North Pacific Fishery Management Council's Electronic Monitoring Cooperative Research and Implementation Program

Introduction

The North Pacific Fishery Management Council (Council) has established an intention to integrate electronic monitoring (EM) tools into the Observer Program for the fixed gear small-boat groundfish and halibut fisheries. The Council's intent is to develop EM to collect data to be used in catch estimation for this fleet. The Council has set an interim goal of pre-implementation in the small boat longline fleet in 2016, focusing on vessels that have trouble carrying an observer. This research plan describes multiple research projects targeted for 2015, which will collect information that will help inform pre-implementation decisions and future Council alternatives for integrating electronic monitoring (EM) into the Observer Program.

These research projects were developed and refined through a Council committee, the fixed gear EM Workgroup (EMWG). The EMWG provides a forum for all stakeholders including the commercial fishing industry, agencies, and EM service providers to cooperatively and collaboratively design, test, and develop EM systems that are consistent with Council goals to integrate EM into the Observer Program.

The Cooperative Research Plan includes analytical and field work projects to address the following four elements:

- Deployment of EM Systems
  - Operational testing with standard camera
  - Self-reported data elements
- Research and Development of EM Technologies
  - Assess the feasibility of EM data to estimate catch by weight
    - Pot Gear, IFQ setline, IPHC survey
  - Integration of Sensor Data with e-logbook
- Infrastructure to support EM implementation
  - Application development to support EM data integration into the observer database
- Analyses to support EM implementation decision points

Project Goal

The overall goal of this cooperative research project is to assess the efficacy of EM (in combination with other tools) for catch accounting of retained and discarded catch, and to identify key decision points related to operationalizing and integrating EM systems into the Observer Program for fixed gear vessels in a strategic manner. As an interim step, the Council has endorsed a target date of 2016 for taking the first steps towards operationalizing EM on small fixed gear vessels, especially for the vessels for which accommodating a human observer onboard is problematic. Information from the 2015 research projects will be used to identify procedures to test EM in an operational mode, to estimate catch from a group of vessels in 2016.

Conceptual Approach, and Integration of Research Elements

This goal will be achieved through: 1) field trials testing methods to provide quantifiable image-based data from fisheries, which can be used to support discard estimation in Alaska's fixed gear fleet; and 2) analysis of information from these field trials and past EM research where appropriate. This cooperative research will inform evaluation of multiple EM program design options and consider various EM integration approaches to achieve management needs. The research will: assess the functionality of EM for catch accounting, evaluate the operational costs for implementation of EM technology, identify implementation needs (e.g., people, training, infrastructure), and identify what self-reported data is required from vessel operators for data validation, accountability and catch accounting.

Data and analysis produced on costs, data quality, risks, operational procedures, and vessel compatibility will inform decisions on implementation phases, future investments in technology, and identify the combination of tools that will best meet NMFS, Council, and stakeholder management objectives for catch accounting. These decision points will be analyzed in a regulatory amendment, and the Council's recommendation, and subsequent NMFS rulemaking that will result in integration of EM options into the Observer Program.

Linkage to Council's EM Strategic Plan

In June 2013, the Council adopted a Strategic Plan for Electronic Monitoring/Electronic Reporting in the North Pacific. The document provided a vision for integrating electronic technologies into the North Pacific fisheries-dependent data collection program:

> ***Vision:*** A future where electronic monitoring and reporting technologies are integrated into NMFS North Pacific fisheries-dependent data collection program, where applicable, to ensure that scientists, managers, policy makers, and industry are informed with fishery-dependent information that is relevant to policy priorities, of high quality, available when needed, and obtained in a cost-effective manner.

This cooperative research program has been developed to be responsive both to the Council's EM Strategic Plan, and to Senate language included in the 2014 NMFS appropriations bill, which directed NMFS to work with the small boat fixed gear fleet to implement a program designed to test the functionality of available electronic monitoring systems. The cooperative study addresses the following components of the Council's EM Strategic Plan:

- **Goal II, Objective 1**: Conduct scientific research to advance the science of monitoring and data integration.
    - Strategy C: Evaluate EM technologies in the 2013-14 EM project on volunteer vessels in the <57.5 ft longline and pot vessels.
        - Action: Evaluate species identification issues.
        - Action: Identify data gaps and potential solutions for species weight estimates, biological samples and rare species interactions.
        - Action**:** Assess the efficacy of using technology for capturing information that would quantify discard and provide spatial and temporal distribution of effort.

Analyses of the results from the cooperative study will be used to develop a suite of alternatives for the Council to choose from, to address:

- **Goal III, Objective 1**: Implement EM/ER technology where appropriate and cost effective to improve catch estimation and better inform stock assessments.
    - Strategy A: Implement EM as appropriate based on scientific research from goal II.
        - Action: Select EM approach.
        - Action: Analyze EM approach, impacts, cost, and benefits. Following Council action, the next step will be to initiate Strategic Plan
        - Action: Write implementing regulations,
        - Action: Implementation, roll out, outreach.

- **Goal I, Objective 3**: Continue to develop the regulatory framework to implement EM/ER requirements.
    - Strategy A: Develop requirements to use EM for catch estimation.
        - Action: Identify agency/industry responsibilities
        - Action: Identify performance-based standards for regulations.
        - Action: Assign and prioritize staff for regulation development.
        - Action: Develop vessel monitoring

Integration of EM fieldwork with the Council process and the Observer Program

The focus of this cooperative research effort is to identify and resolve implementation issues associated with integrating EM into the North Pacific Groundfish and Halibut Observer Program. These implementation issues will then be evaluated in a Council analysis, leading to a regulatory amendment to allow the use of EM to be integrated with the Observer Program. The regulations will specify technical requirements for EM, after which the Council and NMFS may use the Annual Deployment Plan process to deploy EM and/ or human observers to the groundfish and halibut fleets. The Council and NMFS are not able to use the observer fee, currently collected from vessels participating in the partial coverage category of the observer program, to support EM until the regulatory process is complete.

EM development is expected to be an ongoing process, with a sustained Council commitment to building EM capacity. EM integration may be implemented in phases upon recommendation by the Council, as results warrant, with ongoing refinement of EM technology, field services, and data review elements, as circumstances warrant. The timeline described below is subject to change.

Year	Fieldwork / Pre-implementation (Pre-Imp)	Council process, Regulations	Observer Program/ Annual Deployment Plan (ADP)
2014	*Fieldwork*	EMWG developing purpose & need, alternatives, 2015 Cooperative Research Plan (CRP)	October – 2015 ADP places 10 vessels that are participating in EM research into the no selection pool
2015	Jan-Feb – stereo camera field research on pot vessel (RFP)		
	Feb – SSC reviews CRP	Feb – SSC reviews CRP	
	Mar-Apr – stereo camera field research on longline (RFP and NPRB) Mar-Sep – operational research	EMWG evaluates field data	
	(other fieldwork too)	October – present a refined 2016 Pre-Imp concept to Council	October – 2016 ADP proposes all EM Pre-Imp vessels in no selection pool
2016 (Pre-imp 1)	Pre-implementation will likely focus on longline vessels <57.5'. Size of fleet will be dependent on available funding *(independently sourced)* and Council requirements.		
	Fieldwork as necessary/ possible for other elements (e.g., pot vessels, >57.5') *(requires independent funding)*	October – initial review for EM analysis. Focus on what type of EM program should go forward, and what regulatory changes are needed to allow it	October – 2017 ADP proposes all EM Pre-Imp vessels in no selection pool
		December – final action on EM analysis	
2017 (Pre-Imp 2)	Pre-Imp 2, potentially expanded to include other fixed gear vessels *(requires independent funding)*	Develop regs for integrating EM	June – 2016 Observer Annual Report provides preliminary analysis to support how to allocate observer fee between observer and EM deployment
			October – 2018 ADP allocates funding between observers and EM deployment
2018	**Integrated observer/EM monitoring program**		

Council decision junctures:

- **February 2015** – SSC review and Council approval of the utility of each of the 2015 Cooperative Research Plan to inform decisions points related to 2016 pre-implementation.
- **October 2015** – Council approves proposal for 2016 pre-implementation year. Involves approving design of 2016 program, and allowing an exemption from human observer coverage for those vessels that are participating.
    - Scale of pre-implementation will largely be determined by funding and number of boats that are life raft or bunk space limited. Both factors remain to be determined, but the scale is anticipated to be considerably larger than the 14 vessels participating in 2015 research.
    - In considering the scope of pre-imp, the Council will also need to weigh the higher risk that monitoring data from pre-imp may not be usable in catch accounting system in 2016, as kinks of integration are worked out.

  - While the constraints of the 2016 pre-imp program will be reconsidered in the final analysis, significant changes in the pre-implementation design could potentially delay implementation.
- **October/December 2016** – Council decides on regulations to integrate EM into the monitoring plan, including decision points about how the EM option will look
- **October 2017**, and subsequent years – Council decides how to allocate the available observer fee funding between human observer days and EM deployment

Overview of cooperative research projects

The various research projects that have been initiated by the EM Workgroup to inform Council decision points for moving forward to pre-implementation and eventual implementation are summarized in the tables that follow. Detailed study designs for the 2015 field research projects are provided in the appendices. For projects shaded in orange, at least some component of that project is critical for the Council's discussion, in October 2015, of the design of the 2016 pre-implementation EM program.

Project	Deployment	R&D	Infrastructure	Analysis	Description	Key Outcomes
Deployment projects						
Operational testing fieldwork *(study design in Appendix B)*	x				Results from the spring 2014 field season and written products (described above) will be used to determine research priorities for the 2015 season. It is expected that the field program will continue to evaluate program operational infrastructure in key ports, continue to socialize EM technology with the fleet, and test some aspects of the strawman monitoring options. This work will be a collaborative effort involving service providers, the fishing industry, NMFS and PSMFC.	Field testing: The key elements of this program include decision points, operational plans, field work, EM data sets, dockside monitoring data, and a technical report, jointly prepared by PSMFC and service providers.
Vessel Obligations	x			x	Each strawman monitoring option will carry specific vessel obligations in order to ensure the data collection objectives are met. This work task provides a comprehensive description of vessel requirements for each option, including duty of care responsibilities, on board catch handling requirements, ancillary data collection and other reporting obligations.	Discussion document summarizing the vessel requirements for each monitoring option; feasibility evaluation for each fishery/fleet; analysis of strengths and weaknesses of each approach.
Monitoring Program Deployment Design	x			x	The use of EM technology for fisheries monitoring requires support services to ensure technology is deployed correctly, operator responsibilities are met, and on-board data sets collected and evaluated against dockside information in a timely manner. This task outlines key elements of an operational EM program, tailored to the Alaska fixed gear fishery.	Discussion document outlining the key elements of the monitoring program and relative cost contribution. The report will present different strategies for equipment deployment and examine the impact of the number of service ports.
Dockside Monitoring Program Design	x			x	Some of the monitoring options require dockside monitoring to obtain an independent estimate of landed catch by species. This task summarizes the information requirements, monitoring procedures, and other program elements for a dockside monitoring program.	Discussion document of key elements and decision points of a dockside monitoring program, information needs, monitoring procedures and cost elements.

Project	Deployment	R&D	Infrastructure	Analysis	Description	Key Outcomes
Strawman Monitoring Options	x			x	There are a series of 'strawman' monitoring options that can be used to address the different alternatives. A 'strawman' is a methods summary of the key elements of each monitoring option and describes how EM technology integrates with other tools to meet management needs. Key elements include vessel size criteria, data requirements for catch estimation, vessel operator responsibilities, EM system operating specifications, EM data collection specifications, analysis requirements, and integration with other tools. The strawman links the data requirements with the specific way EM technology and other tools are being used.	Discussion document to provide a summary of monitoring approach and decision points for an EM configuration that meets the Council's goal for estimating catch; analysis of each approach in terms of overall suitability, the level of difficulty, decision points, strengths and weaknesses and operational feasibility by fishery/fleet.
Self-Reported data elements	x				Discussion of what self-reported (fishery dependent) data elements need to be collected to support EM catch, the timelines and accuracy of these data.	Outline of self-reported data fields & how those compare to current IPHC and NMFS logbook data elements; the timelines and accuracy needs of these data for EM.
Data review protocol	x	x			Identify which data elements should be extracted from the imagery obtained under the various field studies, and the review processes that should be followed.	Continue to refine the video data review protocol procedure document
Seabird Handling	x			x	1) the handling procedures that will be required for seabird interactions when operating EM, and 2) if any permits will be required of EM vessels	Recommendations for handling procedures for 2015 fieldwork
Research and Development projects						
Standard configuration fieldwork *(study design in Appx C, D)*		x			The research is intended to provide field-tested methods that allow collection of quantifiable image-based data from fisheries that can be used to estimate species-specific catch and at-sea discard amounts. Specifically, we will evaluate the applicability of EM technologies in a standard configuration at the rail to collect catch, effort, and species composition data.	A research document that will describe results of testing: differences in count and species composition data between EM (single and stereo cameras) in a standard configuration at the rail and an at-sea biologist; ability to derive length from stereo camera.
Chute camera fieldwork *(study design in Appx C, D)*		x	x		Image quality from EM systems are often influenced by environmental conditions and system maintenance reducing our ability to distinguish species, an essential part of estimation. A camera chute system provides a way to collected high definition images constantly thus has the potential to derive lengths and improve reliability of species identification.	Research document that describes hypothesis testing to be completed: differences in count, length, and species composition data between a stereo camera in a chute and an at-sea biologist; ability to derive length; potential for automation of species identification.
Stereo camera fieldwork *(study design in Appx C, D)*		x			A stereo camera system provides a way to accurately derive lengths from which weight could be inferred. This is a requirement since catch estimation is designed to produce discard estimates of weight by species.	Research document that describes hypothesis testing to be completed: differences in count, length, and species composition data between a stereo camera in a chute and an at-sea biologist; ability to derive length; potential for automation of species identification.

Project	Deployment	R&D	Infrastructure	Analysis	Description	Key Outcomes
Halibut discard mortality rate (DMR) fieldwork		x			Fieldwork to investigate the relationship between release methods and discard mortality rates. IPHC interested in pursuing this for fixed gear as well as trawl vessels.	Research study that will allow IPHC to assign discard mortality rates based on a release method, rather than based on injury codes.
Incorporate e-logbook into EM system		x	x		Application development and testing of e logbook that could be used to collect self-reported data elements for EM and capture sensor data. Sensor data has great potential for automated identification of set and haul positions in setline fisheries.	Identify QC procedures and automation methods for improving data accuracy and fishermen friendly attributes that could into e-logbooks (e.g. could sensor data automate entry of set and haul positions in elogbook).
Infrastructure projects						
Programmer			x		NMFS will hire an application developer to support EM data integration that includes development of GUI interface to enable post-processing video and image data into the observer database that feeds into catch accounting. The infrastructure support and work is a necessary component regardless of the type of EM system it will support.	The meta-data derived from sensor information and e-logbook/self-reported data will provide the link to sample data information both temporally and spatially.
Evaluations that will be used in the analysis						
Alternatives				x	Refine the 'purpose and need' and alternatives document to be analyzed for a Council amendment package, and how the elements of the strawmen mesh with the amd analysis.	Discussion draft of 'purpose and need' and alternatives
Fishery Demographics				x	Summarize the fishery demographics - number of vessels, gear used, landing ports, target fishery. Also, summary of effort (trips, length, hauls per day, length of sets), vessel configurations (side/stern haul, shelter deck or open).	Summary paper that describes demographics of the fixed gear fleet in terms of effort, retained and discarded catch by catch area and/or port.
Catch Composition *(In Appx A)*				x	Summarize the catch composition and disposition in each fixed gear target fishery (halibut, sablefish, Pacific cod), and which species are discarded; also which species need inseason data.	Tables describing the catch composition
Catch Estimation *(Initial discussion in Appx A)*				x	List potential catch estimation procedures for EM data for a presumed strata (alternative).	Discussion paper that describes the tradeoffs and assumptions of various catch estimation procedures for expanding catch to the fishery level.
Weight *(Initial discussion in Appx A)*				x	There are a number of potential methods to derive weight for piece counts. Each of these methods will have an accompanying list of assumptions and data collections that will be evaluated.	Summary paper that describes potential ways to derive weight estimates for piece counts.
Video Review Tradeoffs				x	Analysis of how much video review is needed	Summary paper describing the tradeoffs of reviewing video for all fish, or only discards; subsampling; etc.
Cost Framework *(Initial discussion in Appx E)*				x	How will costs be analyzed with respect to EM decision points, what is the framework that will be used in the analysis? What are major cost centers in the program, and how does that affect design or decisionmaking?	Discussion paper framing the range of costs that might be associated with different decisions in the suite of alternatives, and how fieldwork or other methods will be employed to inform those costs.

Overview of parallel EM projects

There are several other EM research projects underway in Alaska, which are not strictly part of this cooperative research plan, but whose results may influence the Council's eventual EM implementation discussion. A summary of these projects is provided below.

