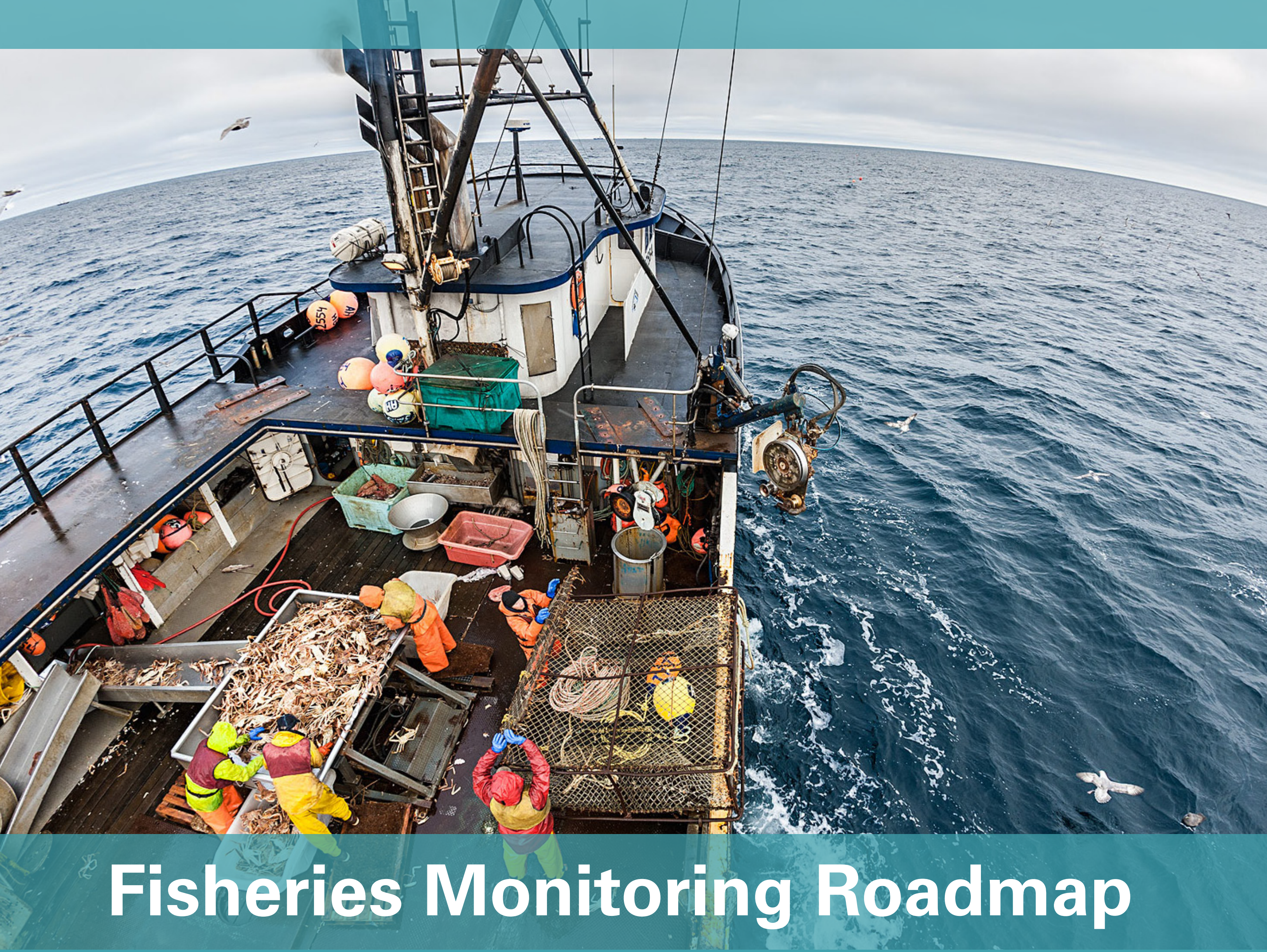

Fisheries Monitoring Roadmap

A guide to evaluate, design and implement an effective fishery monitoring program that incorporates electronic monitoring and electronic reporting tools.

2013

FISHERIES MONITORING ROADMAP

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Acknowledgements

During the fall of 2011, Environmental Defense Fund convened a "Charrette", bringing together a group of fishery experts in a series of workshops to discuss new and creative ways to support the sustainable management of U.S. fisheries. A subgroup, focused specifically on fisheries monitoring, identified new technologies, such as camera-based electronic monitoring (EM) systems as a potentially valuable tool to address challenges associated with increasing monitoring costs.

