Appendix 2. Transition Plan for Integrating Electronic Monitoring into North Pacific Fishery-Dependent Data Collection to Enhance Catch and Bycatch Monitoring

1. Purpose/Objective

The purpose and objective is to transition EM stereo camera technology in Alaska's groundfish fisheries from research and development to an operational program in 2019. The goal is to improve the timeliness, quality, integration, and accessibility of fishery-dependent data for catch and bycatch accounting. Additional field work, technology development and regulatory development are needed to transition EM in Alaska groundfish fisheries from research to application. The overall goal of this project is to provide field-tested methods to provide quantifiable image-based data from fisheries with stereo camera and perfect next-generation camera chute based sampling systems. There are four primary objectives of the work including:

1. Integration of EM data.

This work will integrate EM/ER data into the current Observer Program's database which provides information to the Alaska Region for catch accounting and fisheries management to operationalize catch estimation similar to how observer data is now being collected, stored and served. Application development is currently under way and in 2016 NOAA Fisheries will conduct testing and development in an operational environment to ensure seamless integration into catch accounting in 2018. The goal during pre-implementation is to make the necessary infrastructure modifications and catch estimation programming changes to incorporate EM data into the catch accounting system so that it is available for inseason fisheries management.

2. Fish Detection

This work will improve upon and operationalize existing camera control software for fish detection as fish pass at different times under a set of stereo rail cameras or a camera chute. The application will involve testing to determine optimal settings and evaluate possibility of taking rapid stereo-camera sequences and selecting best image pair for further analysis. Work on the hardware systems, including cameras, strobes (chute only), and fish chute is underway at AFSC. Algorithms developed should be able to separate two or more fish that are potentially touching, but not overlapping. While identification of catch events and image capture is well developed for the camera chute system much work is still needed for the stereo camera system, which this funding would provide.

3. Size estimation

Stereo camera and/or chute camera systems will be calibrated using open source (OpenCV) or Matlab approaches, and the length of fish targets estimated as precisely as possible, including potential corrections for curved body position. Stereo-camera arrangement will remove the necessity of exact placement of cameras relative to fish passage surface, making the system more flexible for future installations. Initial analysis of stereo image pairs taken during 2015 show that image quality and background is extremely important for segmentation (cutting fish from background view) required to obtain accurate fish lengths. Image quality is highly influenced by light glare especially at night and in poor environmental conditions. However the quality of images taken with infrared (IR) and mono-chrome cameras is not as influenced. This project

would allow initial testing of IR and mono-chrome cameras to improve event detection and length measurement using a stereo camera system.

4. Automated species classification
Fish targets that are detected and separated from the image background will be passed on to a classification algorithm that will change into class membership. The classifications will be made in a probabilistic framework, allowing users to incorporate classification uncertainty in to data analysis. A potential hierarchical structure can be applied to group fish with low species level classification confidence in species groups of similar appearing fish types. Targets with high uncertainty can be identified for manual review. Although this work is underway using camera chute images it is not developed for stereo images taken at the rail, which this funding would provide.

NOAA Technical Memorandum NMFS-AFSC-276[2] identifies a detailed list of goals and objectives in the Strategic Plan for Electronic Monitoring and Electronic Reporting in the North Pacific, and the Alaska Region Electronic Technologies Implementation Plan[3] includes a schedule for integrating EM technologies into the Observer Program.

2. Research background

This project provides a proof-of-concept demonstration of EM in Alaska groundfish fisheries. The AFSC has developed a stereo camera system known as CAMTRAWL that is placed in the mouth of the trawl on fishery independent surveys to identify, enumerate, and provide length estimates of fish entering the trawl. This project aims to draw upon this technology to address a problem of estimating catch and bycatch in commercial fisheries using EM on small hook and line vessels where placing observer to collect data is challenging due to space and safety concerns. Estimating catch and bycatch, and more specifically, measuring lengths of fish as they come aboard a commercial longline vessel has never been achieved. The stereo camera system and associated applications that automate the identification and measurement of fish would represent a major breakthrough in EM technology that would have significant benefits to NOAA Fisheries and the fishing industry.

