover the balance. This blend results in a daily equipment cost of about $35, or about 20% of total daily EM program cost. If all vessels rented systems, the daily program cost would rise by about 25% as a result of a doubling of the equipment cost component. If all vessels purchased systems the cost would be higher than the blend because there are a number of vessels that have very low activity levels.
- Cost Recovery Method – Who pays and how cost recovery is structured influences both how program resources are used and overall program costs. The BC groundfish longline EM program is mostly (~75%) funded by industry and there are strong incentives for operational efficiency and prudent use of program resources by industry. License holders have developed strategies to utilize the program in a manner to minimize their costs. With industry funding, the industry participates in contractor oversight, providing advice on ways to tailor program services to meet their needs cost effectively. With agency funding, industry is in a position to place costly demands on the program without bearing the financial consequences. With industry funded programs it is also important to consider the impact cost recovery structures. Program revenue received through monthly invoices carries much different administrative cost than separate billings for each landing event in the fishery. Fee structures can be used to influence how program resources are used. For example, levying monitoring program fees as a cost per landed pound will not provide incentives for efficient use of program resources to the same extent that would occur by charging program fees on an hourly basis. Cost per pound fees can also create large cost disparities between vessels (high versus low volume fisheries) when the service provided may not be very different.

FUTURE TECHNOLOGY DEVELOPMENTS

Technology is advancing rapidly and there are a number of opportunities to improve the capabilities of EM systems and analytical tools. While the technology development possibilities are seemingly limitless, the practical reality of keeping EM cost as low as possible will guide the development process. This section provides some thoughts on development possibilities that are likely over the next few years.

EM System

The EM system will increasingly be developed as a standalone fishery business center for fishing vessels. The general design focus for the system will be to make it more compact, more reliable, quieter, lower in power consumption, and easier to install on a vessel. Some specific development initiatives include:

Control Box Software – The control box software will become more comprehensive in the various functional areas. Continual improvements with system reliability will be a high priority, monitoring system status, error trapping, and recording more system performance data. Also important will be the development an electronic logbook to enable direct entry of fishing data at sea. Communications integration will also be an important focus. Integration with VMS systems enables real time monitoring of EM system performance, vessel logbook data and other summary data. Access to other communications networks (cellular, WIFI, or satellite) may provide less expensive option for data transmission.

Sensors - Peripheral sensors for EM system will be expanded to monitor more fishing gear (multiple winches and hydraulic pressure systems) to better resolve different vessel activities. Additional sensors will likely also be included for the vessel benefit. These include temperature monitoring for fish holds, engine lubricants, etc.

Imagery - The EM system is currently limited in terms of image quality and the number of images stored per second. The barrier is because of the processing burden of converting analog camera images, to digital, then compressing and writing them to hard disk. Faster processer speed is becoming accessible as are digital cameras that do not need analog to digital signal conversion. These developments will provide higher resolution imagery, higher frame rates and the ability for more than four cameras.

Analytical Software

Analytical software improvements streamline data processing operations and reduce labor costs. One area involves integration of image and sensor data sets for inventory and cross-referencing purposes. Image viewing software priorities include improved navigation, synchronization of multiple images, still and video clipping, and templates for data entry.

SUMMARY AND CONCLUSIONS

EM technology has a wide range of uses for fisheries monitoring applications. The technology is particularly well suited for providing routine monitoring of issues such as:

- Fishing Time and Location,
- Gear and Catch Handling Processes, and
- Monitoring the use of mitigation devices.

The utility of EM systems to monitor catch is dependent upon the fishing method, working very well with fishing methods such as gillnet and longline gears where catch is retrieved serially. EM is not well suited for catch monitoring in high volume fishing gears such as trawl and seine. EM is also not well suited for complex activities such as the collection of biological samples. EM is well suited for monitoring protected species interactions that occur as catch, but less so for interactions where these species are present around the fishing vessel.

