Appendix C Study Design for Pot gear

Background

Four research tracks were developed and refined through a series of ad-hoc industry/stakeholder meetings, public workshops, and follow-up conference calls during the fall of 2013 and spring of 2014. In April 2014, the Council established a Fixed Gear EM Workgroup (EMWG) as a Council committee, to allow industry, agency, and EM service providers a forum to cooperatively and collaboratively design, test, and develop EM systems that are consistent with Council goals and objectives to integrate EM into the Observer Program. The EM workgroup met during May and June 2014 to design a cooperative research program to be responsive to both the implementation of the North Pacific Fishery Management Council (Council) 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. Multiple research tracks are being undertaken, in order **to collect information that will help inform future Council alternatives for EM to enable catch estimation.** The overall goal of the cooperative research project is to assess the efficacy of EM (in combination with other methods) for catch accounting of retained and discarded catch, identify key decision points to operationalize and integrate EM systems into the Observer Program for fixed gear vessels in a strategic manner.

In July, 2014 the Pacific States Marine Fisheries Commission (PSMFC) posted a request for proposals (RFP) to charter approximately14 fixed gear vessels (e.g. longline or trap/pot fishing vessels) engaged in the sablefish, halibut and Pacific groundfish fisheries in Alaska to participate in a cooperative research project for testing camera based electronic monitoring (EM) systems. This project is a collaborative study between the PSMFC, the National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center (AFSC) and the North Pacific groundfish and halibut fishing industry. Originally, vessels were to be split into two groups for testing; 1) non-stereo EM operating systems (Standard EM) was to be installed on approximately four vessels and 2) stereo camera operating systems (Stereo EM) was to be installed on approximately ten vessels. Both groups of vessels would be required to carry an at-sea biologist for all contracted trips while vessel crew responsibilities differ between Standard and Stereo EM.

PSMFC advertised the RFP opportunity to charter vessels during July 2014; representatives of all fixed-gear Industry groups fishing in the North Pacific were contacted and informed of the RFP opportunity and the 30 day response period. A single vessel owner/operator showed interest and applied for the RFP. This vessel will be targeting Pacific cod using pot gear during the fall-winter of 2014/2015. As part of the cooperative research an EM system will be integrated into vessel operations and will carry an at-sea biologist. This Appendix is intended to provide information on project goals and objectives, methods, study design and analytics that will be performed while the vessel is fishing pot gear. This vessel will switch to set line gear during the spring halibut fishery and the research conducted for set line gear is described above.

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. 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.”

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 and reduce 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 information to evaluate EM sampling rates (e.g. the amount of video data to be reviewed) and procedures necessary to achieve a specified level of precision while minimizing costs. Further, 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 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[1], 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 will be 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 will contract with an EM provider for installation of EM systems and one vessel has been charted through a competitive bid process (see Request for Proposals posted). The EM provider will be 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 maintain both the single camera and stereo cameras EM systems. Vessels 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 fixed gear 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. This project will inform decisions on future investments in technology and identify appropriate technology that will best meet NMFS and Council management objectives.

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

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.
    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.
    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 26 trips will be chartered including 18 trips targeting Pacific cod with pot gear and 8 trips targeting halibut using set line gear. The first set of trips (4-6) 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, 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 identification, 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 with a plastic curtain that allows passage of the fish while

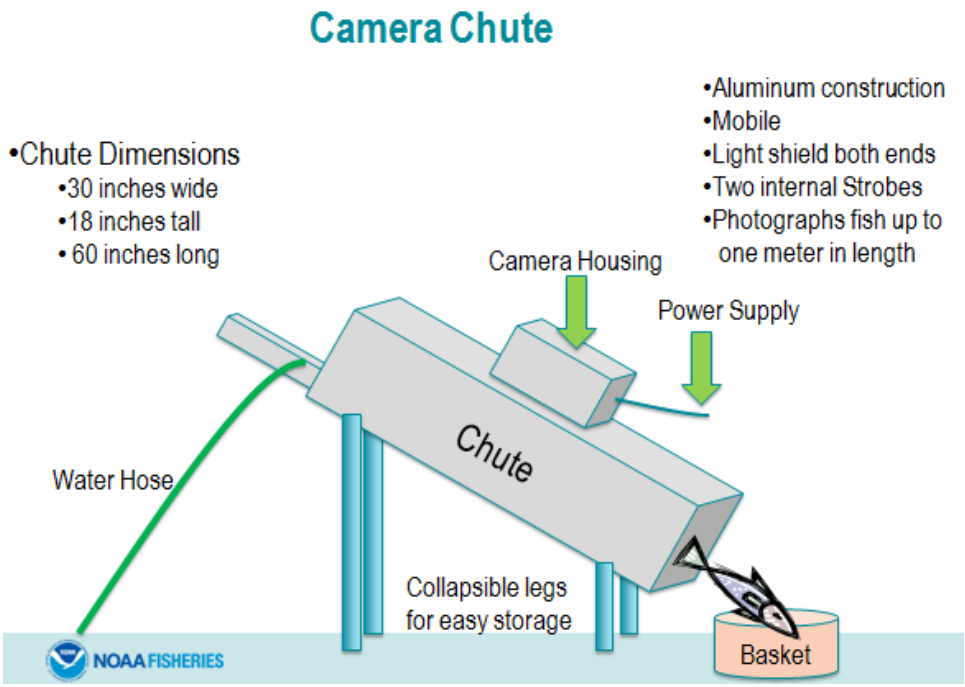

Figure 1 Illustration of camera and chute design that enables imaging as fished are passed through.

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.

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 the entire set for those sets that are randomly chosen to be sampled. In the case where the set is too long for all catch to be monitored by the at-sea biologist, data will be collected for a systematic 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 requires 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 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) when only the non-stereo camera system is being used (first set of trips). Once the camera chute is integrated into the study, 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. The 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 rail camera; stereo rail camera; and 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.

This is the comparison that will be used on the initial set of research trips.

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).

This comparison will be used once the chute camera is incorporated into the study or any time that data are available for individual fish (e.g. fish pass the research cameras in the same order as they pass (data are recorded by) by the at-sea biologist or other cameras).

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, … , n_v

n_v = number of pots set by haul v

v = index on the haul, v=1, …. 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/).