NFWF project – Transitioning EM from Pilot to Integrated Component of Management

Organization:	Alaska Longline Fishermen's Association
Award Amount:	$ 135,000.00
Matching Contribution:	$ 38,000.00
Grant Period:	6/30/2014 - 6/30/2016

The goal of this project is to construct a structured, transparent process with extensive stakeholder collaboration to transition electronic monitoring (EM) from pilot program to an operational and integrated component of the North Pacific Research Plan/Groundfish Observer Program (NPRP) for Alaska's fixed gear fisheries. As originally proposed, the project had four objectives. The first was to support and coordinate stakeholder participation in the Council's EM workgroup meetings. The need for "all hands at the table" has been documented as critical to the success of developing EM programs in numerous forums including, the National EM workgroup meeting in January 2014, and most recently in a paper published on development of the Canadian EM program[1]. The second objective was to develop local capacities needed to support EM integration. This objective was intended to build EM support capacity through the training of local port coordinators to install and service EM systems. Requested budget reductions by NFWF forced a significant reduction in this objective. The third objective was to develop a process for timely data review and feedback to the fleet. Quality control methods and timely feedback to the vessels have been identified as critical lessons learned from past pilot programs. The ability to achieve this objective is directly tied to developing local EM field support capacities. Both of objectives 2 and 3 are now largely dependent on outside cooperative research funds to support. The final objective was to actively communicate EM pre-implementation results to stakeholders and fishery managers. This is ongoing and part of the stakeholder coordination and outreach activities.

NFWF project – GPS data loggers as a low cost alternative to Vessel Monitoring Systems

Organization:	Alaska Longline Fishermen's Association
Award amount:	$ 110,000.00
Matching Contribution:	$ 181,500.00
Grant Period:	5/01/2013 - 4/30/2015

This two stage field-trial is intended to evaluate and document the use of GPS data loggers and sensors as a low cost alternative to VMS in Alaska's catch share halibut and sablefish fisheries. The first stage of the project tested GPS data loggers on three halibut and sablefish vessels in Southeast Alaska for an average of 18 sea days/vessel. The data loggers deployed represented various technologies including archival GPS data loggers, multiple sensor input data loggers, and cellular transmitting GPS data loggers. Cost and reliability were documented as well as the ability to detect fishing events based on various polling rates, speed filters, and hydraulic sensors. Stage 2 testing focused on reliability over longer deployments. Five vessels were equipped with GPS data loggers for deployments ranging between one and five months. Data from Stage 2 is being evaluated and a final report will be prepared documenting lessons learned in early 2015. In addition to evaluating data loggers as a potential VMS replacement, the work done on

[1] Stanley, R.D., Karim, T., Koolman, J., and McElderry, H. Design and implementation of electronic monitoring in the British Columbia groundfish hook and line fishery: a retrospective view of the ingredients of success—ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu212.

detecting fishing events based on polling rates, speed filters, and hydraulic sensors may be informative to related work on e-logs and "EM lite".

NFWF project – Testing EM on Small Fixed-Gear Cod Boats

Organization:	North Pacific Fisheries Association, working with Saltwater Inc.
Award amount:	$ 127,400.00
Matching Contributions:	$ 120,000.00
Grant Period:	10/01/2013 – 12/31/14, extended through 3/31/2015 with NMFS funding

The project goal is to assess whether EM could capture data on pot cod boats that would allow for an accurate record of effort, and counts and identification of catch and bycatch in a cost effective way. Saltwater is working closely with active pot cod fishers to adapt an EM system to their vessels and fishing operations. Industry volunteers have helped to define camera placement, appropriate sensor options, power supply considerations, use of RFID reader, and are commenting throughout the project on the EM system and the experience of having it onboard. Through December 31, 2014 Saltwater installed EM systems on 6 pot cod boats of different sizes (49' to 82') in three ports – Kodiak, Homer, and Adak. Work is continuing with three vessels in the first quarter of 2015.

Saltwater developed data review protocols and conducted data review to evaluate system performance (completeness and quality of image) as well as catch information (fishing effort data, species composition). To date Saltwater Inc. has reviewed EM data from 4 vessels representing 18 trips, 85 sea days, and 4,155 hauls. Initial findings support industry's view that the Pacific cod pot fishery is an ideal fishery to monitor using EM. Over 97% of the fish catch items were able to be enumerated and identified to the species level.

Saltwater Inc. and NPFA are looking for money to continue the pot cod research with the industry volunteers from July 2015 – July 2016, focusing on a) capturing weights and b) making the data collection and review process more efficient through the use of RFID. They have submitted a NFWF pre-proposal to collect weights by: a) creating a visual reference on the sorting table that would facilitate estimates of lengths from video imagery, and b) using piece counts and average weights to estimate total bycatch weight.

NMFS project – Pre-Implementation of EM/ER in the North Pacific

Organization:	NMFS
Award amount:	$ 375,505.00
Funding Period:	11/01/2015 – 12/31/16

This project proposes to develop automatic detection, sizing, and classification of fish targets from stereo-video imagery of fish passing on a conveyor belt or sliding on a chute. The project involves controlling image acquisition, developing and applying computer algorithms for image processing, and providing user interfaces and suitable data outputs for operation of software by fisheries biologists. Tasks can be accomplished by applying and modifying classification algorithms developed in computer vision industry, with improvements and adjustments for the specific challenges of fish imagery. This project also proposes to integrate EM data collection into the Observer database (NORPAC) that could eventually be used in catch estimation.

NMFS project – Image Data Collection

Organization:	NMFS
Award amount:	$ 78,113.00
Funding Period:	3/01/2015 – 2/28/16

This project will provide HD images and size data to support applications development needs for the currently funded FIS project "Automated Image Processing for Fisheries Applications". The image data set will be compared to at-sea sampler information to test the accuracy of EM sizing and automated species identification. We plan to collect a wider range of images during the 2015 Gulf of Alaska Bottom Trawl Survey conducted by the AFSC's RACE Division. The trawl survey vessel allows for interception of many species that would be difficult to collect from the fishery due to the wide coverage area of the survey and difficulty of collecting multiple images of less frequently occurring species in the fishery. GUI application development for human processing images and video will proceed late in 2014 based on standard images collected from volunteer vessels and a single chartered vessel. High definition images from this project will support automation of species identification beginning July, 2015 as images are recovered from the first leg of the trawl survey.

Appendix A: Estimation Requirements

Catch Accounting

Alaska groundfish fishery scientists and managers use the best scientific information available to determine the status of the stocks and to monitor species quotas through catch accounting. Catch accounting refers to the process NMFS uses to estimate the catch of all organisms caught in the process of fishing. Total catch accounting for all managed species is mandated by Magnuson-Stevens Fishery Conservation and Management Act (MSA) and necessary to comply with statutory requirements for Annual Catch Limits (ACLs) and National Standards[2].

Each year, the North Pacific Fishery Management Council (Council) recommends, and the Secretary of Commerce publishes, harvest specifications for the Bering Sea and Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) groundfish fisheries. Harvest specifications[3] establish specific annual limits on the harvest of groundfish used to manage the groundfish fisheries. Harvest specifications establish the overfishing level (OFL), acceptable biological catch (ABC), and total allowable catch (TAC) for each species or species group, and prohibited species catch (PSC) limits. The NMFS Alaska Region monitors the catch rate of groundfish and prohibited species according to the allocations and the gear, seasonal, and sector apportionments found in the harvest specifications. Further description of the inseason management process is available at: http://www.alaskafisheries.noaa.gov/sustainablefisheries/inseason/harvestdiscussion.pdf.

Each year, quotas are established in the Alaska Regional Office's Catch Accounting System (CAS) that match the annual harvest specification tables. The CAS uses information from multiple data sources to provide an estimate of total groundfish catch, including at-sea discards, as well and estimates of PSC and other non-groundfish bycatch. The taxonomic levels to which species are managed and identified vary, although primary importance is put on fish species, seabirds, and marine mammals that are federally managed (Table A-1).

Currently, NMFS uses landings data to account for retained catch in catcher vessel fisheries. Discarded organisms, including sea birds incidentally caught, are estimated from at-sea observer data using a step-wise expansion in the CAS (see Cahalan et al., 2014 for more details[4]). Mammal interactions are reported to NMML staff and are estimated independent of the CAS.

In order to accomplish catch estimation and support stock assessments, NMFS currently uses information on:

- species identification, count, and weight of all species discarded from any location on the vessel or from the gear, including drop-offs from the gear;
- fishing effort: set and retrieval dates, times, and location for all sets that occur on the fishing trip, and the number of hooks on each set;
- number, species identifications, and tag recoveries of sea-birds caught or killed by fishing gear;
- number, species identifications, and types of interactions with marine mammals;
- number, species identification, length, photographs, tissue samples, and disposition (dead, released alive, etc) of marine mammals caught in the gear.

[2] http://www.nmfs.noaa.gov/sfa/laws_policies/national_standards/index.html
[3] http://www.alaskafisheries.noaa.gov/sustainablefisheries/specs14_15/
[4] http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-286.pdf

The method for collecting all of this information under an EM program will be accomplished through a combination of EM and some level of observer coverage. However the specifics, such as what data elements be collected from EM, and how much observer coverage will be needed, have not yet been determined. For some data, such as biological specimens, it is obvious that the information will not be collected from EM and therefore this information will continue to be collected by at-sea observers. The collection of other data elements, such as species identification and fishing effort from EM and/or self-reported data, will be evaluated through the 2015 Cooperative Research Plan (CRP). Other methodologies, such as how to derive weight of discarded fish from video images are continuing to be developed so that options can be examined and analyzed as part of the regulatory process.

Species that present catch accounting and management challenges

The GOA hook-and-line gear vessels who are participating in the EM CRP fall into the directed Pacific halibut, sablefish, and Pacific cod fisheries. The species that currently present catch accounting and management challenges in these fisheries include: most rockfish species, sharks, skates, Pacific cod, Pacific halibut, and sablefish (Table A-1).

Estimates of discarded catch of Pacific cod in these fisheries are critical for management because the TAC of Pacific cod is fully allocated by sector. Pacific cod is open for directed fishing during the A (January 1 – June 10) and B (September 1 – December 31) seasons and all sectors have A and B season allocations. Any catch prior to the B season is usually covered by the B season allocation. However, a management concern occurs in the B season when the catch could exceed the sector allocation or even total TAC by all sectors. Therefore, NMFS needs timely data to monitor the total catch (including discard) of Pacific cod to determine if management action is necessary. Usually, the GOA hook-and-line Pacific cod sectors are open until December 31.

Rockfish and skates present a monitoring challenge since many of the species can be difficult to differentiate and they are managed at either the group level (e.g. Demersal Shelf Rockfish) or the species level (e.g. Dusky Rockfish). Therefore, identification of the species is important so that fish can be accounted for in the appropriate grouping. In addition, many rockfish and skates species are of management concern because the hook-and-line fisheries catch most of the TAC of these species and the TAC is set equal to ABC. Also, if catch approaches an OFL then the Regional Administrator may need to close fisheries in areas that catch the most of the species approaching an OFL. Thus, NMFS needs timely data to be able to monitor the discards of these species in-season relative to the TAC to determine if management action is necessary. Rockfish species that present less of a management challenge in these fisheries are: dusky rockfish, northern rockfish, and Pacific ocean perch.

Halibut and sablefish are a concern because the TACs are fully allocated under the IFQ Program. Vessels with IFQ permit holders with available IFQ onboard are required to retain halibut (legal size) and sablefish. The season dates usually change every year for the halibut and sablefish IFQ fisheries, but are usually open around mid-March through November 7. Vessels without IFQ permit holders that have available IFQ onboard are required to discard halibut and sablefish. This also occurs in the Pacific cod fishery. The halibut discarded in the Pacific cod fishery accrues to a halibut PSC limit that if reached closes directed fishing for Pacific cod. The sablefish discard in the Pacific cod fishery accrues to the sablefish TAC. If catch approaches an OFL then the Regional Administrator may need to close fisheries in areas that catch the most of the species approaching an OFL. Thus, NMFS needs timely data to be able to monitor the discards of these species in-season relative to the catch limits to determine if management action is necessary.

Sculpins and sharks present a management challenge because of the high discards of these species by the small boat hook-and-line fisheries and because the TAC is specified GOA-wide. In 2013, sculpins catch was about 33% of the TAC, and sharks catch was about 36% of the TAC. Since most of the sculpins and

shark catch occurs in these hook-and-line fisheries, the ability of EM to collect data on sculpins and sharks and identify the catch to species is also important to inform the stock assessment. Additional documentation on catch reporting needs for stock assessment for the GOA hook-and-line fishery were addressed in a February 2014 Alaska Fisheries Science Center memo, available at http://www.npfmc.org/wp-content/PDFdocuments/conservation_issues/Observer/EM/AFSCmemo214.pdf.

An iterative process is envisioned to refine sampling protocols to meet catch accounting and stock assessment needs in the small-boat hook-and-line fisheries. The results of the research under the CRP will enable evaluation of EM program design options and various EM integration approaches that could be used to achieve management needs, including species identification and timelines for data being available for management.

EM Technical Requirements

The Council's intent is to develop EM to collect data to be used in catch estimation for the fixed gear small-boat groundfish and halibut fisheries. To meet that requirement, NMFS will develop regulations that specify the EM technical requirements and vessel operator responsibilities. So far in Alaska, three regulatory approaches have been used to implement the electronic reporting and EM programs: 1) prescriptive requirements; 2) type approval requirements; and 3) performance standards. The regulations that are currently in place governing the use of EM for compliance monitoring on catcher/processors and motherships have been implemented using a combination of prescriptive requirements along with performance standards.

Current regulations at §679.28[5] outline requirements for EM on catcher/processors. Some of the current regulations are specific to the compliance monitoring role of the current EM regulations and are not applicable to the small-boat fleet. However, many of technical requirements provide a model for how EM regulations would be developed for the smaller vessels. Current regulations include requirements that:

- The EM system must have sufficient data storage capacity to store all video data from an entire trip;
- Each frame of stored video data must record a time/date stamp in Alaska local time (A.l.t.);
- The EM system must include at least one external USB port or other removable storage device approved by NMFS;
- The EM system must output video files to an open source format or the vessel owner must provide software capable of converting the output video file to an open source format or commercial software must be available for converting the output video file to an open source format;
- Color cameras must have at a minimum 470 TV lines of resolution, auto-iris capabilities, and output color video to the recording device with the ability to revert to black and white video output when light levels become too low for color recognition;
- The EM system must record at a speed of no less than 5 unique frames per second at all times when the use of a video monitoring system is required;
- NMFS employees, or any individual authorized by NMFS, must be able to view any video footage from any point in the trip using a 16-bit or better color monitor that can display all cameras simultaneously and must be assisted by crew knowledgeable in the operation of the system;
- Each EM application has a specific regulation that specifies what the cameras must see and when they must be recording. A similar regulation would need to be developed for the hook and line catcher vessel fleet. This requirement is an example of one of the performance standards for the

[5] http://alaskafisheries.noaa.gov/regs/679b28.pdf

current EM systems: The system must record and retain video for all periods when Pacific cod are being sorted and weighed; and Provide sufficient resolution and field of view to monitor all areas where Pacific cod are sorted from the catch, all fish passing over the motion-compensated scale, and all crew actions in these areas.

The details of the regulatory approach and the specific EM technical requirements and vessel operator responsibilities to support catch estimation in the small fixed-gear fleet will be developed and refined throughout the CR project.

Table A-1 List of species, both targeted and incidental catch, in the GOA halibut, sablefish, and Pacific cod fisheries (source: 2013 observer data). Species are listed by management category where: FMP = federally-managed groundfish species under a Fishery Management Plan; IFQ = species managed under an Individual Fishing Quota; PSC = Prohibited Species Catch as identified in the FMP, which are required to be discarded in the groundfish fisheries; non-FMP = species that are caught incidentally and not federally managed; state managed = species that are managed by the state of Alaska.