While a number of people, agencies and organizations contributed to the content, scope and concepts outlined in the Fisheries Monitoring Roadmap the principal authors were Charrette Fishery Monitoring Workgroup members Dorothy Lowman (Lowman and Associates), Randy Fisher (Pacific States Marine Fisheries Commission), Mark Holliday (National Marine Fisheries Service), Sarah McTee (Environmental Defense Fund), and Shawn Stebbins (Archipelago Marine Research). The Fisheries Monitoring Roadmap is product of a year of their collaborative work, and an attempt to advance efforts to find effective and efficient approaches to fisheries monitoring but does not necessarily represent the views or positions of their respective organizations.

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Introduction

During the fall of 2011, a group of fishery experts convened in San Francisco, CA to discuss challenges to sustainable fishery management. One of the key issues identified was the implementation of robust and cost effective fishery monitoring programs. New technologies, such as camera-based electronic monitoring (EM) systems were identified as a potentially valuable tool to meet challenges associated with the increasing costs of monitoring; however, the use of such systems was not wide-spread. A cursory review of the EM pilot studies suggested the limited implementation of EM tools was not a result of deficiencies in the tools themselves, but by a recurring failure to identify monitoring objectives and explore how EM data could be combined with, or complement monitoring data from other sources. Further, EM has often been misconstrued as a wholesale replacement for at-sea observers or at-sea monitors, rather than a tool that can be integrated into a monitoring plan that likely employs a variety of monitoring approaches.

Electronic Monitoring Tools

The term "electronic monitoring" or "EM", as currently used in the context of U.S. fisheries, typically refers to closed circuit video cameras, sensors to monitor use of fishing gear, a GPS receiver, and a control center to manage, process and store data. EM tools can also include vessel monitoring systems (VMS), which are becoming increasingly sophisticated in the types and amount of data they can transmit.

Electronic Reporting Tools

Electronic reporting tools (ER) include electronic logbooks and electronic fish tickets. E-logbooks generally report on fishing activities and catch, while e-fish tickets report on fish landed and sold. E-logbooks are essentially software where catch data, fishing location, gear used and details of fishing events are recorded in a standardized format and then submitted online or as an email attachment once the vessel returns to port. As long as internet connection is available, e-fish tickets or landing reports can be submitted directly via an online platform.

Need for the Fishery Monitoring Roadmap

Fishery management goals that require accurate accounting of annual catch levels are increasing the need for robust fishery-dependent data. Limited financial resources to support fisheries monitoring, underscore the importance of cost efficiency and transparency in how government funds and industry fees are being used. Fisheries managers and industry stakeholders interested in optimizing the economics of their monitoring programs are encouraged to evaluate tools currently used to meet monitoring objectives, explore how those tools could be optimized, and determine the appropriateness of new or additional monitoring approaches, including EM and ER tools.

Incorporating new tools or technologies into a monitoring program is often not as simple as trading out one tool for another, but will most likely require modifications to regulatory, data, and funding infrastructures. Additionally, the success of revised monitoring programs will be dependent upon collaboration with industry and other stakeholders as these changes are enacted. Incorporating EM or ER into a fishery monitoring program is therefore a multi-step process that must be tailored to the specific needs of the fishery, fleet and often vessel.

Purpose and Objectives of the Roadmap

Fishery monitoring tools differ, not only in the type and quality of data they collect, but also in their initial and ongoing operational costs, ease of use and ability to meet the diverse needs of stakeholders. The Roadmap does not offer recommendations or guidance on which tool or tools to employ, but instead outlines a process for designing or revising monitoring programs, assuming EM and ER tools are available for use. The Roadmap is therefore intended to help fishery managers and other stakeholders better understand the differences between monitoring tools, match monitoring tools with clearly identified management and monitoring goals, and ultimately allow for the optimization of fishery monitoring programs. Specific objectives of the Roadmap include: (1) clarifying what EM can and cannot do; (2) outlining a process for effectively incorporating EM into a fishery monitoring program; and (3) identifying fishery characteristics that will influence the cost of deploying EM and other monitoring tools.

