NOAA Technical Memorandum NMFS-AFSC-276

# Strategic Plan for Electronic Monitoring and Electronic Reporting in the North Pacific

by
M. R. Loefflad, F. R. Wallace, J. Mondragon, J. Watson, and
G. A. Harrington

**U.S. DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

April 2014

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The NMFS-NWFSC series is currently used by the Northwest Fisheries Science Center.

This document should be cited as follows:

Loefflad, M. R., F. R. Wallace, J. Mondragon, J. Watson, and G. A. Harrington. 2014. Strategic plan for electronic monitoring and electronic reporting in the North Pacific. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-276, 52 p.

Document available: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-276.pdf

NOAA Technical Memorandum NMFS-AFSC-276

# Strategic Plan for Electronic Monitoring and Electronic Reporting in the North Pacific

by
M. R. Loefflad[1], F. R. Wallace[1], J. Mondragon[2], J. Watson[2], and G. A. Harrington[1,2]

[1]Alaska Fisheries Science Center
Fisheries Monitoring and Analysis Division
7600 Sand Point Way N.E.
Seattle, WA 98115

[2]Alaska Regional Office
National Marine Fisheries Service, NOAA
222 West 9th St.
Juneau, AK 99802-1668

*www.afsc.noaa.gov*

**U.S. DEPARTMENT OF COMMERCE**
Penny. S. Pritzker, Secretary
**National Oceanic and Atmospheric Administration**
Kathryn D. Sullivan, Under Secretary and Administrator
**National Marine Fisheries Service**
Eileen Sobeck, Assistant Administrator for Fisheries

April 2014

# CONTENTS

# 1. INTRODUCTION

## 1.1 Background

We live in a world of great technological advances, many of which are applicable to fisheries monitoring issues, and some that are already in use to support fisheries management in the North Pacific. The National Marine Fisheries Service (NMFS) and the North Pacific Fishery Management Council (Council) have been on a path of integrating technology into our fisheries monitoring program for many years: we have advanced Electronic Reporting (ER) systems in place for logbook and observer information; we have implemented a variety of monitoring tools like motion-compensated flow scales and Vessel Monitoring Systems (VMS); and have integrated video monitoring into several fisheries in a compliance capacity. We have conducted and continue to conduct experimental projects with Electronic Monitoring (EM) to configure and advance the technology appropriate for fisheries in the North Pacific. Further, application development, database and web technologies are continuing to revolutionize how we manage and report information to both internal and external constituents and improve cost efficiencies.

Developing and implementing technology requires careful thought given that technologies and automated image processing techniques are rapidly evolving. Technological investments made today may not best fit the needs of future processing and data delivery capabilities in the near future. Consideration of cost must extend beyond the acquisition of the technology and provide for infrastructure necessary to support the technology into the future, and to adapt and evolve as technology advances. Decisions about where and what to invest in represent strategic choices; wrong choices can be costly.

Throughout the process of integrating electronic technologies into data collection and monitoring NMFS and the Council have continued to consider the tradeoffs between technologies and their ability to meet specific objectives. At the June 2006 Council meeting, NMFS presented a discussion paper about the issues associated with the implementation of EM (Kinsolving 2006). This paper highlighted several issues that needed to be resolved prior to implementation of a large-scale EM program. Since 2006, EM technologies have continued to evolve and the use of video, in particular, has seen considerable interest and has been the subject of many studies. In January 2011, NMFS presented a discussion paper to the Council that summarized the work that has been done evaluating the potential use of EM in commercial fisheries off Alaska and described the EM programs that had been implemented at that time (NMFS 2011).

In October of 2012, the Council initiated an electronic monitoring strategic planning process by requesting that NMFS:

> "Provide a strategic planning document for electronic monitoring (EM) that identifies the Council's EM management objective of collecting at-sea discard estimates from the 40' – 57.5' IFQ fleet, and the timeline and vision for how the EM pilot project in 2013 and future years' projects will serve to meet this objective, including funding."

And that NMFS:

> "…report to the Council on other EM options that may be appropriate to replace or supplement human observers."

> *"Simply put, strategic planning is clarifying the overall purpose and desired results of an organization, and how those results will be achieved."*
>
> Carter McNamara,
> Authenticity Consulting, LLC
> (McNamara 2007).

This strategic plan is intended to explain the goals and objectives of NMFS and the specific actions that it will take to accomplish these goals and objectives in the North Pacific fisheries-dependent data collection program. Goals are broad aims. Objectives are specific, measurable targets. A strategic plan provides an assessment of (1) where an organization is now, (2) where it wants to be in the future, and (3) how it will get there. The purpose of this Electronic Monitoring Strategic Plan is to clarify the purpose, guide integration of monitoring technologies and provide benchmarks necessary to evaluate attainment of goals.

The strategic planning process requires collaboration and support by all parties affected by the plan and those who must contribute to make the plan a success. The first step in the strategic planning process was presentation of an outline of the strategic planning document to the Council in April 2013. Strategic planning also requires clear identification of goals and objectives before specific action items are identified open discussion and exchange of information, and thorough and accurate information about resource requirements and constraints. As the next step in the strategic planning process, the plan was presented to the Council in June 2013, and the Council adopted the plan as a guidance document for incorporating EM into the Observer Program. In addition, the Council recommended use of a catch estimation approach to develop EM for the halibut and sablefish fisheries. Finally, the Council created an EM Workgroup that will be formed in the fall of 2013 and will: identify EM performance standards, operational procedures, and sampling and deployment plans appropriate for IFQ vessels and also look at implementation vehicles and potential phase-in approaches. The Council recommended that the EM Workgroup use the following sections of the strategic plan to focus its efforts to develop a catch estimation based program for the IFQ fisheries: Goal II, Objective 1, Strategy C and Goal III, Objective 1, Strategy A.

Implementation of a strategic plan requires sufficient staff and budget resources to undertake the actions in the strategic plan, a willingness to set priorities, continuous reporting and evaluation to monitor if actions are being undertaken and milestones met, and periodic adjustments to the plan, as necessary. As such, the plan is intended to be a living document that will evolve to keep in step with new technologies and software advances as they come available.

Concurrent with the development of this North Pacific EM/ER strategic plan, NMFS headquarters (HQ) staff developed several white papers on the use and development of electronic technologies. Drafts of five of these white papers were presented to the Council Coordination Committee (CCC) in February of 2013. These papers provide helpful information that may be useful to NMFS and the Council in future EM/ER developments. The white papers are available on the CCC web site at: http://www.nmfs.noaa.gov/sfa/reg_svcs/Councils/ccc_2013/Agenda.htm.

## 1.2 Definitions

**Electronic monitoring (EM)** – The use of technologies – such as vessel monitoring systems or video cameras – to passively monitor fishing operations through video surveillance, tracking, and sensors. Video monitoring is often referred to as EM in the literature.

**Electronic reporting (ER)** – The use of technologies - such as phones or computers - to record, transmit, receive, and store fishery data.

**Goals** – Our goals describe how the future world will be different. They do not describe what we will do. Goals address: “How will the world be different” and should not change over time.

**Objectives** – Measureable, attainable milestones that we want to achieve on the way to meeting the goals.

**Strategies** – How we organize our resources and actions to maximize our effectiveness and efficiency to meet the Objective (examples will be provided to illustrate).

**Actions** – Concrete and sometimes completed steps implementing the strategies.

## 1.3 Primary Authorities

NMFS' ability to collect information is authorized under several primary authorizations:

1. Magnuson-Stevens Fishery Conservation and Management Act (MSA), which was amended by the 2006 Magnuson-Stevens Reauthorization Act: The MSA is the primary domestic legislation governing management of the Nation's marine fisheries. NOAA manages fisheries in federal waters through fishery management plans (FMPs) developed in conjunction with the Councils.

2. Marine Mammal Protection Act (MMPA): The MMPA provides for, in part:

- A program to authorize and control the taking of marine mammals incidental to commercial fishing operations.
- Preparation of stock assessments for all marine mammal stocks in waters under U.S. jurisdiction.

3. Endangered Species Act (ESA): NOAA's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibility for implementing the ESA.

There are approximately 2,050 species listed under the ESA. Of these species, approximately 1,430 are found in part or entirely in the United States and its waters; the remainder are foreign species. Generally, USFWS manages land and freshwater species, while NMFS manages marine and "anadromous" species. NMFS has jurisdiction over 94 listed species. The ESA requires NMFS to designate critical habitat and to develop and implement recovery plans for threatened and endangered species.

## 1.4 Electronic Monitoring/Reporting Approaches

EM/ER technologies provide a variety tools and potential configuration of tools that may be used to help accomplish specific objectives. Clarity in the desired objectives is essential and will help determine the appropriate methods. Decisions related to costs, feasibility, and effectiveness will help to determine the right combination of tools needed to achieve objectives. Where possible, NMFS will seek to implement EM/ER programs that can meet a variety of functions across a broad spectrum of vessels. Here we describe two broad EM/ER approaches that are available to meet specific monitoring objectives and provide examples of where these approaches have been investigated and/or implemented in Alaska and other fisheries. A summary of the EM/ER tools currently being used in Alaska fisheries is provided in Appendix A.

### 1.4.1 Compliance Monitoring

A compliance monitoring approach uses EM/ER tools to enable and/or improve regulatory compliance monitoring and provide independent information to inform agencies if industry is complying with specific regulations. The EM data obtained under the compliance monitoring approach do not feed into catch accounting or stock assessments. Instead EM used in this approach is often used to support data collection through other methods (e.g., observers or industry self-reported data).

Depending on the monitoring objectives, there are different approaches to implementing a compliance-monitoring program with EM/ER tools.

#### *1.4.1.1 Compliance monitoring for a specific requirement*

The Alaska region has had success with the use of EM for compliance monitoring and has implemented this methodology in the AFA pollock fishery, Rockfish and Amendment 80 Programs, and the Pacific cod freezer longline fishery in the Bering Sea. In all of these cases, EM is being used to verify compliance with regulations for catch sorting and weighing. For example, EM is being used on catcher/processors in the BS pollock fishery to verify that salmon have been sorted and stored properly to enable observer sampling.