Species	Management category	Management Resolution (in GOA)	GOA group name	Management timing needs for discard data	Notes on species ID
Arrowtooth Flounder	FMP	Species		Inseason	
Atka Mackerel	FMP	Species		Inseason	
Big Skate	FMP	Species		Inseason - timing critical	Need species ID to distinguish from "skates" group
Dusky Rockfish	FMP	Species		Inseason	
Flathead Sole	FMP	Species		Inseason	
Longnose Skate	FMP	Species		Inseason - timing critical	Need species ID to distinguish from "skates" group
Northern Rockfish	FMP	Species		Inseason	
Pacific Cod	FMP	Species		Inseason - timing critical	
Pacific Ocean Perch	FMP	Species		Inseason	
Pollock	FMP	Species		Inseason	
Rex Sole	FMP	Species		Inseason	
Rougheye/ Blackspotted Rockfish	FMP	Species		Inseason - timing critical	Species ID critical
Shortraker Rockfish	FMP	Species		Inseason	Species ID critical
Arrowtooth/ Kamchatka Flounder	FMP	n/a		Inseason	Currently, in instances where the species is not identified by observer, NMFS uses other observer data to determine species ratios.
Shortraker/Rougheye Rockfish	FMP	n/a		Inseason	Currently, in instances where the species is not identified by observer, NMFS uses other observer data to determine species ratios.
Deepsea Sole	FMP	Group	Deepwater Flatfish	Inseason	
Dover Sole	FMP	Group	Deepwater Flatfish	Inseason	
Greenland Turbot	FMP	Group	Deepwater Flatfish	Inseason	
Kamchatka Flounder	FMP	Group	Deepwater Flatfish	Inseason	
Canary Rockfish	FMP	Group	Demersal Shelf Rockfish	Inseason - timing critical	Species ID critical
China Rockfish	FMP	Group	Demersal Shelf Rockfish	Inseason - timing critical	Species ID critical
Copper Rockfish	FMP	Group	Demersal Shelf Rockfish	Inseason - timing critical	Species ID critical
Rosethorn Rockfish	FMP	Group	Demersal Shelf Rockfish	Inseason - timing critical	Species ID critical
Tiger Rockfish	FMP	Group	Demersal Shelf Rockfish	Inseason - timing critical	Species ID critical
Yelloweye Rockfish	FMP	Group	Demersal Shelf Rockfish	Inseason - timing critical	Species ID critical
Octopus	FMP	Group	Octopus	Inseason	

Species	Management category	Management Resolution (in GOA)	GOA group name	Management timing needs for discard data	Notes on species ID
Harlequin Rockfish	FMP	Group	Other Rockfish	Inseason	Species ID needed to distinguish from DSR
Quillback Rockfish	FMP	Group	Other Rockfish	Inseason	Species ID needed to distinguish from DSR
Red Banded Rockfish	FMP	Group	Other Rockfish	Inseason	Species ID needed to distinguish from DSR
Redstripe Rockfish	FMP	Group	Other Rockfish	Inseason	Species ID needed to distinguish from DSR
Rockfish Unidentified	FMP	Group	Other Rockfish	Inseason	Species ID needed to distinguish from DSR
Silvergray Rockfish	FMP	Group	Other Rockfish	Inseason	Species ID needed to distinguish from DSR
Bigmouth Sculpin	FMP	Group	Sculpins	Inseason	
Darkfin Sculpin	FMP	Group	Sculpins	Inseason	
Great Sculpin	FMP	Group	Sculpins	Inseason	
Irish Lord Unidentified	FMP	Group	Sculpins	Inseason	
Myoxocephalus Sculpin Unidentified	FMP	Group	Sculpins	Inseason	
Plain Sculpin	FMP	Group	Sculpins	Inseason	
Red Irish Lord	FMP	Group	Sculpins	Inseason	
Sculpin Unidentified	FMP	Group	Sculpins	Inseason	
Spinyhead Sculpin	FMP	Group	Sculpins	Inseason	
Warty Sculpin	FMP	Group	Sculpins	Inseason	
Yellow Irish Lord	FMP	Group	Sculpins	Inseason	
Rock Sole	FMP	Group	Shallow water Flatfish	Inseason	
Southern Rock Sole	FMP	Group	Shallow water Flatfish	Inseason	
Starry Flounder	FMP	Group	Shallow water Flatfish	Inseason	
Alaska Plaice	FMP	Group	Shallow water Flatfish	Inseason	
Butter Sole	FMP	Group	Shallow water Flatfish	Inseason	
Flatfish Unidentified	FMP	Group	Shallow water Flatfish	Inseason	
Northern Rock Sole	FMP	Group	Shallow water Flatfish	Inseason	
Yellowfin Sole	FMP	Group	Shallow water Flatfish	Inseason	
Pacific Sleeper Shark	FMP	Group	Sharks	Inseason	Species ID important for stock assessment
Spiny Dogfish Shark	FMP	Group	Sharks	Inseason	Species ID important for stock assessment
Alaska Skate	FMP	Group	Skates	Inseason	
Aleutian Skate	FMP	Group	Skates	Inseason	
Bering Skate	FMP	Group	Skates	Inseason	
Commander Skate	FMP	Group	Skates	Inseason	
Mud Skate	FMP	Group	Skates	Inseason	
Roughtail Skate	FMP	Group	Skates	Inseason	
Skate Unidentified	FMP	Group	Skates	Inseason	
Soft Snout Skate	FMP	Group	Skates	Inseason	
Stiff Snout Skate	FMP	Group	Skates	Inseason	
Whiteblotched Skate	FMP	Group	Skates	Inseason	
Whitebrow Skate	FMP	Group	Skates	Inseason	
Squid Unidentified	FMP	Group	Squids	Inseason	
Longspine Thornyhead Rockfish	FMP	Group	Thornyhead rockfish	Inseason - timing critical	Species ID critical
Shortspine Thornyhead	FMP	Group	Thornyhead rockfish	Inseason - timing critical	Species ID critical
Thornyhead Rockfish Unidentified	FMP	Group	Thornyhead rockfish	Inseason - timing critical	Species ID critical
Sablefish (Blackcod)	FMP, IFQ	Species		Inseason	

Species	Management category	Management Resolution (in GOA)	GOA group name	Management timing needs for discard data	Notes on species ID
Pacific Halibut	IFQ	Species		Inseason - and PSC of halibut critical in groundfish fishery before IFQ season opens	
Bairdi Tanner Crab	PSC	Group	Bairdi Tanner Crab	Inseason	
Blue King Crab	PSC	Species		Inseason	
Brown King Crab	PSC	Species		Inseason	
Chum Salmon	PSC	Species		Inseason	
Coho Salmon	PSC	Species		Inseason	
King Crab Unidentified	PSC	Species		Inseason	Currently, if the species is not identified by observer, NMFS uses other observer data to determine species ratios.
Opilio Tanner Crab	PSC	Species		Inseason	
Red King Crab	PSC	Species		Inseason	
Tanner Crab Unidentified	PSC	Group	Bairdi Tanner Crab	Inseason	
Tanneri Tanner	PSC	Group	Bairdi Tanner Crab	Inseason	
Giant Grenadier	FMP - Ecosystem	Group	Grenadiers	End of year	
Grenadier Unidentified	FMP - Ecosystem	Group	Grenadiers	End of year	
Ascidian - Sea Squirt - Tunicate Unident	non-FMP			End of year	
Barnacles Unidentified	non-FMP			End of year	
Basket Starfish	non-FMP			End of year	
Bering Wolffish	non-FMP			End of year	
Brittle Starfish Unidentified	non-FMP			End of year	
Corals-Bryozoans Unidentified	non-FMP			End of year	
Couesi King Crab	non-FMP			End of year	
Crab Unidentified	non-FMP			End of year	
Crinoids Unidentified	non-FMP			End of year	
Eelpout Unidentified	non-FMP			End of year	
Fish Unidentified	non-FMP			End of year	
Greenling Unidentified	non-FMP			End of year	
Hermit Crab Unidentified	non-FMP			End of year	
Invertebrate Unidentified	non-FMP			End of year	
Jellyfish Unidentified	non-FMP			End of year	
Korean Horsehair Crab	non-FMP			End of year	
Lumpsucker Unidentified	non-FMP			End of year	
Lyre Crab Unidentified	non-FMP			End of year	
Miscellaneous Unidentified	non-FMP			End of year	
Mussels Oysters Scallops Clams	non-FMP			End of year	
Pacific Flatnose	non-FMP			End of year	
Poacher Unidentified	non-FMP			End of year	
Polychaete Unidentified	non-FMP			End of year	
Prowfish	non-FMP			End of year	
Ronquil Unidentified	non-FMP			End of year	
Sea Anemone Unidentified	non-FMP			End of year	
Sea Cucumber Unidentified	non-FMP			End of year	

Species	Management category	Management Resolution (in GOA)	GOA group name	Management timing needs for discard data	Notes on species ID
Sea Onions Unidentified	non-FMP			End of year	
Sea Pen-Sea Whip Unidentified	non-FMP			End of year	
Sea Potato Unidentified	non-FMP			End of year	
Sea Urchins-Sand Dollars Unidentified	non-FMP			End of year	
Skate Egg Case Unidentified	non-FMP			End of year	
Snail Eggs Unidentified	non-FMP			End of year	
Snail Unidentified	non-FMP			End of year	
Snailfish Unidentified	non-FMP			End of year	
Sponge Unidentified	non-FMP			End of year	
Spotted Ratfish	non-FMP			End of year	
Starfish Unidentified	non-FMP			End of year	
Sunstar Starfish	non-FMP			End of year	
Wrymouth Unidentified	non-FMP			End of year	
Bird Unidentified	Protected Species			End of year	
Black-Footed Albatross	Protected Species			End of year	
Glaucus Gull	Protected Species			End of year	
Glaucus-Winged Gull	Protected Species			End of year	
Gull Unidentified	Protected Species			End of year	
Laysan Albatross	Protected Species			Inseason - timing critical	If use EM for bird estimation, need to identify albatross (as group) and collect all albatross
Northern Fulmar	Protected Species			End of year	
Sea Birds Unidentified	Protected Species			End of year	
Shearwater Unidentified	Protected Species			End of year	
Short-Tailed Shearwater	Protected Species			End of year	
Black Rockfish	State-Managed				
Dark Rockfish	State-Managed				
Lingcod	State-Managed				

Appendix B: Operational Testing Plan for Deployment of Standard EM Systems with the Alaska Fixed Gear Fleet

Prepared by: **Howard McElderry**
Archipelago Marine Research Ltd.
525 Head Street
Victoria, BC V9A 5S1 Canada

Telephone: +1 250 383 4535
Email: howardm@archipelago.ca
Internet: www.archipelago.ca

Contents:

1.0 Introduction

The overall goal of integrating EM in the North Pacific Research Program (NPRP) is to improve fishery dependent data collection by providing an alternative on small fixed gear vessels that cannot accommodate an observer without operational disruption or introducing bias, and where EM may be more cost effective thus allowing optimization of resources. The integration of EM data is intended to improve data quality by providing an estimate of catch composition from vessels currently not able to carry an observer, by increasing the portion of the fleet available to provide fisheries dependent data thus reducing non-sampling errors, and by reducing potential bias caused by non-representative fishing behavior on vessels where carrying a human observer is problematic.

The choice of technology for EM integration is an important consideration. EM technology is continuously evolving and improving with different products at various stages of maturation. The technology choice should be with fully developed products (i.e., not prototypes) that follow a structured operational testing process. The technology must first undergo pilot testing to understand the basic performance characteristics, costs, support requirements, and information outputs that could be expected. Secondly, it must undergo operational testing in a 'production environment' on a variety of vessels configurations, without onboard technicians, to better understand the operational needs, program costs

and data quality that could be expected from a fully functional live EM program. Operational testing also includes 'socializing' the technology with vessel personnel to ensure fleet acceptance. Field work in 2015 and pre-implementation work in 2016 is premised on the use of using current EM technologies, often referred to as 'Standard EM Technology' and incorporating newer technologies as the products become mature and complete these developmental steps.

The fixed gear sector has been identified as a priority for EM integration by the Council with specific emphasis on the 40' to 57.5' LOA hook-and-line vessels in the GOA. The initial management objective for vessels carrying EM systems identified by the Council is to estimate discarded catch. Recently, the Council also identified validating deployment of seabird avoidance gear on hook-and-line vessels as an EM management objective.

1.1 Purpose

The purpose of this document is to describe the 2015 Operational Testing Plan for the deployment of standard EM technology. The document is also designed to provide the necessary context to inform how this research will support the Council stated goal of estimating discards from the 40' to 57.5' LOA fixed gear vessels, and target of conducting expanded pre-implementation work in 2016.

The following introductory sections provide background to summarize a number of key considerations that informed the field program. Three appendices are included to provide further details on the onboard methodology, the technology to be deployed, and data specifications. Additional information is also available in EM Working Group discussion documents.

1.2 Key Program Design Considerations

An operational EM program is more than 'putting cameras on boats'. It is the result of a careful design process in order to optimize data needs (quantity, quality, timeliness) against operational impact and cost considerations. This is a business planning approach to consider options, evaluate risks associated with each option, and develop alternatives in order to come up with the most viable options within the planning constraints. A successful program aligns the available funds with the information needs, the fishery characteristics, the technology (hardware and software), program operations (services), and vessel obligations. Regardless of the specific technology choice, the EM program design must take all these elements into account, as well as address how EM information will integrate with other data sources such as observer information, logbooks, and landings information. The following outlines the goals and objectives of a successful EM program design based on the current understanding of Council priorities, identified management needs, target fleet demographics, and stakeholder input on limitations associated with vessel compatibility and operator requirement considerations.

Management Goals

- To enable monitoring on 40' to 57.5' vessels that are difficult to monitor with observers.
- To develop cost effective discard monitoring for the fixed gear fleet.
- To develop an integrated monitoring package (observers and EM) to produce higher quality information for the groundfish and halibut fixed gear fisheries.

Operational Goals

The intent is to develop a cost effective EM program that easily integrates with the existing observer program. It will also have (or continue to have) these characteristics:

- Compatible with vessel operations;
- Scalable to required number of ports;
- Flexible to address changes as the information needs evolve;
- Comprehensive with respect to species, vessels, and gear type used by fixed gear vessels;
- Data should be timely to meet management, operational, and scientific goals;
- Aligned with other existing data activities (data collection, enforcement);
- The program design should be understandable and transparent; and
- The program should provide catch estimates that are accurate enough to meet science, management and enforcement needs.

Operational Objectives

- Total cost of EM program should align with the funding established under the North Pacific Research Program (the EM portion has not yet been specified);
- The new monitoring program should maintain current existing patterns of fleet landing patterns in current ports and vessel fishing patterns in multiple areas; and
- The EM data system must be aligned with observer data, fish landings information, and enforcement needs.

1.3 Fishery Characteristics

Discussion documents provided to the EM working Group included an analysis of the Alaskan fixed gear groundfish fishery using data provided by NMFS for the 2013 fishing year. The analysis was directed at characteristics of the fishery which would influence the design of an EM program. Some of the relevant findings were as follows:

- Collectively, and excluding State landings, the <40' to >57.5' fixed gear fleet comprises nearly 2,000 vessels making nearly 7,300 landings at about 50 ports.
- Among the 40' to 57.5' fleet, landings occur at 33 ports with 50% from three ports, 75% from seven ports and 90% from 19 ports. The top five ports are Homer, Juneau, Sitka, Kodiak and Seattle (72% of landings).
- Among the 40' to 57.5' fleet, the greatest activity is the Southeast (44%), followed by Southcentral (32%), Aleutian (24%) and the Western region (0.5%).
- Halibut target trips represent 52% of total landings, followed by Pacific Cod (25%) and sablefish (23%).
- About 70% of the Pacific Cod landings occur in the first quarter of the year, while halibut and sablefish are distributed more evenly between the months of April and October.
- Half the halibut trips are by <40' sector, followed by 40' to 57.5' (30%) and >58' (20%).
- Nearly 70% of the total fixed gear fleet fished <10 days per year. About 20% fished 11 to 20 days per year, while about 15% fished more than 30 days per year.
- Over 75% of the total fixed gear fleet made 1 to 3 fixed gear trips per year. About 16% make between 4 and 6 trips per year, while about 15% fished more than 30 days per year.

- Species composition varies by fishery. Catch patterns in the halibut, sablefish and Pacific Cod fisheries were similar in showing a very rapid attenuation of catch items with a handful of common species and a very long list of uncommon species. For example, of the nearly 100 catch items recorded in the Pacific Cod fixed gear fishery, just five make up 85% of the catch (in pieces), and three-quarters of the catch items occur at frequencies of less than 0.1% (i.e., less than one in a 1,000 catch pieces).

2.0 EM Deployment Considerations

2.1 Monitoring Options

Monitoring of Alaskan fixed gear vessels can be achieved in various ways and are presented as a series of options each representing different levels of operational complexity and reliance on fisher involvement (Table 1). The options outlined are not to be confused with NEPA analysis alternatives, but help in considering different ways to deploy EM as part of an integrated monitoring plan:

1. Status Quo – At Sea observer.
2. Standalone EM – EM deployed with minimal reliance on crew or other information sources.
3. Enhanced EM – EM deployed with more structured catch handling requirements and effort logs.
4. EM Program with discard measurement – As with #3 but including a graduated measurement board or other system to record length information for all discarded species and drop-offs.
5. EM Program with Logbook Audit – Similar to BC EM program where EM data set is used to verify the accuracy of fishing logs.

Further details on the five monitoring options are available in previous EM Working Group discussion documents.

Table 1 Summary of obligations associated with each monitoring option.