EM and observer monitoring methods have some clear differences:

- Vessel Suitability – EM systems can be placed on a wide range of vessels, including those too small to host an observer. EM is less intrusive and provides a practical way of monitoring fleets with short or unpredictable fishing schedules.
- 24/7 Permanent Data Record - EM data can be reviewed in a more controlled setting according to research needs while observer observations occur at the time of the event.
- Simultaneous Multiple Camera Views – EM can operate solo or used to assist at-sea observers with monitoring multiple areas on the vessel at the same time.
- Industry Engagement – The use of EM to audit vessel logbook data encourages self-reporting processes by industry while observers tend to disengage this process.
- Outreach Processes – Observers provide an important communications link between fisheries agencies and industry, whereas EM programs have less opportunity for these communications to occur.
- Cost and Scalability – The ratio of program staff labor to a monitored day at sea is generally much lower with EM programs and therefore, these programs cost less and more easily scale to higher fleet monitoring requirements.

A key weakness of EM is a design inability to prevent tampering. Unlike VMS, which is an entirely enclosed solid-state monitoring device, EM system has exposed cameras, sensors and wires throughout the vessel, and there are too many uncontrollable ways to fault the system. Instead, EM systems should be tamper evident, and EM programs must be designed with measures to discourage tampering.

Efforts to implement EM technology as part of a fisheries monitoring regime starts with pilot programs to gather baseline information, and leads to development of program specifications and an operations plan. There are a number of important considerations in setting up operational EM programs:

- Infrastructure – EM programs have complex infrastructure requirements including equipment supply, field services, and data analysis services. Currently, there is very little expertise and infrastructure in place for the delivery of EM programs.
- Service Delivery – How EM programs are delivered and by whom needs a lot of discussion to determine:
    - Roles of fisheries agency, industry, contractors, and others,
    - Pros and cons of distributed versus centralized service delivery,
    - The appropriate climate to encourage continued research and technology development, and
    - Standards and other approaches for managing multiple providers of EM equipment and services.
- Governance – Effective measures are needed to address both fishery and monitoring program compliance issues. The measures include fisheries regulations, industry lead governance, administrative tools, and participatory approaches aimed at gaining industry acceptance.
- Timelines- Operational EM programs may require 2-3 years to become fully implemented
- Data Policies – Discussion is needed on a number of issues such as data ownership, access privileges, chain of custody requirements, archiving procedures and data uses.
- Program Cost – The cost of EM programs will be influenced by both program inputs (fishery activity, landing patterns, etc.) and outputs (coverage levels, reporting requirements, equipment requirements, cost recovery method, etc.)

With the rapid pace of technology EM can be expected to continually improve, limited by the need to keep EM-based monitoring cost effective. Key development areas in the near future include:

- EM System – Improvements to make the system more reliable, incorporate more fisheries monitoring functions (other sensors, electronic logbooks etc.), establish linkages with VMS and other communication systems, and value-add with monitoring data of use to the fishing vessel. Technology developments will also result in higher quality imagery.
- Analytical Software – Processing of raw EM data will not likely be automated in the near future and further improvements to software tools are needed to increase data processing efficiencies and improve data outputs.

REFERENCES

Ames, R. T., and B. M. Leaman, K. L. Ames. 2007. Evaluation of Video Technology for Monitoring Of Multispecies Longline Catches. North American Journal of Fisheries Management. 27:955-964.

Ames, R. T. 2005. The Efficacy Of Electronic Monitoring Systems: A Case Study on the Applicability of Videotechnology for Longline Fisheries Management. International Pacific Halibut Commission. Seattle, WA, USA. Scientific report no. 80. 64 p.

Ames, R. T., G. H. Williams, and S. M. Fitzgerald. 2005. Using Digital Monitoring Systems in Fisheries: Application for Monitoring Compliance of Seabird Avoidance Devices and Seabird Mortality in Pacific Halibut Longline Fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-152, 93 p. Available at: www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-152.pdf.

Bonney, J., and K. McGauley. 2008. Testing the Use of Electronic Monitoring to Quantify At-sea Halibut Discards in the Central Gulf of Alaska Rockfish Fishery EFP 07-02 Final Report. Alaska Groundfish Data Bank. Kodiak, Alaska, USA. 50 p.

Crysell, S. 2002. Baffling Birds Brings Benefits. Seafood NZ 10(10).

Cusick, J., J. LaFarge, and G. Parkes. 2003. NMFS Small Boats Workshop. March 18-20, 2003. Seattle, Washington. Unpublished Report Prepared by the Northwest Fisheries Science Center, NMFS, Seattle, CA, USA. 24 p.