Another example of a compliance monitoring approach was a pilot project that was conducted in the West Coast trawl catcher vessel hake fishery (http://www.pcouncil.org/groundfish/trawl-catch-share-program-em/). The purpose of video monitoring was to verify compliance with a no discard requirement for hake. In this pilot project, the video appears to be able to detect discard events, although some events occurred outside of the camera view and a well-publicized discard event occurred when the camera was unplugged. There are also "operational" discards where the catch is not brought onboard and no solution for estimating these discard events currently exist. The compliance monitoring design, however, is simple.

In monitoring approaches to verify compliance with specific regulations, EM data can be reviewed when other sources of information suggest the need for review, through random audit checks, or anytime to verify that the EM system is functioning as required. The review can consist of only portions of the information that is recorded or it could be a review of all the information that is recorded. The intensity of the review depends on the need and available resources.

The advantages of EM as a compliance monitoring tool include: relatively low cost to both industry and the agency (especially after the initial years of implementation); depending on the compliance monitoring objective, the data storage and review requirements can be relatively low; and the tool can serve as an enhancement to enforcement that may not be able to do frequent patrols or at-sea boarding of vessels. The disadvantages include: the fact that these types of EM programs are not able to accomplish other tasks such as catch estimation; the compliance approach usually requires some other method such as observers, flow scale or e-logbook to gain the necessary fishery specific information; and special chain of custody requirements may make data storage and handling procedures more complicated since the data may be used for enforcement.

More details about how EM is being used in Alaska to monitor compliance for particular requirements are provided in Appendix B as well as other potential ways that compliance monitoring could be developed for other specific requirements, for example, to verify compliance with a gear handling requirement or a no-discard regulation.

#### *1.4.1.2 Compliance monitoring (audit) of self-reported data*

A different compliance monitoring approach is to require industry self-reported data and to use the EM to audit, or verify, compliance with the record keeping and reporting requirement. The EM program in the Canadian hook-and-line groundfish is the most well known example of this approach. In their program, the goal of requiring self-reported data in the logbook is to document species-specific catch of quota species in an Individual Transferable Quota (ITQ) program. To accomplish this goal, they required detailed logbook reporting by species and by set. All vessels have camera systems and a subset of footage is reviewed after landing by industry contractors to validate the logbook reports. A critical component of this program is that there are immediate financial penalties to individual fishermen for poor reporting in the logbook. If the audit of the self-reported data are not within a specified tolerance, then the entire video may require review and the individual fishermen bears this cost. Another important aspect of the program is a comprehensive dockside-monitoring component where species identifications are verified during offload.

This compliance monitoring approach has been shown to perform well for the species that are included in the audit review, and an advantage of the program is that is provides the public with assurance that self-reported data are being monitored for accuracy.

More information about how a compliance-monitoring program of self-reported logbook data might be implemented in Alaska, as well as a comparison of this approach to extraction of the video data, is provided in Appendix C.

### 1.4.2 Data Collection for Management and Science

The second broad approach is to use EM/ER tools to collect data that are used to manage fisheries and conduct scientific stock assessments. A primary management objective is to track catch and bycatch of fisheries (i.e., total catch accounting). Often there is a management demand for the catch accounting to occur very quickly, especially in catch share management programs that may necessitate near real time quota accounting. In other fisheries that are being managed in season by NMFS, catch accounting may occur within a week or two. In additional to total catch, managers also need spatial information about fishing locations, as well as data about fishing gear. Scientists also rely on fishery catch and bycatch data to estimate mortality, which is a critical component of stock assessments. Other important science data needs are dates, times, location, depth, and gear information that are used to estimate fishing effort; and biological data such as otoliths, scales, lengths, and weights that are used in stock assessments. The timeliness of data collected for science is generally less critical since most stock assessments are conducted on annual cycles.

Here we outline two scenarios where EM/ER could be used to collect data for management and science: near-real time data collection, and less time-critical approaches.

#### *1.4.2.1 Management data under a catch share program (near-real time)*

Catch share programs usually require near-real time access to data by agency and fishery participants; data that are not subject to wide variability on a day-to-day basis; and information that is frequently vessel-specific that can be legally defensible when holding a quota holder accountable for staying within their quota allocations. A combination of observer data and a suite of EM/ER tools have been used to accomplish these goals in multiple Alaska catch share programs. Information needs under catch share management programs, for both the industry and agencies, have also raised the bar for the level of timeliness and quality of the data collected by EM/ER and these technologies have advanced. Other projects have also sought ways to reduce observer coverage by using information collected from EM.

Suite of EM/ER tools in combination with observers

The Alaska Region has implemented several catch share management programs that include large EM/ER monitoring components (Appendix A). The suite of EM/ER tools that have been implemented include: Observer reporting (ATLAS) software for timely reporting of observer generated data; e-logbook for timely reporting of catch and area information; e-landings for timely reporting of landings data; flow scales to obtain the total weight of species caught; and, as described in the previous section, EM as a compliance tool to enhance observer data collection. These tools, in combination with observer data collection, provide a single authoritative record of the amount of quota harvested and have greatly enhanced the ability for NMFS and cooperative managers to monitor and manage catch and bycatch. These tools are costly to NMFS (e.g., IFQ crab reporting through e-landings requires significant agency support staff and infrastructure for development and maintenance) and to industry (e.g., the cost of flow scales installation and maintenance) and do require additional attention and time by industry (e.g., data entry for electronic reporting). However, these costs can be offset by the benefits of a catch share management program and without these EM/ER tools implementation of some catch share programs would not be possible.

EM/ER to reduce reliance on at-sea observers

To date, NMFS has not implemented any operational systems where video imagery is collected and information is extracted for fisheries management; although projects have tested the idea of using data from video for management of a catch share fishery. A series of pilot projects in the GOA rockfish fishery evaluated the use of video to quantify the amount (in weight) of halibut discard from trawl catcher vessels (McElderry et al. 2005, Bonney and McGauley 2008, Bonney et al. 2009). The Rockfish Program requires 100% observer coverage on catcher vessels in order to get vessel-specific estimates of halibut bycatch, which is a species that must be discarded in the trawl fisheries. The cost of the observer coverage is borne by industry. The EM pilot projects in the rockfish fishery sought to reduce the amount of at-sea observer days that were necessary while still accomplishing the vessel-specific accounting of halibut bycatch; although it was recognized that even with a fully implemented EM program, there was likely going to be some level of at-sea observer coverage needed to collect biological samples to inform stock assessments and collect fisheries interaction data on marine mammals and birds.

The pilot projects were able to demonstrate that EM can be used reliably in Alaska on a variety of vessels and that it was possible to quantify the discard of halibut from a single discard location on particular trawl vessels. However, the EM technology at the time the Rockfish Program pilot projects were conducted was not able to meet the stringent demands for data in a catch share fisheries management program, namely high quality data delivered quickly and cost-effectively. As an example, the costs for EM in the rockfish program was higher than observer coverage and the time lag to extract the halibut discard data from the video was unacceptable for NMFS and industry quota managers. Both the costs and the time lag were related to human review needed to obtain full census and length estimate of halibut bycatch. If automation of the video review was feasible then using EM under the catch share management approach might be more cost-effective and timely. To address this topic, NMFS conducted a video automation project that showed potential to lower analysis costs by reducing the review time necessary to obtain a census. However, the project identified issues related to crew sorting and video technology that led to some limitations in the automation results (Mamigo 2010).

In addition to timeliness, issues related to species identification and obtaining accurate weights and counts need to be addressed before EM can be implemented in a catch share management fishery. In the case of the rockfish fishery, only a single species, halibut, was being discarded and quantified by the video. However, depending on the information needs in other fisheries management programs, data may be needed for a variety of different species. For EM to be a valid approach in other catch share fisheries, it must be possible to quickly identify all species to the level they are managed. Many quota species, such as flatfish and rockfish, are very difficult to identify to species using EM. Also, many fisheries are managed by weight and not number of animals. Currently, a system for accurately obtaining weight of total catch in near real time has not been successfully established using EM.

Another example of EM being investigated for use in a catch share management program is the east coast multi-species sector fishery. The Northeast Fisheries Science Center (NEFSC) began a multi-year pilot program in 2010 to test EM technology to collect catch and fishing effort data aboard commercial vessels. The goal of the study was to evaluate the potential of EM to monitor retained and discarded catch on a real-time basis in the northeast groundfish sector fleet (NMFS 2011). This study identified a number of deficiencies that would first need to be addressed before EM technology could be considered in lieu of at-sea observers in the northeast multispecies fishery. Recommendations to improve data quality included the development of a more reliable EM system and modifications to how discarded catch was handled by the crew. The NEFSC stated that further research would also required to improve the accuracy and reliability of species identification and to reliably monitor weights of discard by species, and identified the need to analyze multiple data sources to improve their ability to validate and identify discrepancies between observer and EM-collected data. Given the issues identified under the first year of this pilot project, EM was not incorporated as a monitoring tool in the 2012 fishing year by the NEFSC.

#### *1.4.2.2 Less-time sensitive approach*

The other scenario where data could be extracted from video to be used for science and management would be in less time-sensitive fisheries. Like catch share programs, NMFS has not implemented any operational systems where video imagery is collected and information is extracted for fisheries management in non-catch share fisheries. However, there have been several projects that have evaluated the potential to obtain data from video to be used to estimate catch in fisheries where there was not an immediate (i.e., near real time) demand for the data: in Denmark work has been done to quantify discard (Dalskov 2010 ); in Alaska a series of projects has been done to evaluate the potential of EM as an alternative tool to monitor bycatch on Pacific halibut longline vessels (Ames 2005, Ames et al. 2005, Ames et al. 2007, Cahalan et al. 2010 and a study in Canada to investigate independent sampling based estimates of yelloweye rockfish catch in Canada (Stanley et al. 2011). Many of these projects cite common limitations of using video data that continue to constrain the usefulness of EM; 1) the inability to collect weight of discarded catch, 2) inability to collect biological specimens 3) the inability to determine precise species identification between common species similar in appearance. An assessment of the observer program monitoring activities for hook-and-line vessels in Alaska and the ability of current EM/ER technology to collect those data elements is provided in Appendix D.