	Monitoring Option				
Monitoring Obligation	**# 1**	**# 2**	**# 3**	**# 4**	**# 5**
At-Sea Observer	X				
Effort logbooks			X	X	X
Catch logbooks					X
Standard duty of care		X	X	X	X
Catch control points		X	X	X	X
Restricted discard location		X	X	X	X
Discard measurement grid				X	

2.2 Preferred Option: Enhanced EM Program

2.2.1 Operational Overview

The Enhanced EM Program (Option 3) was considered the most practical starting point for operational testing of EM with the Alaskan fixed gear fleet. The key elements of additional operator responsibility are as follows:

- A standard EM system (Appendix I) will be installed on the vessel for the monitoring period. The system consists of CCTV cameras (rail and deck views), GPS, gear sensors and a control center. The system will be configured to record data as described in Appendix II.
- Except as specified above, vessel masters are instructed to carry out their fishing trip as per normal commercial operations.
- Vessel operator is responsible for providing uninterrupted electrical power while vessel is underway.
- Vessel operator is responsible for conducting pre-departure functions tests to validate system performance before departing on all trips.
- Vessel operator must provide reasonable maintenance to maintain video image quality while underway.
- Vessel operator must ensure all catch items are handled within control points (i.e., recording by CCTV camera) for identification, enumeration and determination of utilization (i.e., kept or released).
- Vessel operator must follow special handling requirements for certain species to ensure full accounting. For example, there may be a requirement for extended presentation of certain species to the camera or full retention for other species (rockfish) for accounting upon landing.
- Vessel operator will report fishing effort as it saves analysis cost (i.e., no hook counts), has low operational impact on vessels, and self reported data are unlikely to be biased (i.e., there is no reason to misreport).
- Vessel operator or local technician must follow proper procedures for data retrieval.
- Piece counts will be converted to fish weight by 'borrowing' average piece weight information from other sources (observer or survey data). Until such time as individual fish lengths are considered necessary the added review cost for length measurement cannot be justified.

2.2.2 Data Elements

Observer Data:

- This alternative does not require the use of onboard observers for hosting EM. Observer data may be used for purposes such as determination of average piece weights or for providing species ratios within "grouped" species.

EM Data:

- Meta analyses to ensure data set is complete (no hidden bias to the data set) and quality of sensor and image data is acceptable;
- Gear setting date, time, and location;
- Gear hauling date, time, and location;
- Seabird interactions during setting;
- Periodic assessment of effort (hooks, skates, hauls); and
- Visual census of catch in pieces by species (or species groups) and disposition.

Skipper Data (Fishing Logs):

- Total effort (hooks, skates, hauls) recorded in a logbook, corroborated by EM data.

Fish Ticket Data:

- Vessel details;
- Landing date and time;
- Total effort;
- Landed weight by species (includes DSR - rockfish); and
- Halibut length (above sublegal limit).

2.2.3 Key information tactics

Primary Sampling Unit:

- The sampling unit is the fishing event (retrieval operation).

Discard Estimates:

- Species discard weights for a fishing event are estimated by applying the total number of pieces by an average piece weight;
- Fishery level species discards are estimated by expansion of the samples to fleet grouping, area and fishery; and
- Expansions are based on effort (number of hooks set).

Trip Level Catch Estimates (Managed Species)

- Landings data provide the trip (vessel) and fleet level total landed catch; and
- IFQ and ACL data are summed from landings data.

2.3 Landings Monitoring

As mentioned, independent monitoring of landings is not an essential component for this option. We have recommended that it be included as part of the 2015 operational testing plan, but simply to strengthen the veracity of the program by providing an independent assessment of retained catch. For example, difficult to identify rockfish species can be verified during offload process. Landings monitoring also provides for more timely collection of fishing logs and EM data sets. The necessity of landings monitoring as part of an operational EM program requires further consideration.

> **Decision Point**: Should landings monitoring be included as part of the future implemented EM program?

3.0 2015 Operational Testing Plan

3.1 Goals and Objectives

The 2015 Operational Testing Plan will use Standard EM Technology (See Appendix I) on the 40' to 57.5' fixed gear fleet to provide catch monitoring in the halibut, sablefish and Pacific Cod fisheries with a focus on discard estimation. The goals are to establish operational infrastructure in key landing ports, continue to socialize EM with the fleet to build industry awareness of technology-based monitoring, and gather operational and fisheries data in order to better understand how EM can be successfully integrated into the North Pacific Research Program. Unlike pilot studies where the principle focus is to understand the capabilities of the technology under research conditions, this study is designed to carry out an EM program on a limited operational scale in order to better understand data quality under production conditions, as well as to gather important operational information that will better enable planning for a larger program.

The objectives of this study are threefold:

1) **Capacity Building** and **Operational Specifications** - To deploy EM systems in a limited scale operational capacity to implement program protocols in the 2016 pre-implementation year and identify the attributes of an operational EM program compatible the target fleet, and when integrated with the ongoing human observer program, will improve fishery dependent data collection.
2) **Cost Considerations** –To gather and report data on EM program costs to assist future program planning and inform Council decision making.
3) **Data Quality** - To gather data and report on EM data quality to inform Council decision making and regulatory development.

3.2 Testing Plan Overview

The 2015 operational testing plan will develop a field program to optimise the data collection opportunities available from the pool of vessels that have been selected by NMFS for exemption under the observer selection pool and to volunteer to carry an EM system. It is expected that field services will be based in the ports of Sitka, Homer and Kodiak for periods of six months or longer. During this period trained EM technicians will be available to install and service EM systems on volunteer vessels. Vessels carrying EM systems will be requested to follow strict procedures as outlined in their vessel monitoring plans. Upon completion of a fishing trip, the EM data set will be collected from the vessel, along with effort logs and other information. Landings monitoring will also take place on an opportunistic basis for weights of all landed species, and weights and piece counts of rockfish species. All EM data sets, landings data, and effort logs will be forwarded to PSMFC for analysis. In addition, port-based EM data analysis will be established in order to provide timelier program performance information to participating vessels, and potentially improve timeliness of catch estimates for critical species. Upon completion of participation, volunteer vessels will be requested to complete an exit survey in order to gather industry feedback on program participation. Operational data (time and effort by task) will be recorded by both Archipelago and PSMFC. Both Archipelago and PSMFC will contribute to the development of the final report.

3.3 Project Team

This cooperative research project involves a number of participants that provide specific areas of responsibility:

- Archipelago Marine Research Ltd. – Archipelago is a pioneer and global leader in the development and deployment of EM technologies. Archipelago staff will be responsible for coordinating the field research effort, organizing port services, scheduling participating vessels, providing EM equipment, designing onboard monitoring specifications, providing oversight of field operations, and collating operational data.
- Pacific States Marine Fisheries Commission – PSMFC has established an EM data services and will provide independent analysis of EM data sets collected from this project. In addition, PSMFC will compile the EM data quality results in a similar fashion as was carried out for the 2014 field program. PSMFC provided the EM Working Group with a technical report which outlines the EM data analysis methods that will be used in this study.
- National Marine Fisheries Service – NMFS staff will contribute to the field program through participation in the EM Working Group, providing advice on the field program from a fishery management and science perspective, and providing an agency perspective when considering different deployment logistics.
- North Pacific Fishery Management Council Staff – NPFMC will be responsible for reporting the cost information collected in this study. Archipelago and PSMFC will work with an NPMFC economist (Sam Cunningham) to develop the data collection framework. As well, NPFMC staff will assist the project by providing historical fleet activity information such as landings, ports, fleet makeup and vessel activity patterns.
- Alaska Longline Fisheries Association – ALFA and other industry organizations will assist the project by providing linkages with the fleet, providing information on fleet characteristics, providing local knowledge on resources for port services, and providing a fishery perspective when considering different logistical issues.
- Participating Fishing Vessels – A total of 23 fishing vessels have been identified through a NMFS-led selection process as potential participants for the field program. Vessels selected for participation will carry an EM system for commercial fishing trips and will be required to follow specific procedures as specified by the Enhanced EM Monitoring Program, discussed earlier and in Appendix 3.

3.4 Timeline

This work will be carried out in accordance with the following timeline:

- Program Set up (January/February, 2015)
    - Program design completed: January, 2015
    - Program presentation to SSC: February, 2015
    - Port Services Established: February, 2015
    - Vessel Installations Begin: Late February, 2015

- Operations (Late February to July, 2015)
    - Participant Vessels Monitored: (Late February to July, 2015)
    - Landings Monitoring: (Late February to July, 2015)
    - EM Data Analysis: (Late February to July, 2015)
- Program Reporting: (July to December 2015)

3.5 Objective 1

3.5.1 Capacity Building

Working within the limits of the research budget, we plan to establish operational capacity on a limited scale in the 2015 fishing season. This component of the project establishes a limited scale operational program, sets the stage for other project objectives and includes the following:

- Regionally based EM technical expertise – We plan to establish resident EM technical expertise in the ports of Sitka, Homer, and Kodiak during the study period. These technicians will install, remove and service EM systems. They will collect EM data sets from vessels and provide landings monitoring for trips where there was full retention of rockfish. We plan to trial locally based EM data review to determine if this could be used to reduce data turn around for critical information. EM technicians will also work closely with participating vessels, providing technical support and delivering program feedback.
- Deployment of EM Systems - As mentioned, a total of 23 fishing vessels have been identified, of which there are 10 vessels that participated in the 2014 field study as well as an additional 13 vessels that are available for selection, if necessary. The potential participating vessels are listed by home port in Table 2 below.

Table 2 Number of vessels by port that have agreed to participate in the EM Cooperative Research Program.

Port	2014 Participants	Other Volunteers	Total Available
Sitka	5	3	8
Homer	5	3	8
Kodiak		3	3
Petersburg		2	2
Ketchikan		1	1
Haines		1	1

Vessel Attributes

An important element of the field program will be to deploy EM systems on a variety of vessel configurations in order to better understand strengths and weaknesses of EM in this situations, and operational specifications that should be considered. The following attributes will guide vessel selection and be documented from the participating vessels:

- Vessel Configuration – There are a wide variety of configurations including overall layout (forward and aft wheel house), shelter (covered and open decks), and hauling location (side and stern)

- Gear – There are three basic types of gear deployed – fixed (hooks are fixed to ground line), snap gear (hooks attached to ground line with a clip) and autoline (ground line deployed from automated setting machinery).
- Deck Gear – Fixed gear vessels use different deployment and setting gear including a drum, a sheave, both drum and sheave, and autoline gear.
- Camera Locations – CCTV cameras usually must be mounted outboard of the hauling station to capture catch as it comes out of the water and over the rail. Many vessels have outrigger stabilizer poles that are well suited for mounting cameras. Vessels without this will require a custom camera mounting device such as an extension pole or davit.
- EM Installation Configuration – Differences between vessels also influence the layout of the EM system in terms of the location of the control center and sensors, wire runs, power source, and other issues.
- Fishing Characteristics - There are a variety of different conditions in which vessels fish including time of day (day/night) and weather conditions such as cloud cover, precipitation, and wind and sea conditions.

The study will provide for testing of EM across a range of vessel attributes. This diversity will be limited by the characteristics of the participating vessels but the aim is to better understand installation requirements and system settings for different attributes. Also important in this learning process will be the exposure of EM configuration issues to vessel personnel and gathering their input and ideas toward problem solving.

Estimated Data Volume

Without further information on vessel fishing plans, it is not possible to predict the number of trips and hauls that will be available for sampling by this project. In Table 3 below we provide an estimate of sample size, based on normal fishery activity patterns. The estimated volume of activity will be sufficient to achieve operational scale (i.e., to test the operational program elements) and provide sufficient sample size for the data quality goals of the project.

Table 3 Estimated data collection (trips and hauls) by port based on proposed deployment.

Port	Sitka	Homer	Kodiak	Total
Port-Months	6	6	6	18
EM Systems	5	5	3	13
Vessels	8	8	3	18
Total Trips	30	30	18	78
Total Hauls	240	240	144	624

Field Methods

Program Development

Prior to the start of the operational EM program, a number of organizational activities are required. They include the following:

- Program Design – Determining the best use of program resources given the characteristics of participating vessels, vessel fishing schedules, and ports of operation. This information will be complied to plan a field operations schedule.
- Establish EM Technicians in Ports – This involves the identification of personnel, providing training and issuing resource materials.
- Equipment Organization – EM systems, spare parts and other field equipment must be assembled and shipped to service ports.
- Vessel Information Package – An information package will be assembled outlining the 2015 field program and areas of required participation, vessel monitoring plans, EM system installation and operational requirements.

Port Services

- Installation of EM Equipment
    - Outreach to vessels to verify installation requirements in advance
    - Scheduling
    - EM system installation
    - Training on EM system operation
- Program Coordination
    - Monitor status of deployed EM systems
    - Track shipment of Hard drives
    - Monitor data quality from completed data sets
    - Collate program time and activity data
- EM System Service Events
    - EM System 'Burn-in' Test Period – Thorough review of EM system after the first few trips to ensure EM performance.
    - Scheduled Vessel Service Events - Routine service events will occur at the end of each trip or approximately biweekly basis to collect EM data, assess the data collection performance of the EM system, and gather feedback from vessel personnel on their experience carrying an EM system.
    - End of season events – Service visit to remove EM system, collect data and conduct an exit survey with vessel skipper.
    - On-call Vessel Service Events – On call to address technical issues identified by the skipper.
- Dockside Monitoring – Dockside monitoring will take place in order to enable a comparison of EM reviewer identifications, specifically rockfish species identification, with those from the landings. Dockside monitoring involves the collection of piece counts and weights by species for all rockfish landed. Dockside monitoring will only occur during the following conditions are met:
    - Confirmation of full retention of rockfish for the entire fishing trip.
    - Verification that the EM data set is complete.

3.5.2 Operational Specifications

Based on the operational capacity established in the first part, this component is intended to document what is learned from placement of EM systems on the diversity of vessels, outlining best practices and including an analysis of operational problems and potential solutions. The focus will be toward the field aspects of the project and is aimed at defining optimal conditions for fishery sampling using EM technology. This work will concentrate on two areas:

1. Operational Specifications of deployed EM Systems
    - Define the recommended installation specifications for EM systems for fixed gear vessels, taking into consideration different vessel configurations.
    - Evaluate the suitability of EM for the fixed gear fleet with particular reference to vessel size, and layouts that may not be conducive to EM.
    - Document experiences with the vessel 'burn in' period in order to better evaluate the utility of EM installations on vessel making just a few trips a year.
    - Document the operational requirements and equipment needs to monitor the use of seabird mitigation devices (e.g., streamer lines).
    - Develop an individual vessel score card that can be used to easily characterize vessel cooperation with EM program requirements. This includes metrics such as:
        - Compliance with duty of care requirements (constant power, cleaning cameras and other system care),
        - Compliance with catch handling protocols such as handling catch within control points,
        - Ensuring lighting and other conditions for high quality image recording,
        - Completion of effort logs, and
        - Meeting program operational requirements such as meeting communications needs for EM service events.
2. Service Port Requirements
    - Determine the operational requirements associated with different fleet monitoring activity levels.
    - Determine the operational requirements of landings monitoring in terms of work requirements.

3.6 Objective 2 - Cost Considerations

The field program will report information to assist in estimating the cost of deploying standard EM systems in Alaska fixed gear fisheries. The cost analysis will be led by the NPFMC economist, Sam Cunningham, who will provide guidance in defining the operational information to feed this analysis. It is envisioned that the project will report labor requirements for different operational activities in time. Cost information will be reported for non labor items such as EM equipment, shipping, travel, etc. In cases where we seek to describe the operational impacts of a program element or elements, the evaluation will consist of direct impacts to operations, impacts to data quality, as well as indirect impacts or lost opportunity. It is expected that the analysis will concentrate on the following areas:

Field Services:

- EM system installation and removal;
- Routine servicing of EM systems on vessels;
- Costs and operational impacts of various data retrieval methods (e.g., EM technician versus skipper mail-in);
- Dockside monitoring; and
- Regionalized EM data analysis.

Data Services:

- Data review per data set for quality analysis;
- Data review per set requirements, comparing a review for all information (hook counts, retained and discard enumeration), versus catch accounting (retained and discard only) and discard accounting (only discarded enumeration);
- Data review per trip for deck camera to validate full retention and discard control point;
- Data review per set requirements for including release method with the EM review;
- Data review for seabird monitoring objectives;
- Costs and operational impacts of different data collection schedules (by trip versus monthly);
- Compare the costs and operational impacts of different data turnaround schedules (i.e., < 1 week versus monthly reporting); and
- Compare the cost and operational impact of centralized versus locally based data analysis services;

Participating Vessels:

- Identify the operational impacts, costs and 'hidden costs' associated with vessel responsibilities in carrying an EM system.