The Council has established an intention to integrate electronic monitoring (EM/ER) tools into the Observer Program for the fixed gear small-boat groundfish and halibut fisheries. The Council's intent is to develop EM/ER 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 and 2017 focusing on full implementation into catch accounting for fisheries management in 2018. A number of 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/ER into the Observer Program. Construction and testing of a machine vision stereo camera system was one of multiple research projects begun in 2015, which will collect information to help inform pre-implementation decisions and future Council alternatives for integrating electronic monitoring into the Observer Program.

[2] http://www.npfmc.org/wp-content/PDFdocuments/conservation_issues/Observer/EM/EMStrategicPlan.pdf

As described earlier, the AFSC's Observer Program has completed two relatively small scale EM projects and is actively engaged on two additional projects. The ongoing work provides the raw data (images) from camera chute system to support species identification work and supports development of software applications for integrating EM/ER data for catch estimation and development of new software to automatically detect, identify, and measure individual fish from camera chute images. This proposal will complement on-going research by focusing on the stereo rail camera system; development, event detection, automation of fish sizes and species identification. Data and products/deliverables will be developed in open source software code that can be shared with all other NOAA Fisheries Offices, Fisheries Information Networks, and any other partners.

3. Business case

3.1. Who is the end user?

End users of any EM stereo camera technologies (hardware and applications) developed by NMFS will include the fishing industry, EM service providers, and other parties interested in providing fishery-dependent data collection services in the North Pacific. All products will be open source and made available to all FMC's and NMFS partners on request. This project relates to all NOAA and observer program FMC's and project outcomes, lessons learn will be available for review through report(s) and presentations and metadata provided through InPort (NOAA Fisheries publically-accessible metadata library). For hardware, NOAA Fisheries would develop performance standards but would not necessarily dictate which system to use. NOAA Fisheries intent in providing open source software is to provide the opportunity for EM service providers to use the applications developed by AFSC, or for EM service providers to continue to develop and use their own software applications, or some combination of the two.

3.2. Societal and economic benefits

The greatest societal and economic benefit will be to the commercial fishing industry in Alaska that will potentially be relieved of the burden of carrying a human observer to collect data on catch and bycatch required for management of living marine resources in the North Pacific.

3.3. User Requirements

User requirements are being developed by the Council's EM Workgroup described in Section 2 and are expected to be minimal. Primary requirements will include making the vessel available for installation of an EM system at a designated port or facility, providing a consistent and reliable power source, keeping camera lenses clean, and potentially shipping hard drives to NOAA Fisheries following a pre-determined number of recorded fishing trips and/or hauls. Systems will be installed by NOAA Fisheries or qualified EM service provider companies.

3.4. Current (demonstration) system

A prototype machine vision camera system was deployed on a commercial fishing vessel in 2015. The results of the effort are still being assimilated and will be provided to the Council in February 2016.

3.5. Justification/acceptance criteria for transition

Acceptance criteria for transition would include a fully functioning machine vision camera system with applications capable of automating species identification and length estimation at the rail of the vessel.

4. Capabilities and Functions

4.1. Current (where is it now?)

A prototype machine vision camera system was deployed on a commercial fishing vessel in 2015. The results of the effort are still being assimilated and will be provided to the Council in February 2016.

4.2. Operational/Application (description of intended end state)

The intended end state is a fully functioning machine vision camera system with applications capable of automating species identification and length estimation at the rail of the vessel. NOAA Fisheries would provide the performance standards for the necessary hardware and would provide the applications through open source software (OpenCV) capable of performing the intended functions.

4.3. Data collection and management

Data would be collected at sea on board commercial fishing vessels and would be shipped or transmitted to NOAA Fisheries. Data collection and management responsibilities would reside with NOAA Fisheries.