Most recently, the Alaska Longline Fishermen's Association (ALFA) received funding through a grant from the National Fish and Wildlife Foundation for 2011 and 2012 to focus on EM integration logistics for the small vessel fixed gear fleet in southeast Alaska. ALFA have developed an approach and successfully integrated camera based EM systems on multiple vessels and fishing configurations. FMA staff provided initial technical review of the electronic monitoring information obtained by this study in 2011 and 2012. At the end of that time, many of the data quality issues identified by earlier studies described in this section were still present. These include lapses of EM video data, poor video quality that degraded during a trip unless camera lenses were clean periodically, and difficulty with identification of some fishes to species level. Authors of the study concluded that these systems could provide necessary information to inform retained and discarded catch. Although these EM systems have been shown to be effective if used in a logbook audit and compliance approach, there are many issues that would have to be first addressed before video information could be used for catch estimation.

The EM project underway in the North Pacific in 2013 builds on lessons learned from previous projects and is intended to address and/or evaluate these limitations in the context of fisheries operating in the North Pacific. Results will be used to inform the Council to determine the priority monitoring objectives, the potential capability of using EM or a combination of tools to meet specific objectives, and the level of EM that may be necessary to meet the monitoring objectives that cannot be obtained through observers or to supplement observer coverage where an observer deployment may not be feasible.

One way to increase efficiency and cost effectiveness would be to sample video data and estimate catch instead of census of all fishing events. To sample, video would be randomly selected to sample and those samples would be extrapolated to the entire haul or trip. In some fisheries sampling the video to extrapolate to total catch may not be a viable option, because EM is unable to determine total catch size or consistently estimate sample size. Sampling does hold potential for vessels whose units for gear can be readily determined from video, such as longline and pot or trap.

## 1.5 Strengths, Weaknesses, Opportunities, and Threats (SWOT) of Current State

The State University of New York’s Center for Technology in Government provides a short brief on SWOT analysis:

> “SWOT analysis is a simple framework to help answer the question, "What are the prospects for success?" The approach recognizes that any project should be examined for both positive and negative influences from internal and external perspectives. A SWOT framework prompts you to look in detail at both sides of the coin. That is, the strengths and weaknesses of your project are only meaningful in terms of the opportunities and threats in its environment.”

NMFS conducted a SWOT analysis to assess the current operational environment in which this EM strategic plan is being developed and implemented. In assessing our internal strengths and weaknesses, we considered “internal” to include NMFS and the North Pacific Fishery Management Council working together on EM/ER issues.

**Strengths (internal)**

- Leadership focus on EM advancement
  - Dedicated and capable staff
  - Success implementing performance based approaches in regulation
  - A committed Council
  - AK experience with EM/ER in a range of applications
  - AK experience advancing EM technology in survey applications
- AK reputation for doing things right
- NMFS investment in IT infrastructure
- Large-scale implementation of ER across Alaska
- Inter-agency collaboration on ER

**Weaknesses (Internal)**

- Lack of agreement on monitoring objectives, data needs, and priorities
  - Demands that do not take into account time for regulatory processes and scientific study to make informed decisions
  - Variable, and sometimes unrealistic, expectations of what EM can do
  - Lack of stable funding for EM
- Funding shortfalls, staff resources and competing demands on staff time

**Opportunities (external)**

- EM programs in place in other parts of the world
  - EM work emerging in other regions
- Collaborative fishing industry members who are eager to advance EM

Many advanced technologies that are mature and tested

Emerging technologies with high potential

Many potential partnerships to advance EM work

Various funding sources may be available

**Threats (external)**

Information demands can exceed the capacity of people or EM (census everything!)

An unpredictable federal budget environment

Data quality challenges (prove it!)

Maintaining chain of custody and data integrity

Confidentiality restrictions and protections

Competition for money and time

Industry and agency/Council objectives for EM may conflict

Lack of EM providers

# 2. STRATEGIC PLAN FOR EM/ER IN ALASKA

## 2.1 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.

## 2.2 Goals and Objectives

NMFS has identified the following goals, objectives, strategies and actions to implement electronic monitoring tools into the North Pacific fisheries-dependent data collection program. Goals address "How will the world be different" and this vision should not change greatly over time. In aggregate, the strategies and actions are designed to meet a specific objective and the cumulative achievement of objectives is intended to meet an overall goal.

### Goal I: NMFS has the infrastructure and regulatory requirements to support EM/ER operations

#### *Objective 1: Communicate through planning documents and processes*

Strategy A: Develop an EM/ER strategic planning document in collaboration with the Council to guide actions.

Action: Present EM/ER strategic plan to the Council for feedback.

Action: Periodically update the Council and public on the progress relative to the EM/ER strategic plan.

#### *Objective 2: Dedicate resources to support EM/ER data acquisition, post-processing, and integration*

Strategy A: Provide IT infrastructure that supports catch estimation and/or compliance monitoring.

Action: Develop accurate and timely EM data stream to support management.

Action: Maintain accurate and timely ER data stream to support management.

Action: Identify data storage and data processing methods.

Action: AFSC and AKR maintain database and information support staff as part of agency infrastructure.

Strategy B: Assign EM development work to scientific staff for a comprehensive assessment, evaluation, and advancement of technologies.

Strategy C: Include EM and IT support staff in planning and budget requests for offices with data stewardship responsibilities.

Action: Request distinct EM staffing and budget for FY14.

### *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 work on regulation development.

Action: Develop vessel monitoring plans, maintenance protocols and operator responsibilities.

Strategy B: Adapt and improve existing EM/ER regulations to ensure compatibility with emerging technology and changing fisheries management

Action: Evaluate at-sea flow scale regulations and approval requirements.

Action: Evaluate regulations for EM/ER on freezer longline vessels (flow scales, video, and e-logbook).

Action: Review and improve existing regulations where EM is required in Alaska (Amendment 91, bin-monitoring).

Action: Evaluate VMS type approval process.

### *Objective 4: Secure funding to advance EM/ER technologies and use*

Strategy A: Monitor and initiate action on opportunities within NMFS for internal funding.

Action: Develop RFP system within NMFS for National Observer Program money dedicated to EM efforts.

Action: Apply for internal cooperative research and other funding sources to supplement 2013 EM work.

Action: Secure AKR and AFSC funding to conduct 2013 EM pilot work.

Action: Apply for Fishery Information System project funding (e.g., integrate flow-scales with other technologies, other EM/ER work).

Strategy B: Apply for external grant funding through appropriate sources

Action: Submit NPRB proposals in response to RFPs.

Action: Look for other grant funding opportunities.

Strategy C: Use observer fees to fund research and development.

## Goal II: NMFS is advancing cost-effective EM/ER capabilities through science-based studies and technological developments

### *Objective 1: Conduct scientific research to advance the science of monitoring and data integration*

Strategy A: Improve catch estimation methods by incorporating data gathered through electronic monitoring.

Action: Evaluate broad e-logbook coverage and technology that independently records specific catch location and total effort for improved specification on post strata assumptions and catch rates to support stock assessments.

Action: Develop potential algorithms to estimate or inform discard in the Catch Accounting System.

Action: Evaluate catch estimation assumptions and post-stratification processes.

Strategy B: Develop methods that can improve EM data to fill existing gaps such as length compositions, species identifications, and fish weights.

Action: Develop performance standards for species identification.

Action: Build a stereo camera system (PSMFC funding support) to provide a prototype for testing automated review and collection of length compositions.

Action: Develop vessel monitoring plans to improve ability to identify and quantify discard through discard control points.

Action: Develop procedures where crew could potentially collect random samples.

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.

Strategy D: Provide support to partners in cooperative research and industry volunteers.

Action: Assist in providing technical support and guidance to fishing industry and other constituent research initiatives (e.g., two 2012 NFWF grants, EFPs).

### *Objective 2: Reduce costs by gaining efficiencies in data processing and/or improving data quality*

Strategy A: Develop automated review and data extraction technologies to reduce costs, improve timeliness, and improve data quality.

Action: Collaborate with other AFSC staff to develop image processing applications (automated species ID and length estimation).

Action: Identify potential efficiencies in data processing and improving data quality such as automated review and data extraction technologies.

Action: Build a stereo camera system (PSMFC funding support) to provide a prototype for testing automated review and collection of length compositions.

Action: Identify minimum image quality standards necessary for data extraction.

Strategy B: Identify fish handling practices and integration methods that will facilitate automation and improve data quality.

Action: Collaborate with industry to develop Vessel Monitoring Plans.

### *Objective 3: Understand all aspects of costs associated with EM technology integration, implementation, and processing*

Strategy A: Evaluate associated costs of the 2013-14 pilot study.

Action: Track project expenditures to inform potential logbook audit approach or sample-based approach to inform discard.

Action: Determine cost to support EM such as port sampling and programming personnel, data storage, post-processing, hardware, maintenance and installation.

Action: Determine cost benefit ratios for various fleets or fleet sectors where EM could provide improvements or cost savings compared to observer coverage.

Action: Identify ways to reduce costs and improve cost efficiencies.

Strategy B: Evaluate costs of existing EM programs in the North Pacific.

Action: Track NMFS costs.

Action: Identify fishery participants' costs.

Strategy C: Evaluate trade-offs of using observer fees to fund EM systems versus human observers.

Action: Evaluate impacts on observer deployment and coverage rates of using observer fees for EM.

## Goal III: NMFS has a cost-effective, adaptable and sustainable fishery data collection program that takes advantage of the full range of current and emerging technologies

### *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.

Action: Write implementing regulations.

Action: Implementation, roll out, outreach.

Strategy B: Expand use of e-logbooks to increase the timeliness and fill data gaps.

Action: Implement e-logbooks in the freezer longline fleet.

Action: Develop a catcher vessel e-logbook.

Action: Evaluate logbook requirements and evaluate whether to expand paper and/or electronic logbook requirements.

Strategy C: Expand observer data entry application (ATLAS) requirements to improve the quality and timeliness of observer data.