3.7 Objective 3 - Data Quality Considerations

It will be important to document the level of success from the data collection effort under operational conditions across a variety of vessel platforms to better define operational performance. Using methodology developed by PSMFC during the 2014 field trials, PSMFC will provide an independent assessment from EM data sets collected in this study. The following are the principle areas of data quality focus:

1. Using the methods outlined in the 2014 PSMFC report, provide a quality assessment of the total data collection effort including:
    - Provide a complete summary of the EM sampling effort by numbers of vessels, trips and hauls sampled.
    - Identify instances where there was incomplete data and identify, if possible, the cause of the missing data.
    - Characterize the quality of EM data sets in terms of sensor performance and image quality.

2. Evaluate the potential of EM imagery to provide species identifications.
    - Provide EM reviewer results of species identifications to better characterize EM based species resolutions.
    - Conduct a limited series of duplicate EM data set reviews in order to measure the repeatability of EM analysis.
    - Assess species ID across different video quality in order to establish program performance benchmarks. The purpose of this is to establish the threshold performance requirements of EM imagery for producing usable catch data. The benchmarks could also be used for a vessel scorecard to establish baseline performance requirements for participation in the EM program.
    - Compare EM reviewer results with landings monitor data in order to better characterize EM based species identifications of rockfish.

3. Provide an assessment of vessel compliance with vessel monitoring plan requirements with particular emphasis on the duty of care and onboard catch handling requirements.

Data Review Methods

EM data sets will be shipped directly to PSMFC on the removable hard drives for review. This process will follow a defined protocol to ensure timeliness of delivery, and confidentiality of data. Each data set will undergo a procedure for assessing data quality and system performance on the vessel. The information will be shared with the field services portion of the program to ensure that any performance or data quality issues are addressed on a timely basis. Data analysis staff will record time by task to answer the research questions outlined above, however, there will not be any specified timeline for data review turnaround as there would in an operational program.

PSMFC identified five levels of information identified from the EM data set review:

1) Metadata
    a. ADFG permit #
    b. Date drive retrieved
    c. Field assessment notes (Saltwater/Archipelago notes when drive was picked up)
    d. Logbook: Y/N
2) Initial review to answer the following:
    a. Is sensor data complete? Y/N
    b. Is imagery/video complete? Y/N
    c. Was there dockside monitoring? Y/N
3) Trip data
    a. Port code
    b. Date/time/location start of trip
    c. Date/time/location end of trip
4) Haul data
    a. Date/time/location start of haul
    b. Date/time/location end of haul
    c. Imagery quality:
        i. Useful or
        ii. Something else

5) Complete video review: If useful haul data (4c) and complete video & sensor (2a) and there was dockside monitoring (3b) then review capturing the following data:
    a. Time to review
    b. All fish species IDs to lowest level
    c. All fish counts
    d. All fish disposition (discarded at rail; retained at rail)
    e. All other species
        i. Birds, inverts, mammals
    f. Hook counts (including empty hooks)
    g. Skate/segment counts
    h. For halibut:
        i. Injury key/Release condition
        ii. Release method

Appendix I EM System Specifications

The term "Standard EM Technology" encompasses the spectrum of EM equipment with varying features and capabilities. This study uses mature EM products developed by Archipelago Marine Research Ltd. that are currently used in an operational (or pre-implementation) capacity on similarly configured fixed gear vessels in the US, Canada, Australia, and a few northern European countries. Recognizing there are differences between different EM products, this section outlines what are considered to be the minimum features and functional requirements for EM with the Alaska fixed gear fishery.

An EM system typically consists of a control center to manage the data collection and an array of peripheral sensor components that include: CCTV cameras, GPS receiver, gear sensors and a communications transceiver (Figure 1). The EM system should be a comprehensive data collection platform, designed to record large volumes of sensor and image data, operating autonomously for long periods of time. A typical EM system deployment is shown in Figure 2.

Figure 1 An electronic monitoring system

Control Center and User Interface

The control center should record data reliably and securely, monitoring the status of sensors to trigger image recording from CCTV cameras. Based on previous research within this fishery, the EM system must be able to connect to at least four CCTV cameras. In addition, data must be easy to collect, and suitable for suitable for storage of several weeks of video and sensor data.

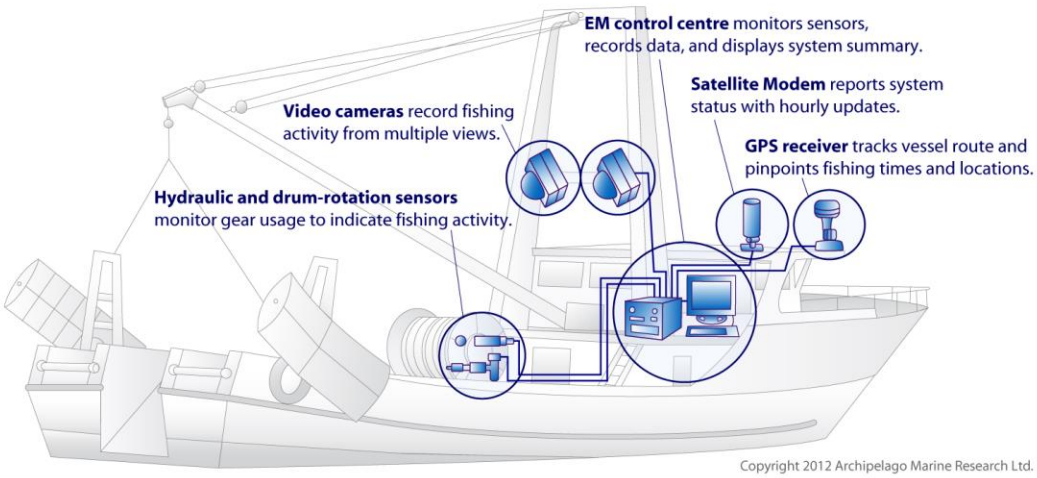


Figure 2 Example of a typical EM monitoring system depicting key components

The EM system should provide a display and user interface for the vessel master where operators can easily monitor the status and performance of each system component (Figure 3).

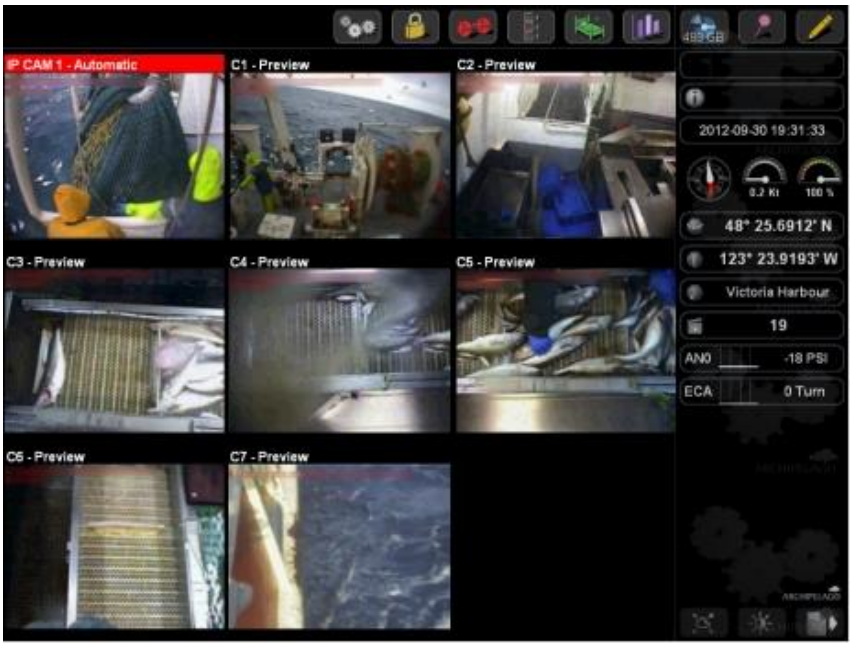


Figure 3 The Archipelago EM system user interface showing camera views, sensor activity and status.

Power Management

Stable power is a challenge on many fishing vessels, and essential to ongoing data collection at sea. To ensure consistent data collection, EM systems should be equipped with the following features:

- Operable across a wide voltage range using both DC (11-32v) and AC (90-240v) power to suite the variety of vessel power arrangements in the fishery.

- To go into a 'sleep mode' to reduce drain on vessel battery systems during periods when the main vessel .engine is off (e.g. night).
- File corruption protection if power interruptions occur during data collection.
- Ability to prevent data loss during 'brown outs' and short power loss through the use of an internal or external UPS, and a controlled shut down with extended power loss, and automatically resuming function when the power resumes.

EM System Data

The EM system should be able to consolidate data inputs from multiple sensors and cameras inputs into an integrated data stream. The EM system should be configurable to start and stop image data recoding using a variety of event triggers such as GPS location, vessel speed, winch or hydraulic system activity, and time. The system should also allow for configurable video collection settings (triggers, frame rate, resolution) for individual cameras as to achieve specific data collection goals (e.g. recording only during hauling vs. always record).

The suggested data specifications have been provided in Appendix II.

Security

The control center should be tamper resistant, and have at least the following features:

- Password protection to limit access to system configuration settings,
- Secure storage of the hard drive using a locking attachment to prevent unauthorized removal,
- All system shut downs recorded in data logs,

To ensure high quality data collection, EM system should compile information including results from:

- Self tests run at the start of the trip by the fisher,
- Data integrity reports run by the technician or fisher at the end of a trip,
- Custom system settings, and
- Comments entered by the fisher during the trip.

Other requirements

In addition to the requirements above, the EM system should have the following capabilities:

- Encrypting technology is a key feature that enables fishermen to deliver EM hard drives, and satisfies NMFS chain of custody requirements. All data recorded by the EM system should be encrypted using advanced encryption standards, and ensure that encrypted data can only be unencrypted authorized data reviewers.
- System self-test to be used by the skipper before the start of the trip to confirm the system is fully operational.
- Safe and reliable hard drive replacements by skippers and assurance that data are intact, and new drive is initialized properly.

Sensors and CCTV Cameras

CCTV Cameras

Cameras used by the EM system should include the following features:

- Waterproof and resistant to the extreme environmental conditions that are encountered on marine fishing vessels (IP66 rating).
- Have multiple installation options for camera placement on the vessel.
- High quality image resolution and frame rates to permit verification of species, fish handling, processing, and discarding,
- Include text overlay for recording information such as vessel name, time, date, and location.

Figure 5 Example of digital video imagery from EM system

Sensors

The following sensors are suggested to fully monitor vessel activity in the fixed gear fleet:

- A dedicated GPS receiver to deliver time, date, latitude, longitude, heading, vessel speed, and positional accuracy to the control center.
- A hydraulic pressure transducer to determine the vessel's fishing status by monitoring the pressure in the vessel's hydraulic systems. The pressure sensor is capable of monitoring the use of fishing gear.
- On a small number of vessels in the fleet a drum rotation sensor can be used to determine the vessel's fishing activity by sensing the rotation winches used for longline, warps, or net drums.
- To enable 'sleep mode' of the system during inactive periods such as night, use of an engine oil pressure sensor or similar indicator should allow the automatic starting/stopping of the control center along with the engine being powered on or off. This feature is essential to preserve vessel battery power during periods of inactivity.

Appendix II EM Data Specifications

We recommend the following minimum specifications for EM system data:

File Formats:

- EM data should be recorded by the EM system in an encrypted format to ensure chain of custody. Once delivered to the agency the EM data files can be unencrypted for analysis.
- All Sensor and Image data should be recorded in an 'open source' format that can be accessed with standard software applications.

Video Image Data:

- Image files shall be recorded in a common video format (e.g., mpg, avi, etc.) and viewable on standard media player applications;
- A minimum image resolution and lens choice to ensure an appropriate field of view;
- CCTV images should contain a 'burned-in' caption showing a distinctive identifier such as vessel name, date, time and location;
- Image files must capture 100% of each catch retrieval event, including a 10 to 30 minute run-on (depending on gear type) after each event;
- Image frame rates shall be not less than 5 frames per second for catch retrieval imagery; and
- Image quality must be sufficient to allow clear resolution of species, or species groupings.

Sensor Data:

- Sensor data should be recorded at a minimum frequency of once every 10 seconds;
- Data format should be to an ASCII, comma delimited file;
- The minimum sensor data format should include the fields in the formats specified below. Items 1-6 are computed by the GPS and delivered in NMEA format.
    1) DATE – fixed width, 6 characters, YYMMDD;
    2) TIME – fixed width, 6 characters, HHMMDD, Pacific Standard Time year round;
    3) LAT – Latitude degrees, fixed width, 2 characters;
    4) LATMIN – Latitude minutes, fixed width 6 characters including decimal point with 3 decimal characters;
    5) LON – Longitude degrees, fixed with 3 characters;
    6) LONMIN – Longitude minutes, fixed width 6 characters including decimal point with 3 decimal characters;
    7) SPD – Speed knots, fixed width 4 characters including decimal point with 1 decimal character;
    8) HDG – Heading degrees, fixed width 3 characters;
    9) SATERR – Estimated horizontal position error (HPE) in metres (radius), fixed width, 3 characters;

10) VIDEO – Video on/off, fixed width, 1 character (0 or 1);

11) EVENT – Operator initiated event marker, fixed width, 1 character (0 or 1);

12) COUNT – Rotation sensor – drum revolutions during sample interval, column width variable;

13) PRES – Hydraulic pressure reading, pounds per square inch (PSI), column width variable.

- An example data ASCII format is shown below:

080602,120041,-07.00,48,26.1305,123,23.7711,1,00.0,277,11.97,005,0,01,0,0

080602,120051,-07.00,48,26.1305,123,23.7711,1,00.0,257,11.95,005,0,00,0,0

080602,120101,-07.00,48,26.1305,123,23.7711,1,00.0,249,11.95,005,0,00,0,0

080602,120111,-07.00,48,26.1305,123,23.7711,1,00.0,252,11.95,005,0,00,0,0

Appendix C: EM Pot Study

Conceptual Research Approach

The purpose of this research is to support Council EM objectives by exploring alternative monitoring methodologies that have the potential to be more cost effective and/or to increase accuracy of the estimates, ultimately providing a viable alternative data-collection methodology. Information collected from this study will be used to inform the final NEPA analysis and development of potential alternatives for deploying EM/ER into the fishery to estimate catch. The goal of this study is to field test and evaluate the efficacy of three electronic monitoring (EM) systems to collect catch data in pot gear fisheries. This study will evaluate the efficacy of a single camera, stereo camera and a camera chute system. The research is intended to provide field-tested methods that allow collection of quantifiable image-based data from fisheries that can be used to estimate species-specific catch and at-sea discard amounts.

We will evaluate the applicability of EM technology to collect catch, effort, and species composition data aboard vessels through use of video and sensor technologies. Catch weights will be based on length approximations from the video record to estimate individual fish weight. At-sea observers will collect pot specific catch information throughout each trip to allow comparison of species composition and species count generated from each EM system to that collected by an at-sea biologist. The hypothesis to be tested is: "There is no significant difference in estimates generated using EM data from estimates generated using at-sea observer data." The study will also provide information to evaluate EM sampling rates and procedures necessary to achieve a specified level of precision while minimizing costs (e.g. deployment rates and/or the amount of video data to be reviewed).

Data gathered during this study will also be used to inform infrastructure improvements, evaluate data integration, and develop video processing applications. The main infrastructure and image processing objective is to develop applications that will provide preprocessing of video data in real time to gain efficiencies in post-processing and reduce costs. This will minimize data storage requirements; shorten the time delay between data collection and when information is available for management. Further, the study will provide valuable information on the compatibility of EM systems with vessels, logistic and operational constraints or opportunities associated with deploying various camera systems on pot gear vessels. Finally, this study will inform development of regulations, performance standards, and vessel operator responsibilities.

Project Implementation

This project is a cooperative effort between NMFS, the fishing industry[6], Pacific States Marine Fisheries Commission (PSMFC), and the North Pacific Fishery Management Council (Council). Study design, goals, and objectives were developed by NMFS and PSMFC staff and will be vetted through the Council's EM work group (EMWG), Science and Statistical Committee (SSC), and the Council at upcoming meetings during 2014 And 2015.

Project responsibilities are shared by NMFS Observer Program staff, PSMFC Staff, EM providers, and vessel operators. Both NMFS and PSMFC staff will work cooperatively to develop the study design and conduct data analyses. PSMFC contracted an EM provider (Archipelago Marine Research) for installation of EM systems and contracted the single vessel (Northern Endurance) that applied through a competitive bid process. The EM provider is responsible for working with the vessels operator to install, troubleshoot and maintain the EM system(s). At-sea biologists will receive training to troubleshoot and

[6] Comprised predominantly but not exclusively of the small hook and line fleet with vessels <58 feet in length

maintain both the chute and stereo camera EM systems. The vessel contracted for the work will be obligated to follow catch handling instructions, help maintain the camera systems and complete e-logbook information on effort, catch, and discard as specified in the charter contract.