5. Transition Activities:

5.1. Identify any "gates" and associated documentation for accomplishing progress from one maturity level to another required to be met by the appropriate Line Offices

Demonstrable progress is being made and would continue to be made at various stages of technical development. The first deployment of a complete machine vision camera system was completed in 2015 and will be expanded to a greater number of vessels in 2016 and 2017. Three significant "gates" would include 1) finalizing the hardware needed to capture the necessary data in an at-sea environment; 2) developing the necessary applications for species identification and 3) developing the necessary applications for length estimation.

5.2. Identify any testbed and proving ground that will be involved

The primary testbed will be on board commercial fishing vessels in an operational environment. NOAA Fisheries has made substantial progress in identifying the necessary fishing platforms on which the stereo camera systems will be deployed in 2016.

6. Schedule and deliverables

6.1. Implementation Plan

NOAA Fisheries has developed two separate EM Implementation Plans for Alaska described previously in this document. The first in a more general and overarching Alaska Regional EM/ER Implementation Plan[4] requested by NOAA Fisheries Headquarters in order to track progress toward implementing EM/ER technologies into fishery dependent data collections across the country. The second is a detailed EM Pre-Implementation Plan[5] drafted by NOAA

[4] http://www.alaskafisheries.noaa.gov/sustainablefisheries/em/akremerimplementationplan.pdf
[5] http://www.npfmc.org/observer-program/

Fisheries and the Council's EM Workgroup to provide the specific operational details for testing various technologies in an operational environment in 2016 with the goal of laying the groundwork for a formal analysis document and a fishery management plan amendment that includes regulations to implement EM technologies in Alaska.

Specific deliverables include:

a) Field trials testing methods to provide quantifiable imaged-based data from fisheries, which can be used to support discard estimation in Alaska's fixed gear fleet; and
b) Analysis of information from field trials and pilot studies. 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 needed from vessel operators for use with EM.
c) 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 NOAA Fisheries, Council, and stakeholder management objectives. These decision points will be analyzed in a regulatory amendment, and the Council's recommendation, and subsequent NOAA Fisheries rulemaking that will result in integration of EM options into the Observer Program.

6.2. Milestones

The following milestones are from p.1 of the Draft EM Pre-Implementation Plan.

Year	Fieldwork / Pre-implementation (Pre-Imp)	Council process, regulations	Observer Program/ Annual Deployment Plan (ADP)
2014	*Fieldwork*	*EMWG develops 2015 Cooperative Research Plan (CRP), discusses alternatives for analysis*	*Oct – 2015 ADP places 10 vessels that are participating in EM research into the no selection pool*
2015	*Feb – SSC reviews CRP* *Jan-Jul – operational and stereo camera field research*	*Feb – SSC, Council review CRP* Oct – propose a 2016 Pre-Implementation plan to Council	Oct – 2016 ADP proposes all EM Pre-Imp vessels in no selection pool
2016	Jan-Dec – Pre-implementation on 60 longline vessels 40-57.5'. Jan-Jul – EM field research on stereo cameras, pot vessels.	Oct – initial review for EM analysis to integrate EM into obs program. Dec – final action on EM analysis	Oct – 2017 ADP proposes all EM Pre-Imp vessels in no selection pool
2017	Jan-Dec – Second pre-implementation year for longline vessels 40-57.5'. Potentially expand to include other fixed gear vessels or other technology.	Jan-Dec – Develop regulations for integrating EM	June – Annual Report provides prelim analysis on allocating observer fee between observer and EM deployment Oct – 2018 ADP allocates funding to observers and EM deployment
2018	**Integrated observer/EM monitoring program**		

6.3. Training manuals

Training manuals have not yet been developed but the EM Pre-Implementation Plan includes development of vessel monitoring plans (VMP) which will identify the specific practices required for each vessel's unique configuration to maximize the success rate of EM data collection on the vessel. The VMPs will be shared with the EM Workgroup to inform the group about elements of VMPs that should be incorporated into a regulated program. NOAA Fisheries may need to hire additional staff that are experts in developing software applications to automate and integrate the various data streams that are to be collected using EM systems. Some additional training of staff may be required.