Action: Analyze adding an ATLAS requirement for AFA catcher vessels.

Strategy D: Continue ongoing development and support of e-landings system.

### *Objective 2: Implement EM/ER technology where appropriate and cost-effective to enhance compliance monitoring*

Strategy A: Monitor, evaluate and improve existing ER compliance monitoring programs.

Action: Perform periodic audits to ensure and improve system performance for freezer longline fleet, Amendment 80, Amendment 91, and Rockfish Program.

Strategy B: Expand use of EM in compliance applications.

Action: Evaluate EM for compliance monitoring in shoreside pollock fisheries (see Appendix B).

### *Objective 3: Improve procedures, methods or technology to enhance quality of EM data*

Strategy A: Evaluate and develop solutions to incrementally improve EM and data quality.

Strategy B: Address challenges to managing a fishery using an integrated system approach that incorporates data collected through a variety of sources that includes electronic reporting (e.g., e-ticket, e-logbook, VMS, and sensors), video systems, scales, and observers.

Action: Work with EM subcommittee to evaluate data needs and data collection approaches.

## Goal IV: The Council and NMFS leverage global EM/ER developments while sharing AK perspectives with others

### *Objective 1: Learn from the experience of others*

Strategy A: Organize and participate in local, national, and international forums on EM/ER and fishery dependent systems.

Action: EM panel participation at IFOC and other international forums.

Action: Participate in regional, national, and international workshops and committees.

Action: Develop EM subcommittee of NOPAT to inventory and track national EM efforts.

Strategy B: Collaborate with partner organizations.

Action: Meet periodically with Pacific States Marine Fisheries Commission, ADFG, other NOAA entities.

### *Objective 2: Influence and inform monitoring policies*

Strategy A: Assist in national EM policy and procedures.

Action: Work on the NMFS draft policy and procedural directives.

Strategy B: Engage in Council processes which inform monitoring policy.

Action: Work with the OAC and OAC sub-committee on issues of onboard catch handling procedures and technology integration or any other tasks assigned by the Council.

Action: Ensure staff members are engaged in standing Council or Agency advisory committees that involve monitoring.

Action: Develop thorough Monitoring and Enforcement sections of analytical documents.

# 3. IMPLEMENTING THE STRATEGIC PLAN

Our vision of the future may include numerous EM/ER tools that are incorporated into the North Pacific data collection program to support stock assessments and management of fisheries operating in the North Pacific. This strategic plan outlines the goals and objectives and the specific actions that it will take to accomplish these goals and objectives to achieve our vision.

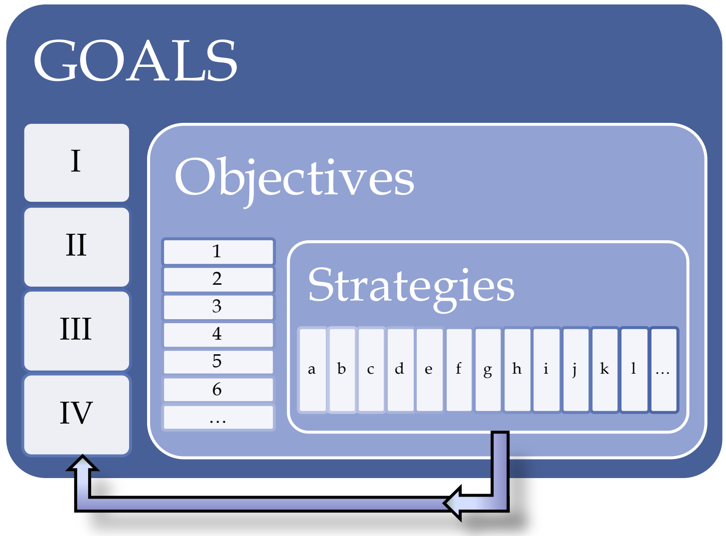


**Figure 1. -- Hierarchal nesting scheme of the Strategic Plan goals, objectives, and strategies.**

The strategic plan enables individual projects, or action items/steps, to be mapped back to the strategies, objectives, and goals. The nested hierarchal design (Fig. 1) provides for flexibility where specific strategies or actions can be periodically added or removed to account for changes in technology and application and/or as priorities change.

**2013-2014 EM PILOT PROJECT**

The first step in developing an EM/ER program is to fully understand current EM/ER capabilities and advance these technologies through science-based studies and technological developments.

In 2012, NMFS designed a video-based electronic monitoring project to achieve the Council's objective of "collecting at-

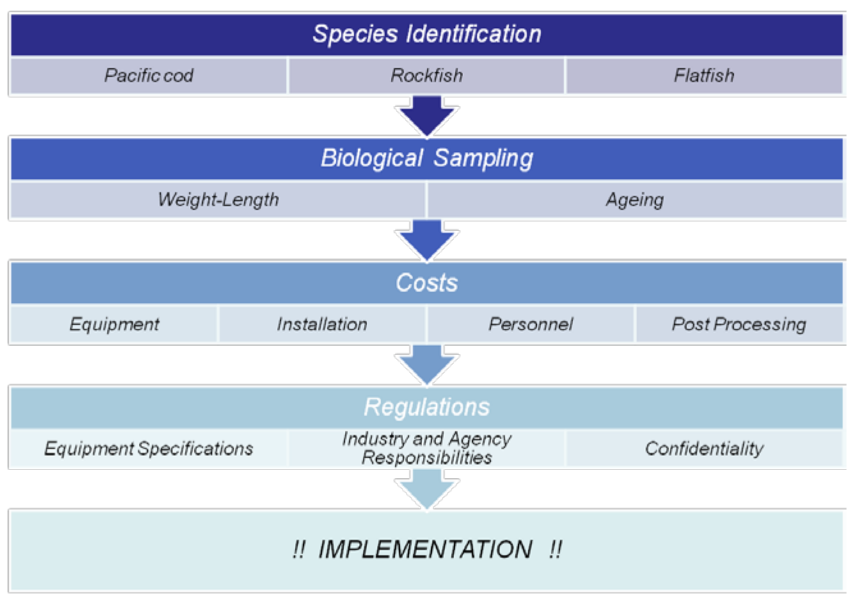


**Figure 2. -- Project benchmarks for the 2013-14 less than 57.5' IFQ fleet.**

sea discard estimates from the 40’ – 57.5’ IFQ fleet” and “explore other EM options that may be appropriate to replace or supplement human observers”.

This project began deployment of video-based EM systems April 1, 2013 and will continue through 2014. It is designed to inform the logistical integration of camera-based systems into the fishery, establish data storage requirements and data processing procedures for implementing a video-based EM program. The goals of this project are to test the feasibility of EM to gather information on the location and magnitude of catch and discard on small (< 60 ft) hook-and-line vessels and to develop the infrastructure and regulations to integrate EM into catch accounting. Information from the video cameras, GPS, and autonomous gear sensors will be used to:

- Estimate haul-specific amounts of catch and discard
- Collect data on fishing effort (locations fished, time fished, etc.)
- Develop performance standards for regulations. For example, specific regulations will describe vessel operators' responsibilities for maintenance of the system, installation requirements for camera placement and specific hardware/software specifications.
- Test integration of camera data into the information that is used for catch accounting and fisheries management, including data storage requirements and data processing procedures that are needed to extract data from video images.
- Determine costs associated with the EM systems, including installation and replacement.

Most importantly, it is designed to evaluate and address universal challenges in using video data to establish or estimate discard. Major challenges include: 1) inability to accurately identify species; 2) inability to obtain weights of discarded fish; 3) time required to obtain and review video and extract all requisite information; and 4) inability to collect biological samples from discarded catch. Without first addressing these issues, it is not possible to fully develop potential strategies to utilize data for either establishing discard through a compliance program (Canada’s logbook audit program) or through video estimation procedures. This information will be required prior to developing methods that could potentially incorporate these data into the catch accounting system.

Another important focus for the 2013-14 EM project is to evaluate cost information. Project costs will be used to inform cost benefit ratios in order to evaluate the relative scale and potential target fishery of the program prior to implementation. We will also be developing performance standards (video, species ID, responsibilities, etc.) and required EM/ER integration procedures/protocols for specific vessel layout and design. Only after this step is taken can we then establish performance standards for which to base regulatory requirements on that will be required to support an EM data collection program to inform discard, stock assessments, or management.

**INNOVATIONS (R&D)**

NMFS is also evaluating a number of innovations in both image analyses and hardware that could dramatically improve collection of video data and post-processing of those data. We are currently assessing the potential to automate capture of single catch events and provide length composition through image processing techniques of both stereo and non-stereo images. We believe image processing in real time has great promise to greatly reduce processing time, storage requirements and enable collection of length composition that could be used to infer weight of discarded species. We will also be investigating in software applications that use wireless technologies to automate data acquisition through download from vessels landing catch in ports where wireless services exist. The combination of technology advances, continued price reductions in hardware, and development of image analysis applications have great prospect to drastically change the cost benefit ratio of collecting and processing video images to inform discard or provide near-real time catch information on temporal and spatial distribution of fishing effort. These studies are critical to promote Strategic Plan Goal II to advance technologies and Goal II that NMFS has a cost-effective, adaptable, and sustainable fishery data collection program that takes advantage of the full range of current and emerging technologies. Research and Development efforts are supported through funding from the NMFS and the Pacific States Marine Fisheries Commission (PSMFC) and the North Pacific Research Board.