Research Goals and Objectives

The main goal of this research is to provide field-tested methods to provide quantifiable image-based data from fisheries that can be used to support discard estimation in the small vessel pot fleet operating in the North Pacific. Testing of multiple EM designs will provide necessary data to evaluate the effectiveness, reliability, and logistical feasibility of each system under commercial fishing conditions using pot gear. This project will inform decisions on future investments in technology and identify appropriate technology that will best meet NMFS and Council management objectives.
There are three primary objectives of this study:

1) Collect pot-specific catch data of fish species using an EM system and an at-sea biologist.
    a. Compare accuracy of species identification and species counts obtained using the EM system with species identification as determined by an at-sea biologist.
2) Estimate catch and bycatch amounts based on data from each of the three data collection methods:
    a. Estimate bycatch and bycatch amounts from video data collected using non-stereo, commercially available, EM system. Because there is no mechanism to collect length or weight with the standard camera system, weight will be "borrowed" from observer data.
    b. Estimate bycatch and bycatch amounts from video data collected using a stereo camera focused on retained catch and a second camera contained within a discard chute. Here weight will be inferred from species specific length information collected by the chute camera and stereo camera.
    c. Estimate bycatch and bycatch amounts from data collected by an at-sea biologist.
3) Evaluate precision of estimates and estimated sample sizes required to achieve a specified precision for each species of interest for each data collection system.

Study Methods

EM system will be deployed onto vessels along with an at-sea biologist (observer) simultaneously to collect side-by-side data for each sampled set. Throughout the study, individual hauls will be identified to ensure that haul-specific data from each data collection system are available. In addition to catch data (species composition and amounts), effort data (set locations and times, amount of gear set) will be collected and used in the estimation Process and other analyses.

Approximately 8 trips targeting Pacific cod with pot gear will include a standard EM system that consists of a non-stereo data collection camera located above the sorting table, wide angle or hemispheric validation (deck view) camera, , camera chute GPS and hydraulic sensors, and an at-sea biologist. We will then phase in additional sensors (RFID) and the stereo and chute camera systems on later trips.

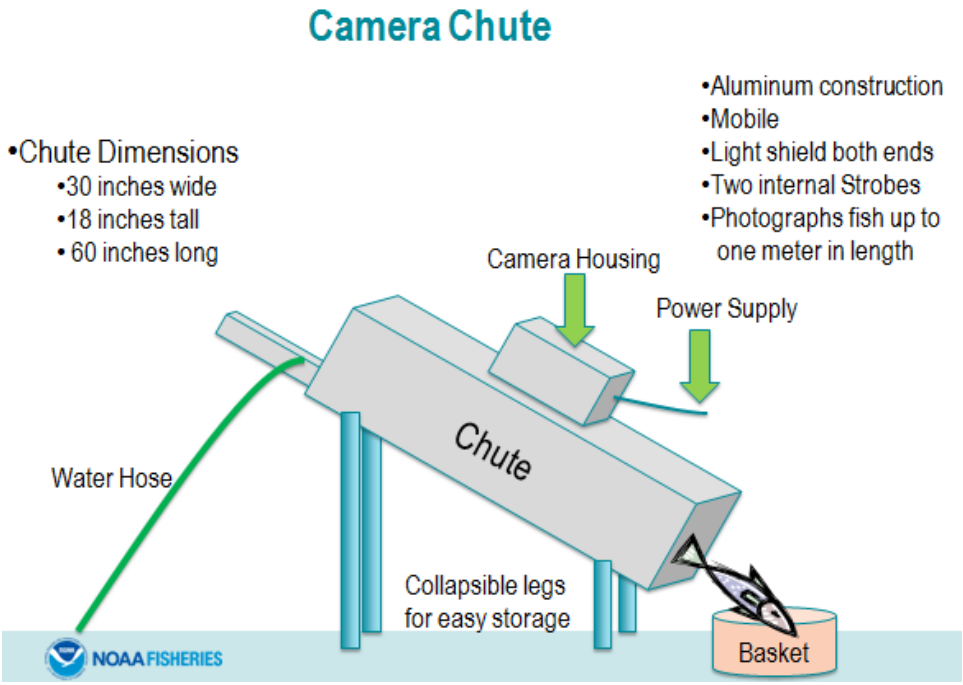
Description of EM systems

There are three major components of all of the EM system that are required to enable collection of scientific data that can be used for catch estimation using an EM system. They are highly interdependent and are major determinants of the success or failure of this system. The components are 1) e-logbook, 2) validation camera(s) system, and 3) scientific data collection camera(s) 4) sensors. The e-logbook data will be required to capture self-reported information on set locations, total effort (e.g. gear set), catch, and catch disposition. These data will be compared with sensor data (validating logbook reports) and Integrated with the video data (and/or images) to provide location of effort for each specified catch event captured by the cameras. In addition, all three EM systems will time stamp images and events to allow the

separate data streams to be matched. The validation camera(s) will determine if specific vessel operators' responsibilities are being followed and to allow monitoring of deck activities to confirm the catch handling protocols are being followed. Validation camera video data will be reviewed to determine if the camera(s) can fully document vessel catch handling and discard events during an entire trip.

The scientific data collection camera systems (non-stereo, stereo and chute) will provide images that will be processed to collect information on species composition, count and length. Scientific data collection cameras will be mounted above the catch sorting table. The chute-camera system will be located within a water-proof camera housing located above a chute (Figure 1). Because camera strobes will be used in this system, the chute will be enclosed that allows passage of the fish while minimizing light leakage. This system will test whether clear, high definition images can be taken reliably in any weather condition, allowing consistent species recognition, automated length measurements, and facilitating on-board processing of image data. The unit is mobile and can be moved between hauls or stored; the system weighs approximately 50 lbs and its location and integration into vessel operations will be determined between NMFS personnel and the vessel operator to maintain safety and operability. This system will require a power connection and potentially a water hose connection to improve specimen flow through the chute and is fully automated to collect images as fish are passed through the chute.

Figure 1 Illustration of camera and chute design that enables imaging as fish are passed through



Both the stereo and chute camera systems borrow many of the features developed for CamTrawl (Williams et al., 2010a; Williams et al., 2010b) that was deployed during AFSC acoustic pollock surveys in 2011 and 2012. A stereo camera is actually two cameras in one housing that create two images that are processed using automated software routines that isolate fish targets, estimate fish length using stereo-correspondence, and track individuals across frames to provide accurate fish counts. Automated species classification algorithms are currently being developed to complete the analysis process. An image library will be created to store all images and meta-data that could be used in future projects to develop a set of key characteristics including color/shape patterns that could potentially be used to automate species or species group identification. Because all images will be time stamped and linked to GPS information,

precise location of species specific catch could enable other analysis such as mapping of high bycatch rate areas, potentially improving future management strategies to lower bycatch.

Each EM system may also include a number of additional components including: 1) a dedicated GPS receiver to collect positional information; 2) a magnetic rotation sensor to trigger recording when the drum is setting or hauling gear; 3) an electronic hydraulic pressure transducer; 4) RFID tags attached to individual pots to record onboard presence of gear, 5) a laptop for system operations and e-logbook data entry. Sensors will provide information on vessel position, confirm when fishing activity is taking place, and trigger video data recording. A computer will run the system from inside the vessel cabin allowing monitoring of system activity and enabling troubleshooting if problems occur. The catcher vessel e-logbook program developed by the NMFS AKR will be installed on the computer or notebook for logging haul-specific catch information on a daily basis. Computer monitors will be provided as a means to monitor all camera functions and evaluate whether lens cleaning is required.

Sampling Design

An at-sea biologist will collect pot-specific catch data for each species for those sets that are randomly chosen to be sampled. For each selected set, data will be collected for a systematic random sample of retrieved pots; these pots will be identified explicitly either in the imagery or using a time-stamp match so that pot-specific data from each data collection method can be used in the analysis. This will allow for comparison of observer and EM catch data collection for each pot on each set (complete enumeration of catch within each sampled pot) and disposition of that catch. Vessels participating in the study will be required to modify their catch handling practices such that all discarded catch will be passed through the chute to allow imaging.

A single set of species and species-group codes and species identification materials will be used by both the EM reviewer and at-sea biologists. We will compare estimates of numbers of fish based on at-sea biologist documentation with similar estimates from the review of electronic monitoring (EM) video recordings.

Since every fish within a pot is documented by an at-sea biologist, the total number of fish of a given species in the pot will be without sampling error (subject to measurement errors only). The camera system is designed to collect images of every fish, but experience has shown that this is typically not the case since image quality is a function of environmental conditions and camera maintenance.
It will be crucial to identify the disposition for each catch item as either being discarded or retained. The validation camera(s) will be used to help determine catch disposition (retained, discarded). Disposition of the discarded portion of the catch will be easily identified because only at-sea discards will be passed through the chute system. Data for the retained portion of catch will be collected from either the non-stereo or stereo camera located above the sorting table as the catch is being transferred to the hold. The GPS position and time code will be used to link the haul camera image and chute camera images to the retained/discarded data recorded by the observer.

At-sea biologist(s) will make sure project protocols for data collection are followed and equipment is operating as designed. The at-sea biologist responsibilities will include: 1) assisting crew to manage and maintain the EM system, 2) recording complete species composition (including identifying and recording all invertebrates and vertebrates), 3) ensuring all discarded catch be passed through the camera chute for imaging unless the catch item is too large for the chute it will be individually sampled for species and length by the at-sea biologist, 4) assisting vessel operator in entering specific catch information into an e-logbook between hauls or at the end of each fishing day, 5) transmitting e-logbook information in each port (may be automated) and 6) ensuring EM cameras are triggered to record the hauling events.

At-sea biologist catch data will be aligned with the video record (using time code and coordinates) so that direct comparisons can be made for each sample of catch within each pot. Discrepancies in the identification and the enumeration of the catch by the at-sea biologists and the video analyst will be investigated to determine the reason for and type of discrepancy. At-sea biologists will record the date and haul time for each set/pot, the set/pot number, and the skate number for all sets. The EM will record precise location and time stamp for each frame either in the first row of pixels or key identifier within the name of the image to allow precise identification of a specific catch event.

Data Analysis

Our study design closely follows that of an earlier electronic monitoring study aboard volunteer vessels from the IFQ fixed gear fleet (Cahalan et al., 2010) noting however that there will be three camera systems being tested: non-stereo camera; and stereo camera and the camera chute. Analytical methods employed in that study provided an effective evaluation of the information and similar methods will be used in this study. Modification of catch estimation methods described in that paper will be used here. A series of three analytical comparisons and associated hypothesis tests will be conducted. These comparisons are designed to fully assess the differences in the catch monitoring data collected using EM and at-sea biologist.

Comparison 1: Comparison of the number of fish per pot set of a given species collected using each EM system (standard camera; stereo rail camera; chute-camera) and collected by an at-sea biologist. This is a comparison of data collected using EM with data collected by an at-sea biologist aimed at assessing the variability between the three data collection methods in the number and species of fish caught by the gear.

> *Hypothesis 1: The difference in the number of fish (of a given species) counted in a single pot between the data collection methods is zero.*

In this analysis, there will be one observation for each comparison and each species (difference in numbers between the each of the three camera systems and the at-sea biologist) for each set. A simple t-test will be used to test the hypothesis of no difference; additional analyses may evaluate the potential effects of camera system, EM reviewer, vessel, environmental conditions, and image quality.

Comparison 2: Comparison of observations of pot-specific species identification made remotely by a video reviewer (based on data collected from camera system) with those made by a biologist stationed on the vessel. This comparison of data collected using each EM system (non-stereo, stereo and camera chute) to that collected by an at-sea biologist will assess the variability in species identification between data collection methods.

> *Hypothesis 2: The probability of pot-specific species identification agreement between EM video reviewers and at-sea biologist is equal to or greater than some predefined constant (e.g., 0.95).*

The proportion of matching species identification for a given pot haul will be estimated as follows. Let:

$X_{i,v}$ = an indicator of matching species identification for fish i in pot v, $X_{i,v}=\{0,1\}$, $i=1, \ldots, n_v$
n_v = number of pots set by haul v
v = index on the haul, $v=1, \ldots. V$.

The estimated proportion of pots with matching observations (for a given species) is given in Eqn. (1) with the empirical variance presented in Eqn. (2)

$$\hat{p}_v = \frac{\sum_{i=1}^{n_v} X_{i,v}}{n_v} \quad (1)$$

$$Var(\hat{p}_v) = \frac{\sum_{i=1}^{n_v} (X_{i,v} - \hat{p}_v)^2}{n_v - 1} \quad (2)$$

Given adequate sample size and using $\hat{p}_v$ as replicate observations, these data will be used to model the potential impacts of covariates including camera system used, EM reviewer, vessel, environmental conditions, and image quality.

Comparison 3: Comparison of the pot-specific species identification from a subsample of all video made by two video reviewers. This is a comparison of data collected by two different EM reviewers aimed at assessing the between reviewer variability in species identification.

> *Hypothesis 3: The probability of pot-specific species identification agreement between two EM video reviewers is equal to or greater than some predefined constant (e.g., 0.95).*

This analysis will be similar to that used in Comparison 2.

Data processing

Data collected by the at-sea biologist will be entered and stored in an AFSC database developed for this study. Hard-drives containing the video data will be sent to PSMFC. Video data will be post-processed and also entered into this database by PSMFC video analysis staff. eLogbook data will be transmitted to the eLandings database and will be accessible to NMFS staff as part of the Interagency Electronic Reporting System. Application development has started and will continue for imagine processing of non-stereo and stereo camera video data. Data analysis will be conducted in R (R Core Team, 2013. URL http://www.R-project.org/).

Appendix D: EM Setline Study

Conceptual Approach

The purpose of this research is to support Council EM objectives by exploring alternative monitoring methodologies that have the potential to be more cost effective and/or to improve discard estimates, ultimately providing a viable alternative data-collection methodology to at-sea observer data. Information collected from this study will be used to inform the final NEPA analysis and development of potential alternatives for deploying EM/ER into the fishery to estimate catch. The goal of this study is to field test and evaluate the efficacy of electronic monitoring (EM) systems to estimate discard in the small vessel North Pacific IFQ fleet. This study will evaluate a new EM design using a stereo rail and a standard camera system on IPHC survey vessels. It will also test these camera systems and in addition to a camera chute system on the single contracted Halibut IFQ vessel. This research is intended to provide field-tested methods that allow collection of quantifiable image-based data from fisheries that can be used to estimate discard.

This research will provide data required to evaluate the applicability of EM technology to collect catch, effort, and species composition data aboard vessels through use of video technologies. Discard estimation will be based on using length approximations from the video record to infer fish weight. At-sea observers will collect hook-by-hook catch information throughout each trip to allow comparison of species composition and discard estimates generated from each EM system. The hypothesis to be tested is: "There is no significant difference in discard estimates generated using EM data from estimates generated using at-sea observer data." Data collected during these two studies will be used to evaluate EM sampling rates through simulations and procedures necessary to achieve a specified level of precision while minimizing costs.

Data gathered during this study will also be used to improve infrastructure, evaluate data integration, and develop video processing applications. The main infrastructure and image processing objective is to develop applications that will provide preprocessing of video data in real time to improve efficiencies in post-processing thereby reducing costs. This will minimize data storage requirements; shorten the time delay between data collection and when information is available for management. The study will also provide valuable information on the compatibility of EM systems with vessels and the logistic and operational constraints or opportunities associated with deploying various camera systems on vessels. Finally, this study will inform development of regulations, performance standards, and vessel operator responsibilities.

Project Implementation

The project is a cooperative effort between NMFS, IPHC, the fishing industry, Pacific States Marine Fisheries Commission (PSMFC), and the North Pacific Fishery Management Council (Council). Study design, goals, and objectives were developed by PSMFC and NMFS staff and vetted through the Council's EM workgroup committee, Observer Advisory Committee (OAC), Science and Statistical Committee (SSC), and the Council at the February 2014 meeting.

Project responsibilities will be shared by NMFS Observer Program staff, IPHC staff, PSMFC Staff, EM providers, and vessel operators. Both NMFS, IPHC and PSMFC staff will work cooperatively to develop the study design and conduct data analyses. PSMFC will contract EM providers for installation of the EM systems. This applies to both the fishing industry vessel and IPHC survey vessels participating in this project defined below.

Industry vessel

PSMFC issued a Request for Proposals (RFP) in July, 2014 to contract vessels to carry EM/ER systems (including a camera chute system and a stereo rail camera) and an at-sea biologist. A single respondent (Northern Endurance) was contracted to conduct this work. PSMFC have also contracted an EM provider (Archipelago Marine Research) who will be responsible for working with the vessel operator to install, troubleshoot and maintain the standard EM system. At-sea biologists will receive training to troubleshoot and maintain the stereo camera EM systems. The contracted vessel will be obligated to follow catch handling instructions, maintain the camera systems and fill out e-logbook information on effort, catch, and discard.