Roadmap Overview

To accomplish the above objectives, the Roadmap was developed in five different sections. Section 1 guides stakeholders through five phases of fisheries monitoring program development, which begins with an assessment of objectives and ends in optimal implementation of a monitoring program. Key steps are outlined for each of the five phases, and a list of references and resources is included as Section 4 to provide additional perspectives on incorporating EM and ER tools into fishery monitoring programs. The Fisheries Monitoring Matrix and an Evaluation and Comparison of Monitoring Tools, Sections 2 and 3, respectively are provided to facilitate the assessment process and the selection of fishery-appropriate monitoring tools. Case Studies are provided in Section 5 to illustrate how the Fishery Monitoring Matrix can be employed, and to simultaneously evaluate monitoring programs already in place. These case studies may also provide useful starting points for how to deploy a combination of monitoring tools, while also highlighting how monitoring needs and costs differ among fisheries.

Photo credit: West Coast Groundfish Observer Program - observer Sean Sullivan

SECTION 1: Phases of Developing a Fishery Monitoring Program

The following section provides guidance on the various steps and issues to be addressed when considering the use of EM and ER tools for new or existing monitoring programs. A brief description of each Phase and their associated steps is provided below for reference. Further, Figure 1 attempts to illustrate that many of these steps can take place concurrent with each other. While some steps, may not be relevant to every fishery, Phase One: Assessment of Goals and Objectives, will be one of the most important components for ensuring proper program design. Without a clear understanding of what is needed to properly manage and execute a fishery, it will be difficult for stakeholders to agree on the components of a monitoring program. To help guide active participation, stakeholders key to accomplishing each Phase have been identified in parentheses.

Phase I: Assessment of Goals and Objectives

There are a number of available monitoring tools, each with their own strengths and weaknesses. Before deciding to incorporate EM or ER tools into a fishery, program goals and objectives should be reviewed and updated where necessary. Once monitoring objectives are clearly established, only then can an appropriate combination of monitoring activities and tools be identified to successfully achieve these goals.

Phase II: Outreach and Program Design

During this Phase, options for the monitoring program design are reconciled with the goals and objectives identified in Phase I. Research and initial deployment of selected monitoring tools may be carried out to identify and resolve any operational issues and further refine the program design. Collaboration with stakeholders and wide dissemination of information and data from associated research, including successes and failures, is necessary to ensure successful implementation of phases III-V.

Phase III: Pre-Implementation

Once the goals and components of the monitoring program are clearly defined and operational issues have been resolved, regulatory and technical infrastructure is either modified or developed to support program implementation. This could include training/hiring personnel, scoping necessary regulatory changes, and developing long-term funding strategies. Some pre-implementation activities may need to be initiated concurrent with Phase II activities.

Phase IV: Initial Implementation

This Phase begins with the initial full-scale deployment of the monitoring program and also encompasses the first few years following implementation. As new logistical challenges are resolved and industry and managers adapt to the new monitoring program, this Phase will include a period of initial program refinements.

Phase V: Optimal Implementation

Regular program review and refinements will facilitate the evolution of the program into an optimal or fully mature monitoring program. Technological advances and changes in the nature of how the fishery is operating should be considered during program review. It is during this Phase where the most substantial cost savings and operational efficiencies will be realized.

"It is during this Phase (Phase V) where the most substantial cost savings and operational efficiencies will be realized."

Figure 1.

Summary of the five phases of developing or revising a monitoring program that incorporates electronic monitoring (EM) and electronic reporting (ER) tools. Major steps involved in each phase are identified, with some steps, such as stakeholder engagement, spanning more than one phase.

Phase I: Assessment	Phase II: Program Design	Phase III: Pre-Implementation	Phase IV: Initial Implementation	Phase V: Optimal Implementation
Stakeholder Engagement: industry, scientists, enforcement, managers and third party providers				
• Identify data needs and monitoring goals. • Identify appropriate monitoring tools. • Discuss trade-offs of tools. • Discuss financial resources available and funding options for field work.	• Reconfirm monitoring goals. • Select appropriate monitoring tools. • Develop monitoring plan/framework. • Establish methods to harmonize/link data. • Establish timeline and metrics to evaluate success. • Define terms. • Identify regulatory changes needed.	• Refine regulations • Establish infrastructure for data analysis, program administration and management • Train and hire personnel • Finalize funding plan • Finalize monitoring program: which tools will be deployed and how.	• All components of monitoring program in place and fully implemented. • Fleet wide deployment of EM and ER equipment • procedures. • Refine data collection and processing	• Refine infrastructure and data processing procedures. • Identify economies of scale and consider application of EM/ER tools in other fisheries as appropriate. • Update or upgrade tools (equipment, software etc.) where possible

- Small-scale deployment or trial of new/ revised monitoring program, if needed.
- Develop Vessel Monitoring Plans.
- Refine data collection and processing procedures.