**DISSEMINATION OF PROJECT RESULTS**

The diagram to the right (Fig. 3) provides a conceptual flow of how study results will be disseminated through the Council. We expect that project results from the previous years' studies, advances in research and development

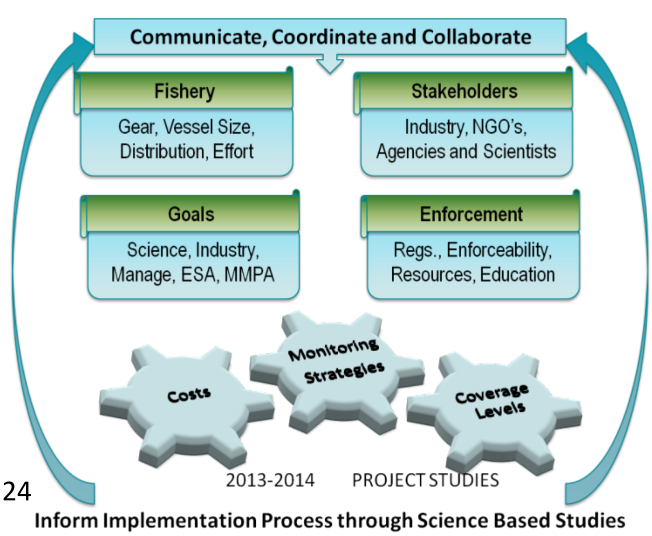


**Figure 3. -- Conceptual flow of how study results will inform the public process and decision-making.**

will be presented to the OAC and the Council each April. These results will provide critical information for making informed decisions on the future of EM/ER in the fishery.

**TIMELINE**

The timeline for implementation of any EM/ER is highly dependent upon results from current studies including advances in research and development, complexity of the program, and funding. The timeline presented below (Fig. 4) should be used as general guideline for a fairly complex program. The timeline is intended to map general scientific and management objectives that will be addressed through study and public process.

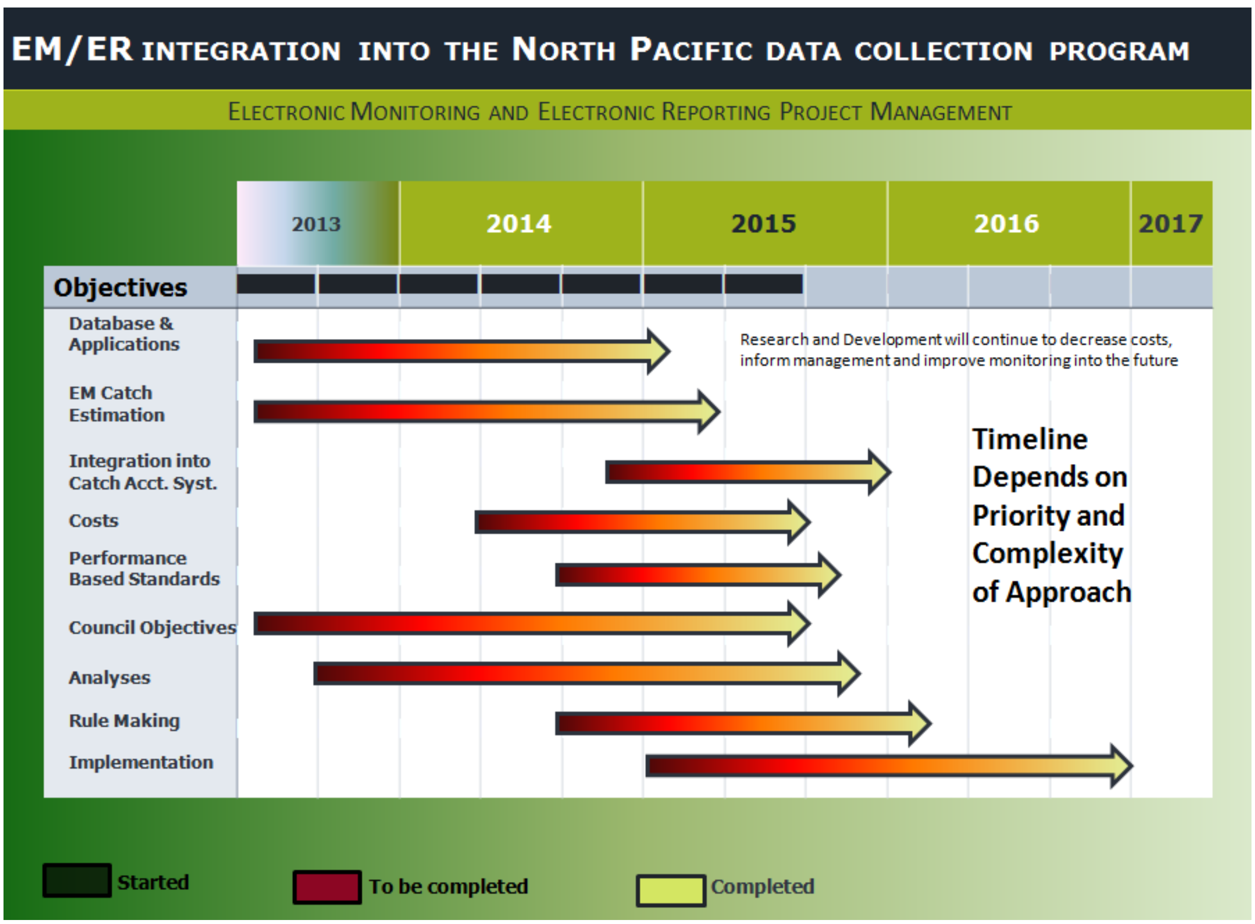


**Figure 4. -- A generalized EM development timeline in the North Pacific, the specific timeline will depend on the complexity of the EM approach.**

# 4. CITATIONS


Alaska Fisheries Science Center (AFSC). 2008. Electronic Fisheries Monitoring Workshop Proceedings, Seattle, WA. July 29-30, 2008. Available: http://alaskafisheries.noaa.gov/scales/elecmonworkshop_proceedings2008.pdf

Ames, R. T. 2005. The efficacy of electronic monitoring systems: a case study on the applicability of video technology for longline fisheries management. International Pacific Halibut Commission Scientific Report 80. Available: http://www.iphc.int/publications/scirep/SciReport0080.pdf

Ames, R. T., G. H. Williams, and S. M. Fitzgerald. 2005. Using digital video monitoring systems in fisheries: application for monitoring compliance of seabird avoidance devices and seabird mortality in Pacific halibut longline fisheries. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-AFSC-152, 93 p. Available: www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-152.pdf

Ames, R. T., B. M. Leaman, and K. L. Ames. 2007. Evaluation of Video Technology for Monitoring of Multispecies Longline Catches. N. Am. J. Fish. Manage. 27:955–964.

Bonney, J. and K. McGauley 2008. Testing the use of electronic monitoring to quantify at-sea halibut discards in the central Gulf of Alaska rockfish fishery. EFP 07-02 Final Report. Available: http://alaskafisheries.noaa.gov/sustainablefisheries/efp/efp0702_em_halibut.pdf

Bonney, J., A. Kingsolving, and K. McGauley 2009. Continued assessment of an electronic monitoring system for quantifying at-sea discards in the central Gulf of Alaska rockfish fishery. EFP 08-01 Final Report. Available: http://alaskafisheries.noaa.gov/sustainablefisheries/efp/efp08-01_halibutdiscards_rpt.pdf

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 Tech. Memo. NMFS-AFSC-213, 66 p. Available: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-213.pdf

Dalskov, J. 2010 Workshop on Fully Documented Fishery, National Institute for Aquatic Resources, Technical University of Denmark, Final Report. Kinsolving, Alan. 2006. Discussion Paper on Issues Associated with Large Scale Implementation of Video Monitoring. Presented to the North Pacific Fishery Management Council, April 2006. Available: http://www.aqua.dtu.dk/~/media/Institutter/Aqua/Publikationer/Forskningsrapporter_201_250/221_2010_workshop_on_fully_documented_fishery.ashx

Kinsolving, A. 2006. NMFS Discussion Paper on Issues Associated with Large Scale Implementation of Video Monitoring presented to North Pacific Fishery Management Council. Available: http://alaskafisheries.noaa.gov/sustainablefisheries/em/longtermem.pdf

Mamigo. 2010. Final Report to Contract# HA133F10SE1558. Trainable Video Analytic Software. Unpublished report prepared for the National Marine Fisheries Service by Mamigo, Inc., Lawrenceville, NJ.

McElderry, H., R. Reidy, J. Illingworth, and M. Buckley. 2005. Electronic Monitoring of the Kodiak, Alaska Rockfish Fishery, a Pilot Study. Unpublished report prepared for the National Marine Fisheries Service by Archipelago Marine Research Ltd., Victoria, BC and Digital Observer, Inc., Kodiak, AK. 43 p.

McNamara, C. 2007. Field Guide to Nonprofit Strategic Planning and Facilitation, Third Edition. Authenticity Consulting, LLC. Minneapolis, MN, USA. 277 p.

MRAG Americas. 2004. Appendix I to the EA/RIR/IRFA for BSAI Amendment 86/GOA Amendment 76: Extension or Modification of the Program for Observer Procurement and Deployment in the North Pacific, public review draft, May 12, 2006. Appendix I: Fisheries Monitoring Technologies of a report prepared for the NPFMC by MRAG Americas, April 2004. Available: http://alaskafisheries.noaa.gov/sustainablefisheries/em/emtech0111.pdf

NOAA Fisheries Office of Policy & Electronic Monitoring Working Group. 2013. Electronic Monitoring White papers. Available at http://www.nmfs.noaa.gov/sfa/reg_svcs/Councils/ccc_2013/K_NMFS_EM_WhitePapers.pdf

Northeast Fisheries Science Center (NEFSC). 2010. Agency cover letter and contractor report are available at: http://www.nefsc.noaa.gov/fsb/ems/2010_EMS_REPORT_FINAL.pdf

North Pacific Fishery Management Council (NPFMC) and National Marine Fisheries Service (NMFS). 2007. Allocation of Non-Pollock Groundfish and Development of a Cooperative Program for the H&G Trawl Catcher Processor Sector. Environmental Assessment / Regulatory Impact Review for Amendment 80 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area. Available: http://www.fakr.noaa.gov/sustainablefisheries/amds/80/earirfrfa0907.pdf

National Marine Fisheries Service. 2011. Use of Electronic Technologies in Alaskan Fisheries. White paper presented to the North Pacific Fishery Management Council. Available: http://alaskafisheries.noaa.gov/sustainablefisheries/em/emtech0111.pdf

Stanley, R.D., H. McElderry, T. Mawani, and J. Koolman. 2011. The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. ICES J. Mar. Sci. doi: 10.1093/icesjms/fsr058. Available: http://icesjms.oxfordjournals.org/content/early/2011/05/09/icesjms.fsr058.full.pdf+html

## Appendix A: Existing monitoring tools in the North Pacific fisheries

The following table summarizes the existing monitoring tools currently implemented in the North Pacific fisheries. Please note that the catch share programs require a more intensive suite of tools for management.