IPHC Grid Survey vessel(s)

Each year, the International Pacific Halibut Commission (IPHC) receive requests from various staff and external organizations to assist in research projects by collecting additional data on the IPHC grid survey vessels. Although the grid surveys are for halibut stock assessment purposes, there can be opportunities to collect additional data. In November 2014, NMFS submitted an IPHC special request project form for placing a stereo rail camera and a standard EM camera system on several IPHC survey vessels in the summer of 2015. In addition, the request proposes adding a third at-sea sampler to the charter vessels with EM. Decisions on the overall grid survey program will occur in January 2015 at the IPHC annual meeting and decisions on the scope of this project will occur in late March or early April. This project is dependent upon finalizing survey vessel contracts and whether vessels have the capacity to carry a third at-sea sampler to collect hook specific catch information.

Overall Project Goals

The main goal of this research is to provide field-tested methods to provide quantifiable image-based data from fisheries with stereo camera based sampling systems. In addition, the goal is to field test if the stereo camera system will enable collection of length compositions for both discarded and retained catch at the rail of longline vessels and to test the camera chute system on an IFQ fishing trip. Individual length verification will be done on the IFQ trips by comparing individual fish length collected by the sampler to the corresponding video image. The stereo camera has been shown to be effective for collecting precise length compositions in a trawl survey application (Williams, et al. 2011). The automated camera chute system has also been shown to collect precise length information during a field test on a factory trawler in 2014 (Wallace, personal communication).

Scope of project

These project will compliment several field projects planned in 2015 including the Councils Cooperative Research Project with the Industry, which deploys EM camera based systems on hook and line vessels fishing out of the ports of Sitka, Petersburg, Homer, and Kodiak. This project will also compliment the 2014-2015 NPRB funded projects to further development and testing of stereo camera based systems in cooperation with the Petersburg Vessel Owners Association member vessels. Lessons learned from this proposed project will be crucial in developing the next generation of stereo cameras systems and applications for fixed gear vessels.

Industry vessel

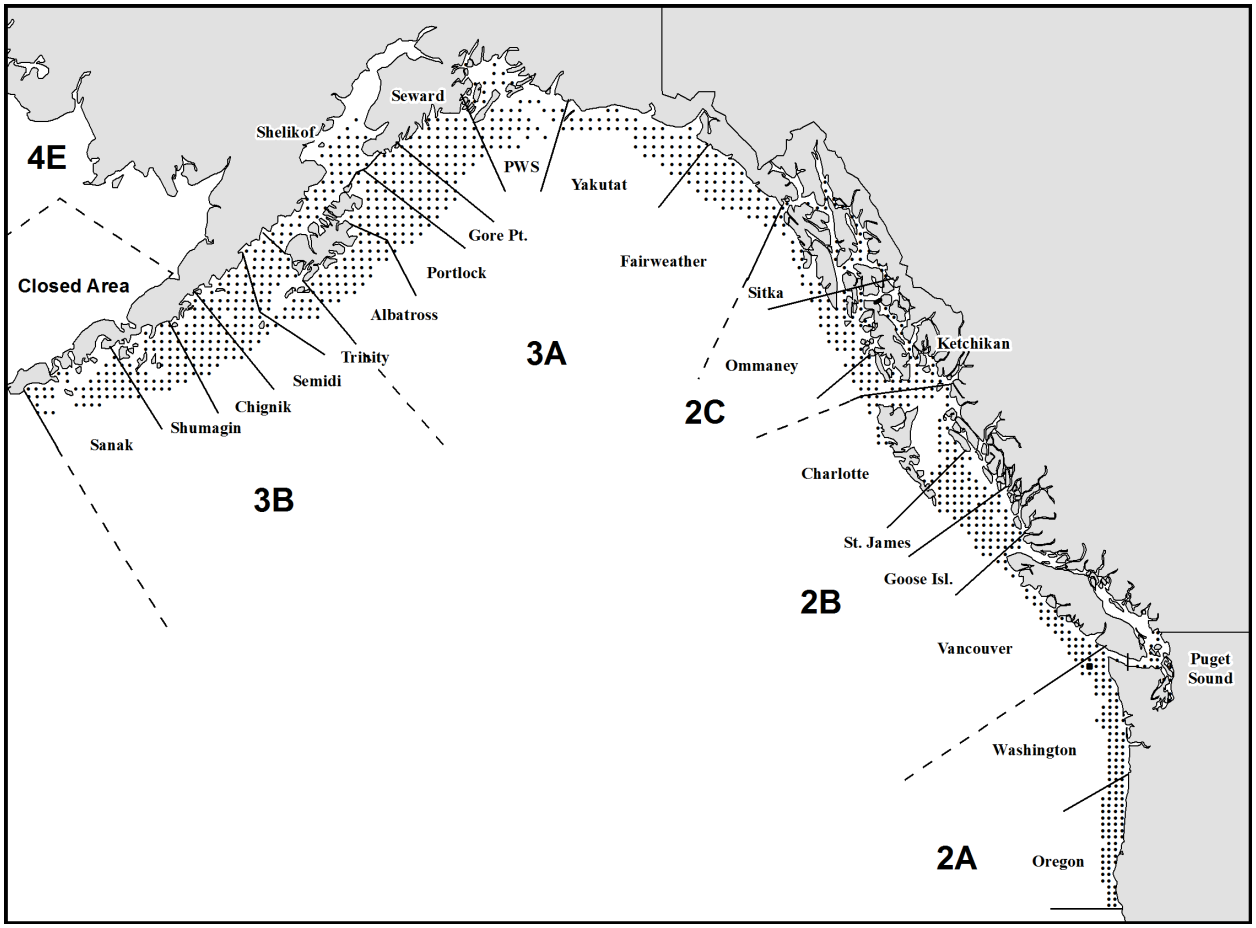
The fishing vessel Northern Endurance will be fishing during the halibut IFQ fishery beginning early March 2015, based out of Kodiak and will end when IFQ Quota has been taken (approximately 8 trips). A single at-sea sampler will be responsible for enumerating catch (each fish on the line: retained and discarded) aboard the Northern Endurance and in addition will collect length data that can be used to match to video records.

IPHC Grid Survey vessel(s)

It is anticipated that the stereo rail camera study will be implemented on 2-3 IPHC survey vessels operating in areas 2A 2B, 2C, 3A or 3B (Figure 1). The number of survey vessels is dependent on space for a third observer. A third sampler will be required in addition to the two standard IPHC samplers to completely enumerate the catch (each fish on the line; retained and discarded). The survey will be conducted between May 25th and August 31st.

These field projects will be completed in 2015 and unlikely to continue in future years.

Figure 1 IPHC Survey Areas



EM system requirements

The EM system must be continuously powered while the vessel is at sea and requires 120v ac power with maximum power consumption 230 watts. An EM provider is responsible to work with the vessel operators to install the standard system and NMFS staff will be present during installation of stereo camera and/or camera chute. All costs associated with installation and removal of system will be covered by NMFS as will be the sampler.

Description of EM system

The EM system will include a number of components on both fishing and survey vessels. These include: 1) a dedicated GPS receiver to collect positional information 2) a magnetic rotation sensor will be installed to trigger recording when the drum is setting or hauling gear 3) an electronic hydraulic pressure

transducer 4) a standard and stereo rail camera (s) and 5) a computer system for operations. A camera chute system (described in Appendix C). An additional deck view camera (Figure 2) will be installed to on the fishing vessel (not survey) to validate protocols are being followed and will be used to demonstrate the system to the Industry and gain acceptance among the commercial fleet. Sensors will provide information on vessel position, confirm when fishing activity is taking place and trigger recording. A laptop will run the system from inside the vessel cabin, can be used to monitor system activity and enable troubleshooting if problems occur. The catcher vessel e-logbook program developed by the NMFS AKR will be installed on the computer system with which at-sea samplers will log haul-specific catch information and transmit when they reach port. Timing of data entry could be different for the IFQ trip versus the IPHC charter trips. Monitors will also provide the vessel crew and samplers a way to monitor camera function and evaluate whether system maintenance is required.

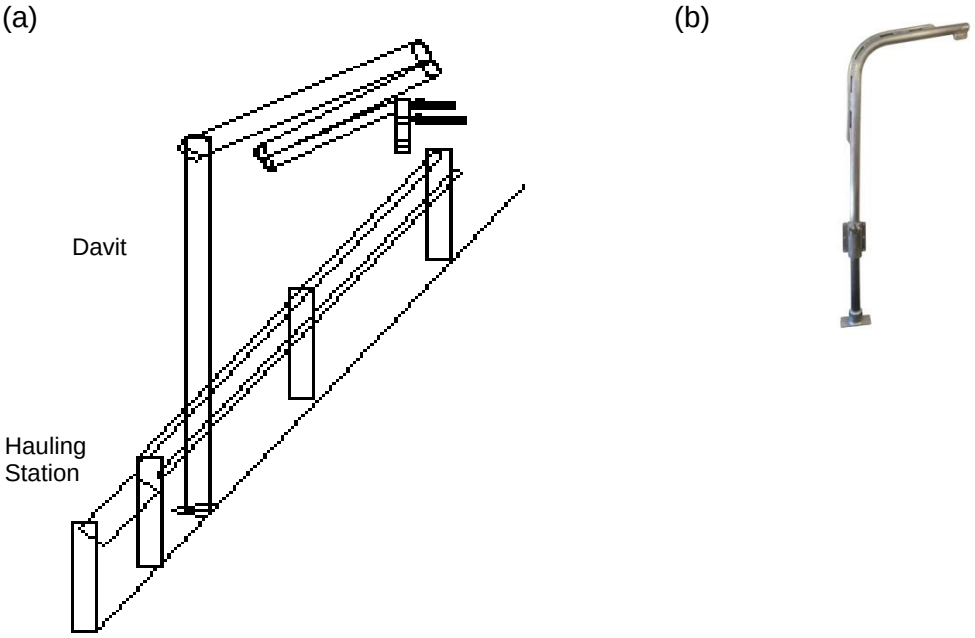
Figure 2 Typical placement of deck camera

This stereo camera system borrows many of the same features developed for CamTrawl (Williams et al., 2010), which has been deployed during AFSC acoustic pollock surveys in 2011 and 2012. The stereo camera will be positioned to focus on catch and discards at the rail hauling station. However, because drop offs may occur outside the stereo camera view, a standard camera system with a wider angle view will be installed at the rail to collect information on these drop-offs. This information will also be used to improve next generation camera system to facilitate future deployments. At-sea samplers on both the fishing vessel and survey vessel will receive training on monitoring and maintaining camera systems and to ensure these systems are working properly. If there is a system failure that cannot be repaired at-sea a technician would be available at the next port of landing to identify the problem, repair or replace the camera system(s).

The stereo rail camera system will require installation of a camera deployment system which is a modified davit that consistently places the camera in a location to allow consistent recording and lighting of the retained and discarded catch (Figure 3). The davit system will follow earlier system design (Ames et al. 2007) to be easily deployed once hauling of catch is underway and easily retracted once the haul ends. A technician and NMFS staff will work with the vessel operator to locate an area at the deck rail adjacent to the hauling station for design and placement of the camera deployment system as to not interfere in fishing handling or deck operations. The stereo camera system will be located in a water-proof camera housing located at the end of the davit. This system is necessary to ensure that a head on view of catch can be imaged reliably, which promotes consistent species recognition. This system will require a power and Ethernet connection and that will be run through the davit system eliminating external wiring.

Initially, images will be processed by PSMFC personnel using a video review application. However, automated species classification algorithms are currently being developed to complete the analysis process. Data collected in this project will be used to ground truth automated software routines that isolate fish targets, estimate fish length using stereo-correspondence, and track individuals across frames to provide accurate fish counts. Because all images will be time stamped and linked to GPS information, precise location of species specific catch will enable mapping of high bycatch rate areas, potentially improving future management strategies to lower bycatch. An image library is being created to store all images and meta-data that could be used in future projects to develop a set of key characteristics including color/shape patterns that could potentially be used to automate species or species group identification.

Figure 3 (a) Line drawing of the modified davit on which the stereo camera is mounted; (b) commercial davit



The Camera chute system and supporting software developments is intended to improve collection of EM images in three ways. First, it will economize video post-processing, since only single capture events will be imaged, allowing analysts to focus on a collection of high-resolution images of an individual fish for identification instead of reviewing an entire retrieval for catch events. Second, images collected by this system will improve our ability to consistently identify catch, since images will be of high consistent quality providing precise detail of fish characteristics. This is in contrast to images captured by exposed camera systems where image quality is dependent on environment conditions and system maintenance by operators. We are attempting to address these issues on the stereo camera systems by incorporating wiper blades and washing spray. The wiper systems are readily available and in use in security camera applications. Thirdly, collection of consistent high quality images support development of automated species identification applications based on a set of key characteristics, color/shape patterns and other salient features that could be used to automate species or species group identification.

Sampling Methods and Analyses

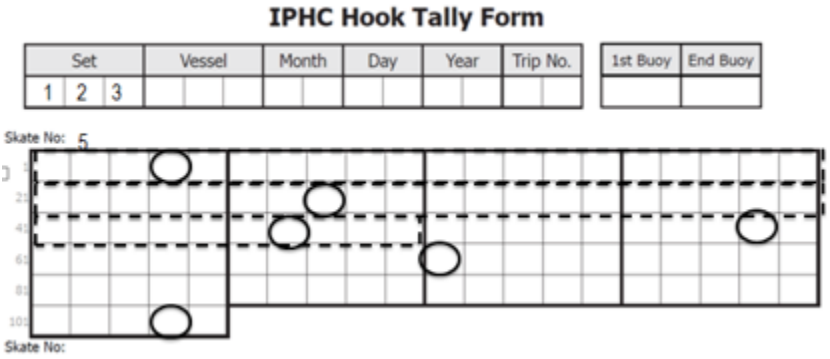
A third sampler (or single sampler on board the fishing vessel) will be required to collect hook-specific catch data for each species for either an entire set or randomly sub-sampled sets when necessary. In an effort to standardize data collected from the two sampling methods (IPHC hook-status method and video method) we will employ a single set of species and species-group codes (presumably IPHC codes) and will distribute species identification materials used by the IPHC to both the EM reviewer and at-sea samplers. We will compare estimates of numbers of fish based on at-sea sampler (combined sea sampler and additional hook-specific sampler) documentation with similar estimates from the review of electronic monitoring (EM) video recordings.

Since every fish on the longline is assumed to be documented by the sampler for selected sets, the total number of fish of a given species on the gear will be assumed to be enumerated without sampling error (subject to measurement errors only). For the analysis it is assumed the sampler data is correct although it is recognized that previous work has demonstrated that human observations are subject to error.

The stereo and standard rail camera(s) are designed to collect images of every fish during a haul, but experience has shown that this is typically not the case since image quality is a function of environmental conditions and camera maintenance. To address this issue, sampler and/or vessel crew will be required to clean camera lens as needed a task that is much simpler since the stereo camera can be easily retracted. On the fishing vessel, a random sub-set (skate) of selected hauls will be sampled by the crew passing both retained and discarded catch through the camera chute system.

At-sea samplers will sequentially record the catch for each hook in the set and the status of that catch. For the fishing vessel sets, each hook-status record will be aligned with the video record (to the extent practicable) so that direct comparisons could be made for each hook in the sample. In cases where hooks are misaligned due to missed hooks (by either the sampler or the video reviewers or snarls) realignment will be based on matching individuals of obvious species. Discrepancies in the identification and the enumeration of the catch by the at-sea samplers and the video analyst will be investigated to determine the reason for and type of discrepancy. Data collected by the camera chute will add another comparison for species count between at-sea observer and stereo rail for a particular skate. The length frequency information collected by the camera chute will also be compared to the stereo rail camera length data. At-sea samplers will record the date and haul time for each set, the set number, and the skate number for all sets. The EM system will record precise location and time stamp for each frame in the first row of pixels to allow precise sequential synchronization of images with both GPS position and time code embedded in all image data.

Figure 4 Discarded catch will be designated using an "O" for each species code.



For IPHC trips and at least a portion of fishing vessel sets, it will not be possible to match the imagery to the each species catch tally, so comparison will be done on a set basis. The at-sea sampler(s) will make sure project protocols for data collection are followed and equipment is operating as designed. Responsibilities will included; 1) managing and maintaining the EM system, 2) recording complete hook-status, catch disposition and species composition, to include identifying and recording all invertebrates and vertebrates caught, 3) enter set specific catch information into e-logbook , 4) transmit e-logbook information in each port of call and 5) ensure EM cameras are triggered to record the hauling events.

Our study design and analysis closely follows that of an earlier electronic monitoring study aboard volunteer vessels from the IFQ fixed gear fleet (Cahalan et al., 2010). Analytical methods employed in that study provided an effective evaluation of the information and these methods will be used in this study. Catch estimation methods will follow methods described in that paper.

Comparison 1: Comparison of observations of hook-specific species identification made remotely by a video reviewer with those made by a sampler stationed on the vessel. This is a comparison of data collected using EM to that collected by an at-sea sampler aimed at assessing the variability in species identification between the two data collection methods.

