ICES CM 2013/J:11

Pressing rewind: A cause for pause on electronic monitoring in the North Pacific?

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Summary
The National Marine Fisheries Service (NMFS) is exploring electronic monitoring (EM) as a potential alternative to human observers in the North Pacific. Electronic monitoring is considered an important potential tool for fisheries monitoring due to the logistical and economic difficulties of accommodating an observer onboard small catcher vessels. In an effort to better inform future implementation of EM a literature review was conducted on all past EM studies. Of the 59 EM study summaries located, 6 were published in peer review journals with the remaining either presented to the funding organization or published as a technical report. Lead authorship for the majority of studies was affiliated with the EM provider (59%). Most of the studies (63%) were focused on catch composition, which requires catch identification and quantity. In nearly all cases where species composition data was being collected video data quality was found to be inconsistent or missing for at least a portion of the study thus degrading the ability to reliably distinguish species. Addressing these issues will be an important consideration prior to implementation of an EM program in the North Pacific.

Introduction
Following the North Pacific Fishery Management Council's (Council) intent described in their October 2010 final action motion to "restructure" the North Pacific Groundfish Observer Program (NPGOP) the NMFS began conducting EM research to evaluate the technology as a potential option to carrying an observer. Observers collect a wide variety of data to meet diverse management objectives that include the recording of the identity, quantity, and disposition of catch, collecting biological samples, and monitoring for regulatory compliance. Although EM is perceived by many as a cost-effective alternative to at-sea observer programs, there are many challenges that EM must first meet to match the quality and diversity of information collected by human observers. Having a full understanding of the differences in the types of and quality of data collected using EM versus an observer is essential before committing to the use of EM as a replacement for or a supplement to observers and embarking on a large scale EM program. This analysis is intended to provide a general overview of past studies so that future study designs can learn from history rather than simply repeat it.

Materials and Methods
A literature search was conducted for all camera based EM studies that produced a report that was published in a peer review journal, presented to the funding organization, or published as a technical report prior to 2013. Various aspects of each study were categorized (e.g. author affiliation, publication type, study focus or main objective, data sources, data types used for comparison, number and type of species, number of vessels, number of gear sets and number of vessel trips). General comments and quantification of EM performance was also documented as well as catch handling or deck sorting requirements and if biological data such as length or weight was collected.

Results and Discussion
The majority of EM study reports were found in the grey literature; only 6 of the 59 documents were published in peer review journals. Authorship of the reports was largely represented by staff from the

EM provider (59%) or by staff associated with the funding entity (32%). The number of EM publications has been steadily increasing over the last 10 years and studies have now been conducted in numerous fisheries worldwide.

There is a wide range in the number vessels and fishing effort involved in any one study. In many cases, small scale feasibility studies were conducted as a precursor to larger scale studies that included more vessels and sets. All studies reported total fishing effort observed during the study in one or a combination of metrics that included the number of vessels, number of sets, and number of trips. Where reported, the median number of vessels, sets/hauls and trips per study was 4, 190 and 36 respectively. Most EM studies focused on evaluating the efficacy of developing an EM monitoring program that provides catch amounts for quota debiting (Table1). In nearly all studies the EM system incorporated camera(s), GPS, pressure and/or drum rotation sensors with a few studies opting not to include sensors. The number of species evaluated was dependent on study objectives with most authors choosing to evaluate EM data for all species (39%) while others focused on a select group of species (20%) or single species (20%). In studies that focused on compliance aspects (21%), species catch was not evaluated. The results of EM were compared with observer data in 27 studies, self-reported logbook information in 14 studies and a combination of observer and logbook information in 5 studies. Almost one-fifth of studies did not compare EM results with other study results. Nearly half (47%) of all authors enumerated species counts of both retained and discarded catch for species within the scope of their study. Hook-by-hook comparison of species specific catch between EM and observer data was completed in 11 of these studies. Comparison was made at the set/haul or trip level for all other studies that enumerated catch. Approximately 17% of the studies enumerated unspecified catch events and the remaining did not report catch count information.

Table 1. Enumeration of primary study focus.

Study Focus	# of Studies	% of Studies
Quota Monitoring	37	63%
Protected Species	9	15%
Compliance	8	14%
Demonstration	4	7%
Biological Data	1	2%
	59	100%

Nearly all studies (84%) evaluated EM performance in terms of reliability and video quality. EM systems were reported to be reliable although nearly all studies reported some lapse in data collection. All studies found that video quality was largely influenced by environmental conditions, lack of system maintenance. Although discard control points were often mentioned as a potential solution to ensure complete enumeration of discard events only a few studies incorporated discard control points or other devices into their study design.

There have been a sufficiently large number EM studies to illustrate the challenges of collecting data in harsh environments. Yet despite these studies, there have been no significant advances in the implementation of these systems to collect data at sea. Why is this true? One reason is that the very issues that EM suffers from (poor image quality and reliability) are those that have not been resolved. There has been little innovation in camera design, vessel integration of EM systems or video processing techniques over the last 10 years of study. Since system performance and data quality of EM remains largely dependent upon vessel operators and environmental conditions, the data stream cannot be regarded as independent, leading to perception problems that may hinder full-scale implementation of these systems. Improving EM system reliability and an independent flow of data will greatly add to the acceptance of technology to achieve responsible conservation and management of fishery resources.