- Review and share information from EM/ER research
- Review and improve processes for data collection
- Identify additional infrastructure and personnel needs.

Review metrics of success and revise program to ensure monitoring goals are being met.

LEGEND
- Stakeholder Engagement
- Program Design
- Deployment of Tools
- Program Improvements
- Program Review

Phase I: Assessment

Step 1: Engage Stakeholders

- Managers
- Enforcement
- Fishing industry members
- Scientists
- Third party service providers
- Environmental organizations

Step 2: Identify Data Needs

(managers, enforcement, industry, scientists)

- Establish or clarify fishery management objectives
- Review regulatory framework and existing data collection programs
- Outline information needed to support stock assessment and other fisheries-related research and/or management requirements
- Identify appropriate data formats as well as processing and turn-around times
- Outline enforcement priorities and needs

Step 3: Evaluate Suite of Monitoring Tools

(managers, industry)

- Outline the characteristics of the fishery (e.g., fleet size, season duration, discards etc.)
- Determine if current tools efficiently meet data needs
- Identify if and how EM tools can be integrated with
- existing monitoring tools
- Evaluate need for human observers and monitors
- Evaluate need for fishing logbooks including electronic-logbooks and other ER tools
- Identify tools that may be used to fill data gaps

STEP 3

Refer to

SECTION 2: Fishery Monitoring Matrix

and

SECTION 4: Electronic Monitoring Resources

for assistance evaluating monitoring tools.

STEPS 4-5

Building blocks to explore and discuss trade-offs of monitoring tools are provided in

SECTION 3: Evaluation and Comparison of Fishery Monitoring Tools

and

SECTION 4: Electronic Monitoring Resources

Step 4: Explore Potential Trade-Offs

(managers, enforcement, industry, scientists)

- Timeliness of data processing and availability
- Data integrity and comprehensiveness
- Ease of use, suitability, flexibility and reliability
- Industry needs and interest
- Accuracy and reliability of data
- Considerations for rare events.
- Implementation timeline and required infrastructure
- Cost considerations

Step 5: Discuss Funding Options

(managers, industry, third party providers)

- Explore options for cost sharing and mechanisms for cost recovery where appropriate
- Scale monitoring to value of fishery
- Consider industry, public, and government contributions
- Outline costs for different data review/processing options
- Identify funding needs and sources for field work (Phase II)

PHASES II-V

If the analysis and discussion of trade-offs under Phase I led to a decision to include electronic monitoring tools in a new or revised fishing monitoring program, proceed to Phases II-V.

Phase II: Outreach and Program Design

Step 1: Goal Setting

(managers, industry, scientists)

- Clearly identify monitoring goals and objectives necessary to meet the specific management goals and data needs outlined during Phase I, step 2.
- Consider use of a steering committee or neutral third party to coordinate and facilitate stakeholder input and objectively evaluate monitoring program needs.
- Establish goals and metrics to help evaluate the success of the monitoring program.

Step 2: Program Design

(managers, enforcement, industry, scientists, third party providers)

- Taking into account monitoring tools currently in place, and Phase I analyses, select a combination of tools that best balance monitoring goals, resources and other trade-offs.
- Identify ways in which data from all sources, (i.e., VMS, dockside monitors, logbooks, observers, and EM/ER) will be managed and can be integrated with each other, allowing for comparison and timely use.
- Outline data quality control, authentication, and correction/appeal processes, as appropriate.
- Consider incorporating flexibility into program design to ensure efficiencies and allow for future refinement and optimization of program performance.
- Identify and begin scoping any necessary regulatory changes.
- Establish a timeline for moving from development phase to full implementation that includes a funding plan.