Koolman, J., B. Mose, R. D. Stanley, and D. Trager. 2007. Developing an Integrated Commercial Groundfish Strategy for British Columbia: Insights Gained About Participatory Management. Proceedings of the Lowell Wakefield Symposium on Biology, Assessment, and Management of Pacific Rockfishes. Alaska Sea Grant. University of Alaska, Fairbanks, AK, USA. p 353-364

*McElderry, H and B. Turris. 2008. Evaluation of Monitoring and Reporting Needs for Groundfish Sectors in New England. Unpublished Report Prepared for the Gulf of Maine Research Institute, Portland, ME, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 64 p.

McElderry, H., M. J. Pria, D. McCullough, and D. Morry. 2008a. Using Electronic Monitoring Technology to Assess Protected Species Interactions with the 2007 California Drift Gillnet Fishery: Phase II Pilot Study. Unpublished Report Prepared for the Southwest Fisheries Science Center, NMFS, La Jolla, CA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 25 p.

McElderry, H., R. Reidy, and D. F. Pahti. 2008b. A Pilot Study to Evaluate the Use of Electronic Monitoring on a Bering Sea Groundfish Factory Trawler. International Pacific Halibut Commission. Seattle, WA, USA. Technical Report No. 51. 32 p.

McElderry, H., J. Schrader, and S. Anderson. 2008c (In Press). Electronic Monitoring to Assess Protected Species Interactions in New Zealand Longline Fisheries: A Pilot Study. New Zealand Aquatic Environment and Biodiversity Report No. xx. xxp.

*McElderry, H. 2007. Draft Report for the Feasibility of Electronic Monitoring in the New England Small Mesh Midwater Trawl Fishery. Draft Report Prepared for the Cape Cod Commercial Hook Fisherman's Association (CCCHFA), Chatham, MA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 18 p.

McElderry, H., D. McCullough, J. Schrader, and J. Illingworth. 2007a. Pilot Study to Test the Effectiveness of Electronic Monitoring in Canterbury Fisheries. New Zealand Department of Conservation Research & Development Series 264. 27 p.

McElderry, H., J. Schrader, M. Dyas, R. Reidy, S. Oh, and K. Astle. 2007b. Using Electronic Monitoring Technology to Assess Protected Species Interactions with the 2006 California Drift Gillnet Fishery: A Pilot Study. Unpublished Report Prepared for the Southwest Fisheries Science Center, NMFS, La Jolla, CA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 32 p.

*McElderry, H., M. Dyas, R. Reidy, and D. Pahti, 2007c. Electronic Monitoring of the Cape Cod Gillnet and Longline Fisheries – A Pilot Study. Unpublished Report Prepared for the Cape Cod Commercial Hook Fisherman's Association (CCCHFA), Chatham, MA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 54 p.

McElderry, H., J. Schrader, G. Stubblefield, R. Rombs, and M. Dyas. 2006. Electronic Monitoring for the 2006 U.S Shore-based Pacific Hake Fishery – A Pilot Study. Unpublished Report Prepared for the Northwest Fisheries Science Center, NMFS, Seattle, WA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 45 p.

*McElderry, H., 2005a. Report for Electronic Monitoring in the Antarctic Longline Fishery. Archipelago Marine Research Ltd. Unpublished Report Prepared for the Australia Fisheries Management Authority, Canberra, ACT, Australia by Archipelago Marine Research Ltd., Victoria, BC, Canada 16 p.

*McElderry, H. 2005b. Report for Electronic Monitoring in the Area A (Tasmanian) Small Pelagic Fishery. Unpublished Report Prepared for the Australia Fisheries Management Authority, Canberra, ACT, Australia by Archipelago Marine Research Ltd., Victoria, BC, Canada. 11 p.

McElderry, H., A. Crumpacker, R. Wright, and D. McCullough. 2005a. Electronic Monitoring for the 2005 U.S. Shore-based Pacific Hake Fishery – A Pilot Study. Unpublished Report Prepared for the Northwest Fisheries Science Center, NMFS, Seattle, WA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 50 p.

McElderry, H., R. Reidy, J. Illingworth, and M. Buckley. 2005b. Electronic Monitoring for the Kodiak Rockfish Fishery – A Pilot Study. Unpublished Report Prepared for the Pacific States Marine Fisheries Commission, Portland, OR, USA by Archipelago Marine Research Ltd., Victoria BC Canada, and Digital Observer Inc., Kodiak, Alaska, USA. 43 p.