There are many improvements and cost efficiencies that could be realized through automation and electronic transfer of both e-logbook and ATLAS information where it is currently not required. Expanded implementation of these tools could add real value to our scientific data

**Monitoring Tools**

| Program | Fishery | Paper logbook [1] | E-logbook | Flow Scale | VMS | Video | Observer Coverage | 2nd observer | ATLAS |
|---|---|---|---|---|---|---|---|---|---|
| Catch Share | AFA CPs/motherships | N | Y | Y | Y | Y | 100% | Y | Y |
| | BSAI Trawl CPs in H&G | Y | Y - voluntary | Y | Y | Y | 100% | Y | Y |
| | CGOA Rockfish CP | N | Y | Y | Y | Y | 100% | Y | Y |
| | BSAI P.cod Freezer Longliner | N | Y | Y | Y | Y | 100% | Y | Y |
| | CR Crab CP | Y | N | Y | Y | N | 100%- not NMFS | N | N |
| | AFA CVs | Y | few- voluntary | NA | Y | N | 100% | N | Y[3] |
| | CGOA Rockfish CV | Y | N | NA | Y | N | 100% | N | Y |
| | IFQ CP Sablefish | Y | N | N | Y -AI only | N | 100% | N | N |
| | IFQ CP Halibut | Y | N | N | Y -AI only | N | 100% | N | N |
| | IFQ CV Sablefish | Y | N | NA | Y -AI only | N | Partial | N | N |
| | IFQ CV Halibut [2] | Y [2] | N | NA | Y -AI only | N | Partial | N | N |
| | IFQ CV Halibut and Sablefish <40' LOV[3] | Y [2] | N | NA | Y -AI only | N | None | N | N |
| Non-Catch Share | BSAI CP Longline Turbot | Y | N | N | Y | N | 100% | N | Y |
| | GOA CP Trawl | Y | Y- voluntary | N | Y | N | 100% | N | Y |
| | GOA CP Longline | Y | Y voluntary | N | Y | N | 100% | N | Y |
| | BSAI CV Trawl P.cod | Y | N | NA | Y | N | Y-voluntary | N | N |
| | GOA CV Trawl | Y | N | NA | Y | N | None | N | N |
| | GOA CV Longline | Y | N | NA | Y | N | None | N | N |
| | CP Pot | Y | N | N | Y | N | 100% | N | Y |
| | CV Pot >=40' LOV | Y | N | NA | Y | N | Partial | N | N |
| | CV <40' LOV | N | N | NA | Y-AI only | N | None | N | N |
| | Jig | Y | N | NA | Y-AI only | N | None | N | N |

*1-Paper logbooks are required by NMFS for vessels >60ft*

*2-Paper logbooks are required by IPHC for vessels >26ft fishing for halibut; vessels >60ft are also required to submit paper logbooks by NMFS and there is a shared IPHC-NMFS paper logbook.*

3-Length of Vessel (LOV)

*4-Atlas is required for vessels over 125 LOV, but many vessels voluntarily use ATLAS*

# Appendix B: Compliance monitoring and electronic reporting options to inform management and/or supplement observer data collection

Electronic Monitoring (EM) is currently being used in three different compliance monitoring applications in Alaska and in all of these cases EM is being used in conjunction with other monitoring tools (e.g., e-logbooks, flow scales) and full observer coverage. The combination of these data collection and verification methods enables catch accounting at vessel-specific levels in near-real time. Here we describe some additional compliance monitoring objectives where EM could be used to replace or supplement observers. There are likely many other examples of regulations that have potential application for EM, and the North Pacific Fishery Management Council (Council) may wish to ask enforcement personnel, or the enforcement committee, to discuss this concept and identify regulations that are high priority where EM could assist. In short, any required behavior that can be monitored by sight, has potential to also be monitored using camera technology. The compliance monitoring programs currently in place and some potential additional options are summarized in Table B-1.

**Catch Sorting**

Three programs have been implemented in Alaska where EM is being used to monitoring compliance with catch sorting requirements. In the Rockfish and Amendment 80 programs, EM is used on trawl catcher/processors to verify that no pre-sorting of fish in bins has occurred before the observer has had the opportunity to sample the catch. Under Amendment 91 in the Bering Sea, EM was implemented as a tool on AFA catcher/processors to verify compliance with sorting and storage of salmon bycatch. The storage requirements enable observers to identify species, obtain a census count and collect biological samples from salmon.

EM is also being used on longline catcher/processors which catch and process Pacific cod in the BSAI. If vessels are using motion-compensated scales to weigh Pacific cod, then they are required to maintain a video system to monitor sorting and flow of fish over the flow scale. NMFS is also considering using EM to verify proper flow scale use and maintenance for all vessels that use a motion-compensated flow scale.

**Full Retention**

The OAC has previously identified the GOA shoreside pollock fishery as a good candidate for monitoring as it most closely resembles a “full retention” fishery. Pollock discards are very limited (although there are times when there is mandatory discard of Pollock), salmon bycatch are now required to be landed, and the fish are primarily handled in specific deck areas which could be viewed by cameras. If discard is negligible and cameras are proven to be able to fully monitor all deck handling areas on deck, observers may not be needed on the vessels. This approach has been extensively tested on the West Coast in the Pacific whiting fishery and has very similar characteristics to the shoreside pollock fishery.

Note that a lesson learned from the Pacific whiting fishery is that the camera systems could be disabled. In one publicized event, a high bycatch event occurred, the camera was disabled, and the bycatch was subsequently discarded. The event was detected when the bycatch washed up on the beach. Subsequent investigation revealed the facts. Regulations would need to be developed to control this potential behavior.

This approach could also be considered in the Bering Sea shoreside pollock fishery. However, complexity increases with increasing ship size. For example, larger vessels may have more elaborate sorting processes which occur before fish are placed in refrigerated seawater tanks. For example, some have sorting belts which run from the deck into internal sorting areas prior to the fish going into storage tanks. These more complex operations would increase the complexity and costs associated with monitoring using cameras, and may not prove to be cost-effective.

This no-discard monitoring approach could be considered in the currently un-observed catcher vessels delivering to motherships. These catcher vessels have historically been exempt from observer coverage in Alaska as they deliver unsorted codends to motherships. In contrast, the Northwest Region required observers on these same vessels when fishing in Northwest waters and they are exploring the use of cameras instead. They report that limited discard does occur on catcher-vessels in the whiting fishery with 90.5 t in 2012 and 175.2 t in 2011. Please note that when discard does occur, the camera systems would have limited capacity to quantify that discard, or to identify what species were present in the discard.

**Gear Handling**

There are several regulations that exist in Alaska where EM could be used to monitor for compliance with gear handling requirements. For example, regulations that require fisherman to deploy streamer lines for seabird avoidance, to carefully release halibut bycatch, and to not use de-hooking devices are all behaviors which could be monitored with technology.

Current camera systems allow for high-resolution, wide-angle 360 degree capture of images. One, and possibly two cameras, installed above the deck of an open-decked catcher vessel can view both the setting and retrieving of longline gear. Potentially, compliance with careful release regulations, streamer deployment requirements could be accomplished via cameras. An appropriate video review program would need to be established to ensure effective detection and follow up action to have a deterrent effect.

**Area Closures**

EM in the form of Vessel Management System (VMS) has been used for many years as a tool for monitoring time and area closures. A current Council paper summarizes the current status and additional capacities of VMS (NOAA 2013). However, one important point is that the internal infrastructure to support VMS is in place and functioning. Internal infrastructure costs are an important consideration in the development of any new systems. This tool could be implemented at any time.

Alternatively, integration of EM with GPS systems, or GPS data-loggers alone, may provide after-the-fact, but near real-time position information comparable to VMS.

Table B-1. -- Compliance monitoring objectives that are currently being achieved using EM and potential objectives and fisheries where EM could be used to supplement or replace observers in the future.

| Data Need | Compliance Monitoring Objective | Fisheries Where implemented | Supplement/Replace Observers? |
|---|---|---|---|
| Verify proper catch sorting and weighing procedures | Video monitoring to verify that crew is not sorting catch inside the live tanks. Sorting is prohibited so that observers can obtain an unbiased sampled. | Catcher/processors (CPs) in Rockfish and Amendment 80 Programs | Enable observer data collection |
| | Video monitoring to verify that all salmon are sorted and retained to enable census and genetic sampling by an observer. | AFA CPs fishing for BS pollock | Enable observer data collection |
| | | | |

| | | | |
|---|---|---|---|
| | **Video monitoring to ensure all** Pacific cod are weighed on the motion-compensated flow scale | Longline CPs fishing for Pacific cod in BS | Supplement observer data collection |
| | Video monitoring to ensure proper flow scale testing and use. | Being considered in revision to flow scale regulations | Supplement observer data collection |
| Verify compliance with full retention regulations | Video monitoring to verify that no fish were discarded | Not currently implemented in Alaska. Pollock catcher vessels in the GOA and BS are potential fisheries where this approach might be applied. | Replace vessel observers. Instead, observer sampling could occur in shoreside processing plants |
| Verify gear handling Requirements | Verify compliance with regulations to deploy streamer lines, carefully release of halibut, and to not use de-hooking devices | Not currently implemented in Alaska. | Supplement observers |
| Area closures | VMS provides a specific tool that provides tamper evident reporting of vessel positions in real time, on a defined and automated reporting schedule. The information is captured in and OLE data system and used to support enforcement of time/area closures. System requirements are well known and defined elsewhere. There are secondary uses for science and management | There are many examples in AK where VMS is required in order to monitor the location of vessels in relation to area restrictions | Supplement observers |

# Appendix C: E-logbook audit compared to catch estimation approach using EM

This Appendix is intended to provide information to support an informed discussion of the relative merits for choosing a monitoring approach best suited for fisheries in the North Pacific. There are significant tradeoffs that will need to be considered and the Councils' choice will largely control how NMFS directs future resources and rule-making to support development of the desired approach.