Step 3: Collaboration and Program Refinement

(managers, enforcement, industry, third party providers)

- Develop and refine vessel operational procedures and control points for gear handling.
- For gear and vessel types that have not previously tested EM or ER, conduct research to determine how these tools can be best deployed.
- Work with industry to develop Vessel Monitoring Plans (VMPs) to optimize placement and use of EM equipment
- Develop and support communication processes between vessel and land support to help refine implementation of EM
- Develop protocols for handling at-sea EM equipment failure
- Identify any logistical issues with collecting and transferring EM data from the fishing vessel to appropriate management personnel
- Develop a common understanding or technical definition for relevant regulatory and fishery-related terms to aid enforcement activities. Determine what constitutes an infraction, and identify an appropriate course of action.

Step 4: Disseminate Information

(managers, industry, third party providers)

- Synthesize and distribute findings of field testing to inform policy decisions
- Facilitate outreach to fishing industry and other stakeholders.

Phase III: Pre-Implementation

Step 1: Refine Regulatory Infrastructure

(managers, enforcement, industry)

- Identify changes needed to existing fishing regulations or fishery management plans to allow for use of new monitoring tools.
- Explore new or additional regulations and operational conditions (e.g., full retention) that could optimize the use of EM/ER.
- Ensure that the regulatory framework is not unnecessarily prescriptive and allows for technological advances in EM/ER equipment and related processes.
- Determine the level of coverage the fleet will have for each monitoring tool, i.e., full fleet vs. partial fleet.

Step 2: Data Analysis and Infrastructure

(managers, industry, third party providers)

- Define data management and work flow processes.
- Train and/or hire additional personnel.
- Harmonize data formats within and across fisheries where possible.
- Establish appropriate infrastructure for data entry, management and storage.
- Ensure data processing timelines correspond with management needs.
- Identify and address any issues related to chain of custody.

Step 3: Equipment Support Infrastructure

(managers, industry, third party providers)

- Develop an equipment plan to ensure all vessels are able to be serviced.
- Train and/or hire additional personnel.
- Decide upon any necessary equipment specification and hardware/software requirements for EM/ER.
- Work with fishing vessel crew and operators to ensure equipment is deployed according to current or revised Vessel Monitoring Plan.

Step 4: Define Funding Mechanism

(managers, industry, third-party providers)

- Develop a funding plan that includes long-term cost sharing and any required cost recovery.
- Consider how costs of the program and the associated funding mechanism could impact fleet diversity.

Phase IV: Initial Implementation

Step 1: Communicate Plan To Stakeholders

(managers, industry, third party providers)

- Develop outreach to inform all stakeholders of the new monitoring plan and how it will be implemented.
- Identify various representatives (managers, industry and third party providers) that can be contacted for information or to ask questions regarding the monitoring plan, implementation requirements, operational issues, funding, and the ongoing process for program refinement.

Step 2: Install Systems

(managers, industry, third party providers)

- Procure EM/ER related equipment and tools for vessels.
- Work with industry to install equipment on vessels based on the VMPs and data collection standards.

Step 3: Data Collection and Integration

(managers, industry, third party providers)

- Review and analyze EM data
- Begin to integrate EM data into the fishery management processes.

Step 4: Provide Ongoing Feedback

(managers)

- Communicate on a constant and consistent basis with all stakeholder groups.
- Evaluate and refine the monitoring program based on metrics established in Phase II.

Phase V: Optimal Implementation

Step 1: Evolution of Technology

(managers, industry, third party providers)

- Adjust program to match current technological advances to allow for increased cost savings.

Step 2: Evolution of Processes

(managers, industry)

- Review the program on an ongoing basis to ensure that monitoring objectives and data needs are being met in the most effective and cost-effective means possible.