6.4. Mechanism for updating the plan

The primary mechanism for updating the EM Implementation Plan is through the EM Workgroup process. The EM Workgroup meets several times a year to review progress and make changes to schedules and deliverables as needed. The EM Implementation Plan will be updated based on the work of the group.

7. Roles and Responsibilities (for the TRANSITION)

The research and development for this project is being conducted by scientists at the Alaska Fisheries Science Center and Alaska Regional Office. The resulting operational framework will be implemented by NOAA Fisheries to support sustainable fisheries management and inform groundfish stock assessments. Results from these EM studies and transition from research to application will be informative and perhaps applicable in other U.S. and international fisheries. Thus, numerous domestic and international fishery management agencies, industry and non-governmental (NGO) stakeholders, and fishing communities are potential end users of the application.

8. Budget overview

8.1. Cost of current system

See detailed budget in Appendix 1.

8.2. Cost of transition

The cost of transition is estimated at $499K/year for FY17-19.

8.3. Cost of operational system and maintenance

Current studies are designed to develop cost estimates for an operational EM program in Alaska. Funding for an operational EM program will be split between NMFS and industry analogous to the current funding for observer coverage in Alaska in which industry pays a 1.25% landings fee to cover the cost for at-sea deployment of observers. The funds are used by NMFS to award a Federal contract for an observer provider company to hire and deploy observers. NMFS is responsible for training, equipping, debriefing, and providing the necessary shoreside infrastructure to manage the data collected by observers. Although specific details for an operational EM program in Alaska still need to be developed and promulgated in regulation, NMFS has authority to use the same industry fees collected for observer coverage to fund a regulated EM program. Similar to the model used for observer deployment, NMFS would most

likely use industry fees to award a contract to an EM service provider to deploy the necessary equipment and provide field support for an EM data collection program. NMFS would provide the shoreside infrastructure for data management.

9. Impacts of Transition

9.1. Budget--- spend plan

See detailed budget in Appendix 1.

9.2. Risks and mitigation

High	Unable to acquire necessary funds to implement EM	High	Med	Sustained effort to seek additional funding sources
Low	Unable to develop image acquisition software	High	Low	Proof of concept has been developed
Low	Software not developed on time	Med	Low	Hire outside contractor to assist with programming
Low	Ability to share software with other NMFS regions or centers	Low	Low	Collaboration with other NMFS regions or centers during development to ensure compatibility

10. References

AFSC. 2008. Electronic Fisheries Monitoring Workshop Proceedings, July 29-30, 2008, Seattle, WA. Alaska Fisheries Science Center. 55 pp. http://alaskafisheries.noaa.gov/npfmc/PDFdocuments/conservation_issues/ EMproceedings.pdf

Loefflad, M.R., F.R. Wallace, J. Mondragon, J. Watson, and G.A. Harrington. 2014. Strategic plan for electronic monitoring and electronic reporting the North Pacific. NOAA Tech Memo NMFS-AFSC-276. 52 pp. http://www.afsc. noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-276.pdf

Wallace, F., K. Williams, R. Towler, and K. McGauley. 2015. Innovative Camera Applications for Electronic Monitoring. In: G.H. Kruse, H.C. An, J. DiCosimo, C.A. Eischens, G.S. Gislason, D.N. McBride, C.S. Rose, and C.E. Siddon (eds.), Fisheries Bycatch: Global Issues and Creative Solutions. Alaska Sea Grant, University of Alaska Fairbanks. http://doi.org/10.4027/fbgics.2015.06

11. Signature

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