As was described in the section on EM approaches, there are potentially two distinct approaches where discard is either based on self-reported data (Audit) or where discard is estimated using data extracted from video (Estimation). The Audit-based approach utilizes logbook data for catch accounting and the Estimation approach uses data extracted from the video recordings to estimate discard. In both cases, a combination of EM/ER would be required on the vessel. However the amount of observer coverage and where the observers sample (at-sea or in port) could vary greatly and would largely depend on funding and cost controls. Either approach could possibly be applied to the Council's EM management objective of collecting at-sea discard estimates from the 40' – 57.5' IFQ fleet, but could potentially be applied broadly to any fishery where catch is serially caught and discarded. Vessels operating outside the pool of vessels targeted for these approaches would still be required to carry an observer to ensure collection of a suite of information that an observer collects that video data cannot (Appendix D).

<u>Potential model for e-logbook audit with EM/ER (compliance monitoring)</u>

A subset of vessels would be required to carry a suite of EM/ER tools for an entire year and deliver to a subset of ports in Alaska to control costs and make the program efficient and affordable. The suite of EM/ER tools would include video, sensors, and an e-logbook. In order for the program to be implemented quickly, NMFS would require a full retention requirement (except for PSC). The captain or other authorized crew member would be required to identify everything caught and discarded on the line to the same level an observer would be required to without having the fish in hand and record these species in an e-logbook that would be submitted at the end of every trip. The captain or assigned crew would also be required to record disposition. Port samplers would be required at each of the designated ports to verify that the retained species are recorded correctly both in number and in species. EM would be used to audit a set portion of the self-reported logbook data to verify species-specific logbook enumeration of retained and discarded fish. Questions related to species ID would still need to be answered to ensure the quality of the logbook audit.

Since there would likely be substantial penalties in the logbook-audit model associated with incorrectly identifying and enumerating discard in the logbook there would also need to be a period of time of approximately 2 years for training crew and vessel operators. This will be required to help ensure positive identification and enumeration of catch to a specific species with a high degree of accuracy while not putting substantial penalty on the Industry during startup. This approach has been shown to be a precise method for enumerating discard for a defined list of target species and is used in Canada to monitor precise vessel quota's in-season (Stanley 2011)

Estimation-based monitoring approach using video to estimate discard rates in a fishery

This approach has not been used for any fishery under NMFS jurisdiction and methods are currently being developed using information collected in NMFS 2013-14 EM/ER projects in the North Pacific. Data collected from these studies are required to define capabilities and methodology of applying this approach to a fishery. It remains unclear whether this approach can be applied to any fishery at this time, but potential cost savings relative to an Audit-based approach could be very large. Methods would likely be based on similar observer data collection procedures for estimating discarded catch using video data instead of an observer. High image quality will be required to ensure precise and consistent identification of both retained and discarded catch. High image quality also minimizes the cost of post-processing and data storage and supports development of an image processing application that automatically identifies species or species group in the future.

Given limitations of collecting high quality video necessary for species identification under difficult and often changing environmental conditions, this approach will require all hooked fish to be brought onboard. Retained and discarded catch would be required to be separated onboard and then flow past either a video camera designed to record discard or one designed to record retained catch under a controlled environment and lighting conditions. Cameras would be mounted above simple chutes or complex belt driven operations and therefore adaptable to most fishing operations. Vessel operators would be required to record species and weight/length of any drop-offs in the e-logbook. A compliance camera would be used to ensure handling procedures are followed. As with the Audit-based system, an e-logbook would have to be maintained and hydraulic sensors installed to ensure accurate accounting of catch location and effort. Dockside monitoring would not be required in the estimation approach.

Automation of video processing

The current approach to processing video requires video data to be sent to NMFS for post-processing where a video reviewer streams video data on a monitor to find catch events which are then identified to species. This information is then entered into a database along with the location, date and vessel specifics that is used to enumerate species and produce catch statistics. Image processing applications for extracting catch events have been developed that we are hopeful can be applied to fisheries that will allow for onboard processing of video data that extract individual catch events and store only those images. This will greatly improve our ability to devise a cost effective and sustainable approach for video monitoring of fisheries in several ways including; 1) reduce post-processing costs 2) reduce data storage costs 3)reduce data storage requirements onboard and therefore enable data collection for very long periods of time and 4) automate length measurements to estimate average weight. However, there remain a number of challenges that first have to be addressed before discard data collected from video will be sufficient to support estimation procedures. Finding solutions to these challenges and developing performance standards to support rulemaking are the focus of our study efforts in 2013 and 2014.

Comparison of two approaches

There are substantial differences and tradeoffs between these two approaches (Table C-1, C-2, C-3).Based on our understanding of current technology and requirements for a logbook-audit system this approach could be accomplished with existing camera and sensor technologies. However, both approaches would require a substantial amount of time to vet through the public process and write the regulations (1 year minimum). A key question that would need to be answered if logbook-audit approach was going to be implemented in Alaska is how to pay for the cost of the logbook auditing, and how, or if, the same financial incentives that exits in the Canadian program could be implemented in Alaskan fisheries. In the Canadian program, there is extra cost to individual fishermen if the audit reveals a large difference between the self-reported logbook data and the EM data. In these cases, the entire video from the trip may be reviewed and the fisherman pays for this extra review. This system provides a financial incentive to the fishermen to report as accurately as possible in their logbook and has shown to increase the quality of the self-reported data. The regulatory framework for implementing this type of an approach in Alaska has not been vetted and would likely need input from NOAA General Counsel.

Table C-1. -- Comparison of the requirements for a logbook audit approach to establish total discarded weight by species versus an estimation-based monitoring approach using video to estimate discard rates in a fishery.

| Required Elements | Logbook Audit-based[1] | Video Estimation-based |
|---|---|---|
| Logbook | Y | Y |
| EM sensors | Y | Y |
| Video imagery | Y | Y |
| Species weight | Y | Y |
| Hails | Y | N |
| Dockside monitoring | Y | N |
| Port sampling | Y | N |
| Complex scoring/audit | Y | N |
| Catch based on self reported data | Y | N |

1 Stanley, R.D., H. McElderry,T. Mawani and J. Koolman. 2011. The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. ICES J. Mar. Sci. doi: 10.1093/icesjms/fsr058

Table C-2. -- Comparison of general considerations between the logbook audit approach estimation-based monitoring approach using video to estimate discard rates in a fishery.

| General Considerations | Logbook Audit-based | Video Estimation-based |
|---|---|---|
| Scalability is a function of | Ports/Fisheries/Season | Rate/Fishery/Season |
| Coverage flexibility | Difficult | Easy |
| Dependence on compliance | High | Low |
| Species ID limits | Species on audit scoring list | Any identifiable species |
| Industry support and training | 3 years | 1 year |
| Potential cost controls | Audit rate/Scoring list | Sampling rate |
| Precision | Unknown-Self Reported | Depends on Sample intensity and rarity |
| CAS integration difficulty | High | Low |
| Discard species weight required | Yes | Yes |
| Limited port of landing | Yes | No |
| Start up costs | High | Low |
| Monitoring costs | 3.33% [1] | 1.25%[2] |
| Total | 998 | 908 |

1 Stanley, R.D., H. McElderry,T. Mawani and J. Koolman. 2011. The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. ICES J. Mar. Sci. doi: 10.1093/icesjms/fsr058.

2 North Pacific Fishery Management Council, October 2010. Final motion on Observer Restructuring to BSAI Amendment 86/GOA Amendment 76. Available at http://www.npfmc.org/wp-content/PDFdocuments/conservation_issues/Observer/ObserverFundingLtr1110.pdf.

Table C-3. -- Comparison of regulatory considerations between the logbook audit approach estimation-based monitoring approach using video to estimate discard rates in a fishery.

| Regulatory Considerations | Logbook Audit-based[1] | Video Estimation-based |
|---|---|---|
| Retention requirements | Y | N |
| Data confidentiality and control | Y | Y |
| Industry responsibilities | High | Low |
| Enforcement action and penalties | High | Low |
| Port hail requirements | Y | N |
| Dockside monitoring requirements | Y | N |
| System component requirements | Same | Same |
| Maintain logbook | Y | Y |
| Logbook audit requirements | Y | N |
| Species ID requirements | Scoring list | Maybe some |

1 Stanley, R.D., H. McElderry,T. Mawani and J. Koolman. 2011. The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. ICES J. Mar. Sci. doi: 10.1093/icesjms/fsr058.