*McElderry, H., R. Reidy, D. McCullough, and B. Stanley. 2005c. Electronic Monitoring Trial in the Gillnet Hook and Trap Fishery. Unpublished Report Prepared for the Australian Fisheries Management Authority, Canberra, ACT, Australia by Archipelago Marine Research Ltd., Victoria, BC, Canada. 12 p.

*McElderry, H., J. Illingworth, D. McCullough, and J. Schrader. 2004a. Electronic Monitoring of the Cape Cod Haddock Fishery in the United States – A Pilot Study. Unpublished Report Prepared for the Cape Cod Commercial Hook Fishermen's Association (CCCHFA), Chatham, MA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 37 p.

McElderry, H., J. Schrader, and D. McCullough. 2004b. Electronic Monitoring for the U.S Shore-based Pacific Hake Fishery – A Pilot Study. Unpublished Report Prepared for the Northwest Fisheries Science Center, NMFS, Seattle, WA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 35 p.

*McElderry, H., J. Schrader, D. McCullough, and J. Illingworth. 2004c. A Pilot Test of Electronic Monitoring for Interactions Between Seabirds and Trawl Warps in the New Zealand Hoki Fishery. Unpublished Report Prepared for the Hoki Fishery Management Company Ltd., Nelson, New Zealand by Archipelago Marine Research Ltd., Victoria, BC, Canada. 35 p.

McElderry, H., J. Schrader, D. McCullough, J. Illingworth, S. Fitzgerald, and S. Davis. 2003a. Electronic Monitoring Of Seabird Interactions With Trawl Third-Wire Cables On Trawl Vessels – A Pilot Study. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-ASFC-147, 39 p. Available at: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-147.pdf

McElderry, H., J. Schrader; and J. Illingworth. 2003b. The Efficacy of Video-Based Monitoring for the Halibut Fishery. Fisheries and Oceans Canada, Research Document 2003/042. 79 p. Available at: http://www.dfo-po.gc.ca/CSAS/Csas/English /Research_Years/2003/2003_042_E.htm

*McElderry, H. 2002. Electronic Monitoring for Salmon Seine Fishing a Pilot Study. Unpublished Report Prepared for Fisheries and Oceans Canada, Vancouver, BC, Canada by Archipelago Marine Research Ltd., Victoria, BC, Canada. 21 p.

McElderry, H., D. McCullough, J. Illingworth, and J. Schrader. 2002. Electronic Monitoring for the Shoreside Hake Fishing – A Pilot Study. Northwest Fisheries Science Center, NMFS, Seattle, WA, USA by Archipelago Marine Research Ltd., Victoria, BC, Canada. 23 p.

MRAG. 2004. Fisheries Monitoring Technologies. A Project Report Submitted to the North Pacific Management Council by MRAG Americas, Inc. Tampa, Florida. In: Appendix I to the EA/RIR/IRFA for BSAI Amendment 86/GOA Amendment 76: Extension or Modification of the Program for Observer Procurement and Deployment in the North Pacific, public review draft, May 12, 2006. The entire EA/RIR/IRFA is provided at: http://www.fakr.noaa.gov/npfmc/current_issues/observer/OPO606.pdf.

*Riley, J., and S. Stebbins. 2003. 2003 Area H IQ Demonstration Fishery: Project Summary and Evaluation. Unpublished Report Prepared for the Gulf Troller's Association – Area H by Archipelago Marine Research Ltd., Victoria, BC, Canada. 68 p.

Scherr, J. 2004. Area A Crab Fishery 2004 Year End Report. Unpublished Report Prepared for the Area A Crab Association and Fisheries and Oceans Canada by Archipelago Marine Research Ltd., Prince Rupert, BC, Canada. 16 p.

APPENDIX I - EM TECHNICAL SPECIFICATIONS

Overview of the EM System

The EM systems operate on the ship's power to record imagery and sensor data during each fishing trip. The software can be set to automatically activate image recording based on preset indicators (e.g. hydraulic or winch threshold levels, geographic location, time of day,). The EM system automatically restarts and resumes program functions following power interruption, or if a software lockup is detected. The system components are described in the following sections.