Hypothesis 1: The probability of hook-specific species identification agreement between EM video reviewers and at-sea samplers is equal to or greater than some predefined constant (e.g., 0.95).

The proportion of hooks with matching species identification for a given haul will be estimated as follows.

Let:

$X_{i,v}$ = an indicator of matching species identification for hook i on haul v, $X_{i,v}=\{0,1\}$, $i=1, \ldots, n_v$
n_v = number of hooks set by haul v (all trips and longline sets)
v = index on the haul, $v=1, \ldots. V$.

The estimated proportion of hooks with matching observations (for a given species) is given in Eqn. (1) with the empirical variance presented in Eqn. (2)

$$\hat{p}_v = \frac{\sum_{i=1}^{n_v} X_{i,v}}{n_v} \quad (1)$$

$$Var(\hat{p}_v) = \frac{\sum_{i=1}^{n_v} (X_{i,v} - \hat{p}_v)^2}{n_v - 1} \quad (2)$$

We expect data from approximately 200hauls during the survey, hence using $\hat{p}_v$ as replicate observations, these data will be used to model the potential impacts of covariates such as EM reviewer, environmental conditions, and image quality.

Comparison 2: Comparison of the number of fish per longline set (for a given species) derived from data collected using EM and data collected by an at-sea sampler. This is a comparison of data collected using EM with data collected by an at-sea sampler aimed at assessing the variability between the two data collection methods in the number of fish caught by the gear.

Hypothesis 2: The difference in the number of fish (of a given species) counted in a set between the data collection methods is zero.

In this analysis there will be one estimate (difference in numbers between the two methods) for each species on each set. A simple t-test will be used to test the hypothesis of no difference; additional analyses may evaluate the potential effects of EM reviewer, environmental conditions, and image quality.

Comparison 3: Comparison of the hook-specific species identification made by two video reviewers. This is a comparison of data collected by two different EM reviewers aimed at assessing the between reviewer variability in species identification.

Hypothesis 3: The probability of hook-specific species identification agreement between two EM video reviewers is equal to or greater than some predefined constant (e.g., 0.95).

This analysis will be similar to that used in Comparison 1.

This suite of comparisons and associated hypothesis tests was designed to fully assess the differences in the catch monitoring data collected using EM and at-sea samplers.

Estimated time required to complete field portion of project

- Daily - As part of fishing
  - Other
- Per Trip* (i.e. downloading data)
- Pre/Post Charter (prep, dismantle, etc.)

Activity	Time
Hook Status per skate	2 hrs per haul
Monitor/manage data storage	15 mins daily
Haul data entered into e-logbook	30 mins daily
Install and remove EM system	2 days each

** Trip length for western AK regions are generally 7-14 days, whereas other regions are typically 5-8 day trips.*

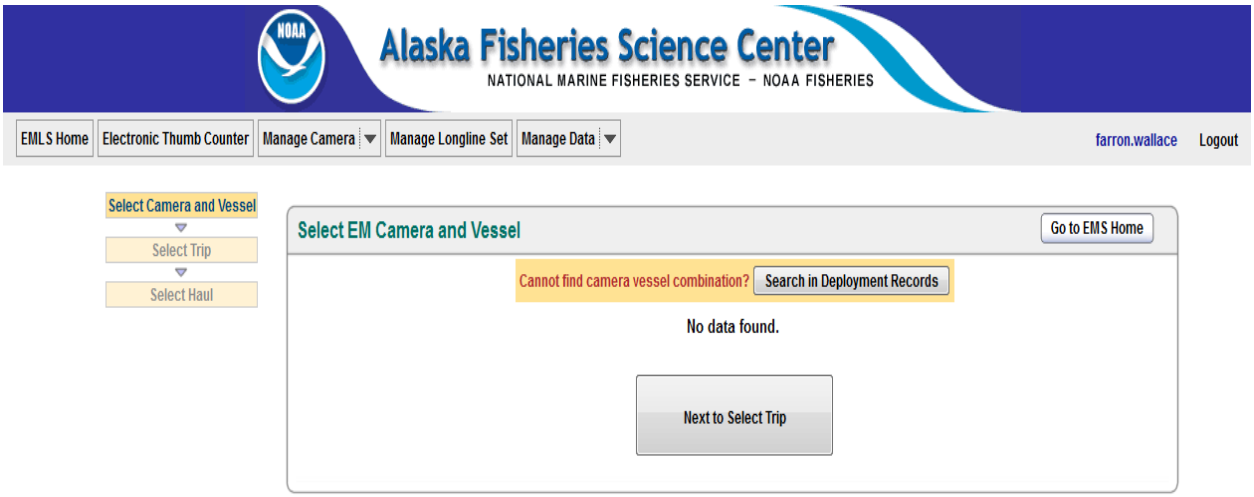
E-logbook

A separate e-logbook will be maintained by the third at-sea sampler on a daily basis. Information will include set specific information on catch, time and location. NMFS is developing an application where transmittal of this information will be automated as the vessel returns to a port. These data will be made available to IPHC and will be used to improve application in future projects and potentially fisheries.

Data storage

Data will be stored in the AFSC NORPAC database in a separate schema developed for this study (Figure 5). Application development has already been started and will continue into the future. GUI interface for post-processing video data are in development. Data analysis will be conducted in R (R Core Team (2013). URL http://www.R-project.org/).

Figure 5 Data entry page to enter image data into the NORPAC (observer) database



Literature

Cahalan, J.A., B.M. Leaman, G.H.Williams, B.H. Mason, and W.A. Karp. 2010. Bycatch characterization in the Pacific halibut fishery: A field test of electronic monitoring technology. U.S. Dep. Commer., NOAA Technical Memorandum NMFS-AFSC-213, 66 p.

Pria, M.J., J. Bryan and H. McElderry. 2011. New England electronic monitoring project 2010. Unpublished report prepared for the National Marine Fisheries Service by Archipelago Marine Research Ltd., Victoria British Columbia, Canada. 42 p.

Wallace,F.R.,C. Faunce and M. Loefflad, 2013. Pressing rewind: A cause for pause on electronic monitoring in the North Pacific? Presented at the 2013 annual ICES Science conference. Extended abstract available upon request.

Williams. K., C.N. Rooper., and R. Towler 2010 Use of stereo camera systems for assessment of rockfish abundance in untrawlable areas and for recording pollock behavior during midwater trawls. Fish. Bull. 108:352–362 (2010).

Williams, K., R. Towler, C.D.Wilson. 2010 Cam-trawl: a combination trawl and stereo-camera system. Sea Technology, December issue: 45-50.

Appendix E: Considerations for Cost Data Collection

The development of an adequate NEPA analysis of EM alternatives requires the identification and collection of information on the program costs borne by a range of involved parties. Until management alternatives are defined, it is not possible to lay out a complete analytical approach. Rather, this appendix to the research plan document categorizes and describes the desirable elements of cost data, identifies the parties that should be able to provide those data, identifies foreseeable data limitations, and describes an approach to elicit additional information during the pre-implementation phase of EM. Feedback from the SSC, AP, and Council will be used to emphasize which metrics should be tracked and reported during 2015 operational testing. Ultimately, the characterization of EM costs will be compared to a 'no action' alternative, which, for the fleet involved in the CRP, is trip selection for human observers.

In the broadest terms, economic costs are either direct or indirect. Direct costs are typically quantifiable, and should be available from the EM field service and data service providers as operational testing progresses during 2015. The level of detail in field service cost data is likely to be limited because the provider, Archipelago Marine Research (AMR), is a private business in a competitive market, and thus has a reasonable expectation of some confidentiality. The indirect costs of EM include 'opportunity costs' and necessary changes to fishing and business operations. Indirect costs are quantifiable to varying degrees. Some operational impacts might be measured with dollar cost estimates. For example, a vessel that is diverted to a different port to receive EM maintenance could estimate additional fuel expenditures. Other opportunity costs are better denominated in time, the value of which varies across individuals. Examples of time costs and the industry's approach to collecting relevant data are described later in this appendix.

A key consideration when characterizing the cost of a fully operational EM program is the difference between cost structures within a research program as compared to a mature EM program with greater economies of scale. While in the operational testing and research phase, the program is likely to require more time to train field service staff and to work more intensively with participating fishermen to address technical and logistical issues that arise. As more vessels begin to use EM, opportunities to share and rotate certain pieces of equipment between vessels may develop, and could provide a cost savings. Identifying and assessing these and other relative differences is beyond the scope of this document. The issue is raised here to emphasize the importance of collecting field service and installation cost data at the finest permissible resolution so that the analysts can break down cost categories into those that are scalable and non-scalable when the program reaches the phase of full analysis.

The Council has not yet defined some of the EM program features for which cost data will need to be compiled. For example, it is not yet clear whether EM will be used to track the condition of discarded fish. If that were to become an objective of the program, analysts would be interested in how fish handling procedures are altered to make use of EM cameras. Other EM objectives might relate to information that NMFS inseason management needs to receive as soon as possible, as the data may affect the closure of fisheries. Shorter data "turn-around" times could bring added costs. Until the scope of the EM program is defined, analysts can only encourage data service providers to identify their review time as specifically as possible, and plan at a later date to look back on the cost of additional video review time along the appropriate dimensions.

Cost Data Elements

Field Services

- EM system purchase or lease –

  The up-front cost of the EM systems used in the operational testing phase should be available from AMR. It is too early to know whether fishermen who use EM under the fully implemented program will purchase their own equipment, lease the equipment from a provider, or whether NMFS will use observer fees to purchase the equipment. The decision to purchase or lease will affect the annualized cost of the equipment. Cost comparisons are currently available from other EM programs, though specific dollar amounts may not be directly applicable to this program.

- System installation –

  AMR will install systems for 2015 operational testing. The analysts expect to receive summary cost information that is somewhat broad due to the provider's confidentiality expectations. Ideally AMR will provide some decomposition of costs associated with wiring and costs associated with camera/CPU installation. Understanding those relative costs, in either dollars or hours, will help analysts gauge cost savings that might be associated with rotating a processing unit between vessels.

- System maintenance –

  AMR should be able to provide annual summary information on the amount of time spent providing maintenance services in ports. It is unclear whether the amount of the fees billed for these services will be available. Ideally, the provider will track and share staff costs associated with salary/wages and travel to make service calls. Understanding maintenance travel costs, at least as a proportion of total service costs, may be relevant when analyzing the relative costs of providing EM field staff in a smaller or larger number of ports.

- Data retrieval –

  AMR could track time costs and dollar costs of pulling EM system hard drives and transmitting the data to Pacific States Marine Fisheries Commission (PSMFC) for review. The analysts will be interested in how often data is retrieved, the method of transmission (shipping, electronic), and whether there were additional costs associated with the need to download and transmit the data on an expedited timeline. It is not yet determined whose responsibility this will be under the fully implemented EM program (i.e. the provider or the fisherman), but the cost structure should be similar. Costs may vary by port location.

- Staff training and outreach to fishermen –

  Training time should be tracked on an hourly basis, per person. It is not clear whether AMR can provide the amount of fees billed for these purposes. It is understood that these costs may be higher for a new, operational testing program compared to a fully implemented program.

Data Services

- Data storage –

  Storage costs may vary with the size of the EM program. Due to the small scale of the 2015 operational testing phase, PSMFC may not incur any variable storage costs. Data storage costs could be estimated from general information technology studies.

- Data review –

  PSFMC will track the amount of time spent on certain tasks, or the total time spent reviewing video of a haul event for a given type of information. Video reviewers could be looking for catch information (piece counts, etc.), retention and discard counts, release methods, presence/absence of seabird deterrence, or other special project studies that are not yet defined. The amount of time spent dealing with data transmission and checking for video quality is also of interest.

  The analysts will also be interested in comparing the time cost of reviewing a haul as stratified by the percentage of the video that was reviewed. Previous EM studies indicate that reviewing less than 100% of the haul video is not always a cost-saving measure, or at least that the relationship between the proportion of the video reviewed and the cost of the review is not linear.

  To the extent possible, the analysts would like the data reviewer's summary reports to track what additional costs were associated with the need to review/analyze haul videos on an expedited timeline (i.e. short turn-around time).

Operational Impacts for Fishermen

The following data elements will help the analysts understand whether and how carrying an EM system changed or added to fishermen's at-sea and shoreside responsibilities. Such responsibilities could require additional time, money, or both. The current strategy to learn about these costs during the 2015 operational testing program is an in-person survey (Trip Debrief Form), designed and administered by industry. The survey is currently in development, but the types of questions to be asked are broadly discussed in the text box included later in this subsection. *Should the SSC and/or the Council recommend that data collection would be significantly improved by having NMFS and Council staff develop an instrument to survey fishermen, staff would need to initiate a process of OMB approval (RE: Paperwork Reduction Act) and explore options to execute and fund the administration of any such survey. A reasonable timeline to develop an approved survey would likely mean that fishermen who participate in the 2015 EM operational testing are surveyed after the fishing season. Survey development would likely require NMFS and Council staff to seek assistance either from a contractor or the Alaska Fisheries Science Center.*

- Altered fishing practices –
  - Vessel configuration –

    The analysts would want to know, at least anecdotally, whether vessel or deck-space configuration was changed in order for the EM system to work effectively. Dollar costs could be estimated, and might include additional lighting, deck bins, or small hardware. Time costs would include time spent making changes to the vessel, or additional time required to complete tasks due to the changes in configuration.
  - Setting/hauling gear –

    The analysts are interested in tracking whether or not the use of EM systems affected the time of day at which gear setting/hauling occurred, as lighting conditions could become a consideration for the skipper. Analysis of whether or not any such changes had an adverse impact would depend on how well skippers could document affected hauls, and small sample sizes would likely be an issue. Nevertheless, it is useful for skippers to have an outlet to report this type of effect anecdotally, and explain how their operation changed.

An increase in the amount of time required to set or haul gear would also be a cost for fishermen. For example, hauling gear could take longer if discarded fish must first be held up for a camera. Many factors affect the duration of hauls, so estimates of additional time due to EM use would likely be anecdotal.

- Trip planning –

  Any deviation (in time or location) from a normal fishing plan caused by the use or maintenance of an EM system should be documented. Changes to the duration of a trip or the location of deliveries could pose a cost to fishermen using EM.

- Fish handling –

  Anecdotal information on altered or additional fish handling procedures could be collected and compared to those required when a human observer is onboard. Procedures for sorting, stowing, and discarding catch may be different, depending on the EM objectives that are yet to be defined.

- EM system maintenance –

  In addition to maintenance work performed and billed by the service provider (AMR), skippers and crew may have to spend time onshore or at-sea to keep the system operational. Operational impacts could include additional time spent onshore coordinating with AMR technicians, or cleaning/maintaining the cameras and sensors during a fishing trip.

- Data retrieval –

  Fishermen may spend time and/or money sending video data to reviewers. The chain of custody for EM data is not yet fully defined. Additional time onshore would be a cost to the fishermen.

- Training and education –

  Time spent in port working with the EM provider to learn the use and maintenance of the EM system is an additional cost to the fishermen. Time spent on post-trip debriefings would also be a cost. Industry debriefing is expected to be part of the operational testing program, but may or may not be included in the final program.

Industry EM Trip Debrief Form

Industry members of the EM Working Group have indicated that they plan to design and administer a post-trip debrief survey for participants (presumably skippers) during the 2015 operational testing program. The results of this effort will be made available to staff analysts.

A draft version of the form includes a series of questions on a Likert scale ("strongly satisfied" through "strongly dissatisfied") regarding how well the technical attributes of the EM system performed. Following that, the draft includes a series of open-ended questions asking if there were any "issues" with the use of the system, whether the system caused any safety hazards, whether fishing practices and fish handling procedures were altered, what amount of maintenance and technical support was required, and whether the operational testing participant has any suggestions for improving the EM system. The wording of these questions can be written to elicit specific anecdotal information. For example, a question that asks about technical issues during a trip can also pose the follow-up question: "Did you spend time at-sea to resolve the issue? If so, how much time?" Analytical staff are particularly interested in eliciting estimates of time spent at-sea and in port on EM system installation, maintenance, and trouble-shooting, especially if that time is additional to normal obligations. The industry survey instrument provides the best potential avenue for fishermen to describe whether they had to make additional vessel reconfigurations to accommodate EM (that would not have been captured in the installation cost estimates provided by AMR), or whether they altered trip plans due to the use of EM.

Administrative Costs

NMFS staff can provide a dollar figure for the annual amount of Agency funds going into EM development during the operational testing phase. These costs cover items including salary, travel, and programming/field staff. Annual expenditures on the smaller "development" program are likely lower than the cost of administering a fully implemented EM program.

For comparison, the National Observer Program's annual report includes an appendix that summarizes human observer costs. NMFS cost categories for the North Pacific Groundfish Observer Program include: training and curriculum development, debriefing and quality control, gear inventory and deployment, field offices (Dutch Harbor, Kodiak, Anchorage), fishery dependent data analysis and interpretation, application development and data presentation, and in-season operations.