## Appendix D: Assessing current Observer Program monitoring activities for hook-and-line vessels in Alaska

Each of the listed activities is a current 2013 data collection requirement for observers deployed on hook-and-line vessels in Alaska. These tasks were excerpted from the observer training manual available online at: http://www.afsc.noaa.gov/FMA/document.htm. This table compares the current observer activities with the potential for other currently available approaches to collect the same data. The table illustrates what is possible right now with current technology and is not an assessment of what might be possible after further research has been completed. Appendix E has information about the potential for various tools to accomplish different objectives in the future.

| Current Monitoring Activities of Observers on Hook-and-Line Vessels | Observer | EM (video) | Industry Reporting (landing reports, e-logbooks, etc) | Notes | Purpose |
|---|---|---|---|---|---|
| **Birds** | | | | | |
| Monitor and report take of short-tailed albatrosses | Yes | No | No | | ESA Biop |
| Document all observations of short-tailed albatrosses | Yes | No | No | | ESA Biop |
| Identify and count all other seabirds within samples | Yes | No | No | | ESA Biop |
| Dead short-tailed albatrosses must be frozen and surrendered to the NMFS or the USFWS. | Yes | No | Potential | Physical specimens | ESA Biop |
| | | | | | |
| **Mammals** | | | | | |
| Record marine mammal sightings | Yes | Potential | Potential | | MMPA |
| Record marine mammal interactions including deterrence, entanglements, lethal removals, ship strikes, and predation on fishing gear by sea lions, sperm whales and killer whales | Yes | Potential | No | | MMPA |
| Collect marine mammal parts (snouts, etc) | Yes | No | No | Physical specimens | MMPA |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Fish** | | | | | |
| Catch composition by species in number and weight to incorporate into the CAS for total catch accounting | Yes, with some species limitations. | No | Yes (for landed catch) | | MSA – catch accounting and ACLs |
| Catch composition by PSC species in number and weight to incorporate into the CAS for total catch accounting. | Yes | No | No | | |
| Disposition of the catch (retained or discarded) by weight | Yes | No | Potential | | MSA |
| Viability of halibut released | Yes | No | No | | IPHC and MSA |
| Sexed length frequency data for target and bycatch species | Yes | No | No | | Stock assessment and Council analyses |
| Sexed length and weight for salmon and crab | Yes | No | No | | Stock assessment and Council analyses |
| Misc biological collections (maturity, genetics, scales) | Yes | No | No | Physical specimens | Stock assessment, genetic, and ecosystem studies |
| | | | | | |
| **Miscellaneous/Invertebrates** | | | | | |
| Numbers, weights and identifications of corals and misc invertebrates (degree of ID varies) | Potential | No | No | | Habitat, potential for ESA issues, ecosystem research |
| | | | | | |
| **All Species** | | | | | |
| Tag recoveries | Yes | No | Potential | Physical specimens | Stock assessment |
| Collection of voucher specimens | Yes | No | Potential | Physical specimens | Training and verification |
| **Fishing, gear characteristics, and management program identifications** | | | | | |
| Set/ retrieval dates, times, and locations | Yes | Yes | Yes | | Stock Assessment, Council analyses, Catch accounting and management |

| | | | | | |
|---|---|---|---|---|---|
| Location of non-fishing days | Yes | Yes | Yes | | Council analyses |
| Quantity of gear deployed in each set | Yes | Yes | Yes | | Effort |
| Quantity of gear retrieved | Yes | Yes | Yes | | Stock assessment, Council analyses, Catch accounting and management |
| Hook counts and spacing measurements of specific set segments (sablefish only) | Yes | No | No | Hook and line-sablefish only | Stock assessment Catch accounting |
| Gear performance, including instances of predation | Yes | No | Potential | | Catch accounting and MMPA interactions |
| Beginning and end depth | Yes | Potential, with sensor integration | Yes | | Stock assessment and Council analyses |
| IFQ- Yes or no | No | No | Yes | | Catch accounting and management |
| CDQ group number if applicable | No | No | Yes | | Catch accounting and management |
| | | | | | |
| **Regulatory Compliance** | | | | | |
| Compliance with careful release regulations | Yes | Yes | | Hook and line only | Regulatory compliance |
| Ensure rehabilitation of injured short-tailed albatross | Yes | No | | Physical handling required | Regulatory compliance |
| Compliance with seabird avoidance measures | Yes | No | | | Regulatory compliance |
| Compliance with time area closures | Yes | Yes, with GPS integration | | | Regulatory compliance |
| Real time position monitoring | Yes | Yes, with GPS integration | | | Regulatory compliance |
| Witness flow scale testing and record test weights and results | Yes | Potential | | Flow scale vessels only | Regulatory compliance |

## Appendix E: Assessing the range of monitoring tools and their applicability to fisheries data needs.

At the North Pacific Fishery Management Council's request, we adopted the table approach used in the Draft "Fisheries Roadmap" document which was distributed at a recent Council Coordination Committee meeting. We used the suggested table approach, and added to it by identifying specific fishery data needs and fishery characteristics relative to the North Pacific, adding additional tools, and providing our own interpretation of the potential utility of those tools in Alaska. We colored coded each cell to reflect the potential ability of a monitoring tool to meet a given data need. The color ratings are scaled as white (highly applicable) as light grey (potential), to dark grey (limited ability to meet data needs) and where tools are not appropriate for meeting specific data needs are colored black. We dropped interpretive text within the table and instead we have identified those areas where we are conducting research to improve the utility of the respective tools.

| **Ability to Meet Data Need** | |
|---|---|
| **Applicable** | |
| **Potential** | |
| **Limited** | |
| **Not Applicable** | |

| Data Needs | Fishery or Data Characteristics | Independent Monitoring | | | | | Industry Reporting | | |
|---|---|---|---|---|---|---|---|---|---|
| | | VMS | Camera Systems | At-Sea Observers | Dock-side Observers | Other technology | Logbooks | Hailing or notifications | Fish tickets |
| Confirm that no catch was discarded | Full Retention- see appendix B also. | | Current research | | | | | | |
| Discards: species and amount (identification, count, length and/or weight) | Serial or low volume catch handling | | Current research | Current research (Coral ID) | | | | | |
| | High volume bulk catch handling – Single target | | | | | | | | |
| | High volume bulk catch handling – Multi species | | | | | | | | |
| | Species which are difficult to differentiate | | | | | | | | |
| Discards: length and condition at release | Halibut discard in Alaska | | | | | | | | |
| Retained Catch: species and amount (identification, count, length,and/or weight) | Serial or low volume catch handling | | Current research | | | | | | |
| | High volume bulk catch handling – Single target | | | | | | | | |
| | High volume bulk catch handling – Multi species | | | | | | | | |
| | Species which are difficult to differentiate | | | | | | | | |
| Spatial information for trip | Single management area | | | | | | | | |
| Spatial information for fishing event | Multiple management areas | | | | | | | | |
| Protected species interactions | Species caught | | Current research | | | | | | |
| | Species sighted | | | | | | | | |
| | Condition at release | | Current research | | | | | | |
| | Behavior in relation to, or interactions with, vessel | | Current research | | | | | | |
| | gear used | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operational Characteristics | quantity deployed | | | | | | | | |
| | gear lost | | | | | | | | |
| | hook spacing | | | | | | | | |
| | Bait type and quantity | | | | | | | | |
| | Economic data | | | | | | | | |
| | Pre-trip logging, and prior notice of landing | | | | | | | | |
| Biological data from catch | Physical specimens (tags, genetic samples, otoliths, stomachs, maturity, voucher specimens) | | | | | | | | |
| | Length frequency | | | | | | | | |
| | Sex | | | | | | | | |
| Data to assess compliance with specific regulations – crew behavior | Specific targeted regulations would need to be identified – see appendix B. | | | | | | | | |
| Time sensitivity for end users | In-season accounting or tracking | | Current research | | | | | | |

# RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: *www.ntis.gov)*. Paper and electronic (.pdf) copies vary in price.

AFSC-

275 JONES, D. T., S. C. STEINESSEN, and A. L. McCARTHY. 2014. Results of the acoustic-trawl surveys of walleye pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, February-March 2013 (DY2013-02 and DY2013-03). AFSC Processed Rep. 2014-03, 81 p. NTIS number pending.

274 ALLEN, B. M., V. T. HELKER, and L. A. JEMISON. 2014. Human-caused injury and mortality of NMFS-managed Alaska marine mammal stocks, 2007-2011, 84 p. NTIS number pending.

273 SMITH, K. R., and C. E. ARMISTEAD. 2014. Benthic invertebrates of the Eastern Bering Sea: a synopsis of the life history and ecology of the sea star *Asterias amurensis*, 60 p. NTIS number pending.

272 DE ROBERTIS, A., D. MCKELVEY, K. TAYLOR, and T. HONKALEHTO. 2014. Development of acoustic-trawl survey methods to estimate the abundance of age-0 walleye pollock in the eastern Bering Sea shelf during the Bering Arctic subarctic survey, 46 p. NTIS number pending.

271 VULSTEK, S. C., C. M. KONDZELA, C. T. MARVIN, J. WHITTLE, and J. R. GUYON. 2014. Genetic stock composition analysis of chum salmon bycatch and excluder device samples from the 2012 Bering Sea walleye pollock trawl fishery, 35 p. NTIS No. PB2014-105096.

270 GUTHRIE, C. M., III, H. T. NGUYEN, and J. R. GUYON. 2014. Genetic stock composition analysis of Chinook salmon bycatch samples from the 2012 Bering Sea and Gulf of Alaska trawl fisheries, 33 p. NTIS No. PB2014-105095.

269 MATEO, I., and D. H. HANSELMAN. 2014. A comparison of statistical methods to standardize catch-per-unit-effort of the Alaska longline sablefish, 71 p. NTIS No. PB2014-104078.

268 FOWLER, C. W., R. D. REDEKOPP, V. VISSAR, and J. OPPENHEIMER. 2014. Pattern-based control rules for fisheries management, 116 p. NTIS No. PB2014-104035.

267 FOWLER, C. W., and S. M. LUIS. 2014. We are not asking management questions, 48 p. NTIS No. PB2014-104034.

266 LAUTH, R. R., and J. CONNER. 2014. Results of the 2011 Eastern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate fauna, 176 p. NTIS No. PB2014-104036.

265 TRIBUZIO, C. A., J. R. GASPER, and S. K. GAICHAS. 2014. Estimation of bycatch in the unobserved Pacific halibut fishery off Alaska, 506 p. NTIS No. PB2014-101866.

264 STONE, R. P., K. W. CONWAY, D. J. CSEPP, and J. V. BARRIE. 2014. The boundary reefs: glass sponge (Porifera: Hexactinellida) reefs on the international border between Canada and the United States, 31 p. NTIS No. PB2014-101865.

263 SHELDEN K. E. W., D. J. RUGH, K. T. GOETZ, C. L. SIMS, L. VATE BRATTSTRÖM, J. A. MOCKLIN, B. A. MAHONEY, B. K. SMITH, and R. C. HOBBS. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012, 122 p. NTIS No. PB2014-104033.

262 WHITEHOUSE, G. A. 2013. A preliminary mass-balance food web model of the eastern Chukchi Sea, 164 p. NTIS No. PB2014-104032.

261 FERGUSON, M. C., and J. T. CLARKE. 2013. Estimates of detection probability for BWASP bowhead whale, gray whale, and beluga sightings collected from Twin Otter and Aero Commander aircraft,1989 to 2007 and 2008 to 2011, 52 p. NTIS No. PB2014-104031.