Control Box

The heart of the electronic monitoring system is a metal tamper-resistant control box (approx. 15x10x8" = 0.7 cubic feet) that houses computer circuitry and data storage devices. The control box receives inputs from several sensors and up to four CCTV cameras. The control box is generally mounted in the vessel cabin and powered from the vessel electrical system. The user interface provides live images of camera views as well as other information such as sensor data and EM system operational status. The interface has been designed to enable vessel personnel to monitor system performance. If the system is not functioning properly, technicians can usually troubleshoot the problem based on information presented in the screen display.

EM systems use high capacity video hard drives for storage of video imagery and sensor data. The locked drive tray is removable for ease in replacement. Depending upon the number of cameras, data recording rates, image compression, etc., data storage can range from a few weeks to several months. For example, using the standard recording rate of 5 frames per second, data storage requirements are 60-100 megabytes per hour, depending upon the image compression method. Using a four-camera set up and 500-gigabyte hard drive, the EM system would provide continuous recording for 52-86 days.

Figure A1. EM control box and user interface installations on two different vessels.

EM Power Requirements

An EM control box should be continuously powered (24hr/day) while the vessel is at sea. The EM system can use either AC or DC electrical power however DC is recommended. In the case of AC power, the control box is generally fitted with a UPS, to ensure continuous power supply. The recommended circuit capacity for an EM system is 400 watts if using 110-volts AC, or 20 amps with 12-volts DC. The EM system amperage requirements vary from about 6 amps (at 12-volts DC) when all cameras are active, to less than 3 amps without cameras (sensors only), and about 20 milliamps during the 'sleep cycle'. EM system continuously monitors the DC supply voltage and can be set to initiate a sleep cycle to save power when the vessel is idle and the engine is off, and shut off completely when vessel power drops below critical levels. During the sleep cycle the EM system box will turn on for 2 minutes every 30 minutes to check status and record sensor data. The EM system will resume functions when the engine re-starts.

CCTV Cameras

Waterproof armored dome cameras are generally used (Figure A2), as they have been proven reliable in extreme environmental conditions on long-term deployments on fishing vessels. The camera is lightweight, compact and quickly attaches to the vessel's standing structure with a universal stainless steel mount and band straps. In general, three or four cameras are required to cover fish and net handling activity and areas around the vessel. In some cases it is necessary to install a brace or davit structure in order to position cameras in the desired locations.

Color cameras with 480 TV lines of resolution and low light capability (1.0 lux @ F2.0) are generally used. A choice of lenses is available to achieve the desired field of view and image resolution. The cameras have an electronic iris that adjusts automatically to reduce the effects of glare or low light levels on image quality. The output signal is composite video (NTSC) delivered by coaxial cable to the control box and converted to a digital image (480 x 640 pixel resolution). Electrical power (12 volt DC) is carried to the camera on conductors packaged in a single sheath with the coaxial cable.

Figure A2 CCTV camera installations on three different fishing vessels. Each camera has a mounting bracket and stainless steel mounting straps.

Figure A3 Installation showing a swing arm camera mount.

GPS Receiver

Each EM system carries an independent GPS, integrated receiver and antenna and wired directly to the control box (there is no attached display interface). The GPS receiver is fixed to mount on top of the wheelhouse away from other vessel electronics (Figure A4).

The GPS receiver is a 12 channel parallel receiver, meaning it can track up to 12 GPS satellites at once while using 4 satellites that have the best spatial geometry to develop the highest quality positional fix. The factory stated error for this GPS is less than 15 metres (Root Mean Square). This means that if the receiver is placed on a point with precisely known coordinates, a geodetic survey monument for example, 95% of its positional fixes will fall inside a circle of 15 metres radius centered on that point.

The GPS time code delivered with the positional data is accurate to within 2 seconds of the Universal Time Code (UTC = GMT). The EM control box software uses the GPS time to chronologically stamp data records and to update and correct the real time clock on the data-logging computer.

When 12 volts DC is applied the GPS delivers a digital data stream to the control box that provides an accurate time base as well as vessel position, speed, heading and positional error. Speed is recorded in nautical miles per hour (knots) to one decimal place and heading to the nearest degree.

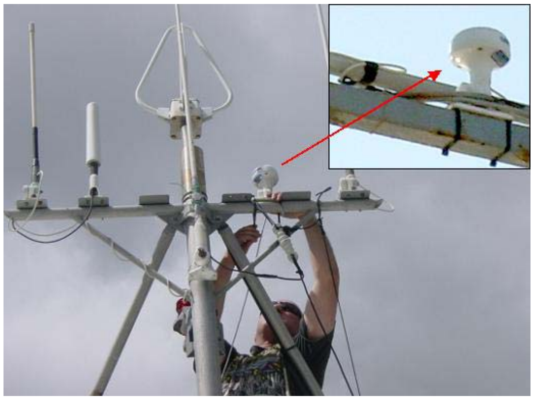

Figure A4. GPS receiver installed in the rigging of a vessel and a close up photograph of the mounted GPS.

Hydraulic Pressure Transducer

An electronic pressure transducer is generally mounted into the vessel hydraulic system (Figure A5) to monitor the use of fishing gear (e.g., winches, line haulers, etc.). The sensor has a 0 to 2500 psi range, high enough for most small vessel systems, and a 15,000 psi burst rating. The sensor is fitted into a ¼ inch pipe thread gauge port or tee fitting on the pressure side of the hauler circuit. An increase in system pressure signals the start of fishing operations such as longline retrieval. When pressure readings exceed a threshold that is established during system tests at dockside, the control box software turns the digital video recorder on to initiate video data collection.

Drum Rotation Sensor

A photoelectric drum rotation sensor is generally mounted on either the warp winch or net drum to detect activity as vessels often deploy gear from these devices without hydraulics. The small waterproof sensor is aimed at a prismatic reflector mounted to the winch drum to record winch activity and act as a secondary video trigger. (Figure A5).

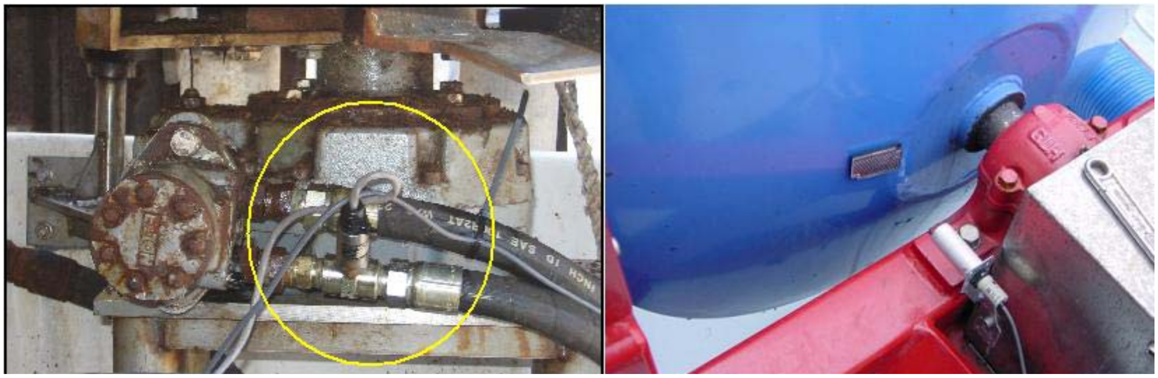

Figure A5. A hydraulic pressure sensor installed on the supply line of a vessel line hauler (left). Drum rotation sensor (right) mounted on pelagic longline vessel, showing optical sensor and reflective surface.

Radio Frequency Identification (RFID)

RFID is used in applications to monitor specific fishing gear (Figure A6). The fishing gear is marked with passive RFID tags carrying a unique serial number. When passed near the onboard tag reader the tag number is detected and recorded as part of the EM sensor data. The RFID tag scanner is custom manufactured to endure the fish work deck environment.

Figure A6. RFID chip inserted in crab buoy (left), and operation of scanning the buoy upon trap hauling (right).

Net Pinger Hydrophone

The net pingers transmit a 10 kHz 300 millisecond pulse every 4 seconds. A custom hydrophone receives the pinger pulses continuously while the EM system is powered (Figure A7). As a pinger nears the vessel the received ping strength increases. The hydrophone output is a relative ping strength with a full possible range of 1 to 500. The hydrophone output is connected to the control box so the pings detected are logged as part of the sensor data collected.

Figure A7. Hydrophone (inset) and shown mounted on the net cage.