Step 3: Economies of Scale

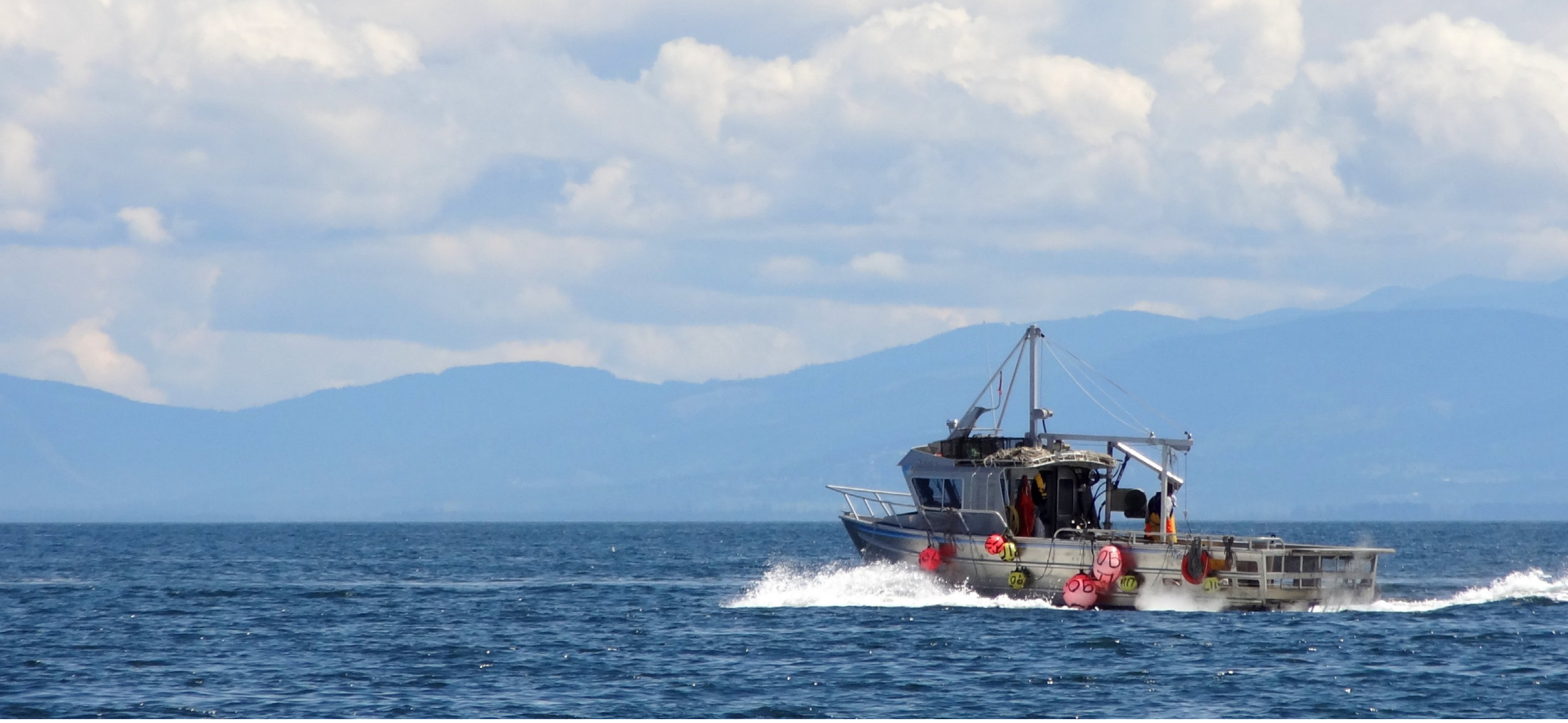
(managers, industry, third party providers)

- Expand the use of EM/ER tools into other related fisheries to further harmonize data collection formats and take advantage of efficiencies of scale.

Step 4: Infrastructure Refinements

(managers, industry, third party providers)

- Ensure that the program infrastructure is consistent with the needs of the program and procedures for collecting and analyzing monitoring data are optimized for time and other costs.



SECTION 2: Fishery Monitoring Matrix

Photo credit: Jeff K. Reynolds

The purpose of the Fishery Monitoring Matrix is to aid stakeholders in identifying the data needs for a fishery, and to provide a visual representation of the relative ability of various monitoring tools to meet those needs. The Matrix is not intended to assess or recommend particular monitoring tools as the "best" or "right" approach to monitoring. The relative ratings provided for each of the monitoring tools represent the collective experience of the authors, and are offered as a starting point for conversations regarding the best application of the various tools available to a particular situation.

The matrix is intended to offer a representation of data requirements and fishery characteristics, cross referenced with a range of commonly available monitoring tools. The Matrix can be tailored to a specific management program and fishery characteristics by deleting rows of the Matrix that are not applicable to that fishery. For example, Section 5 contains four case studies each with a unique Matrix table representing how that fishery is currently monitored. As currently constructed, each monitoring/reporting tool is considered individually; however, combining monitoring tools is usually preferred and often necessary. Using tools in combination can enhance the ability of an individual tool to meet a specific management/data need. For example, if you combine logbooks with at-sea observers or camera-based EM systems, the confidence in data collected will be improved. This and other conditions for improved functionality are not reflected in the Matrix; however, the Matrix may help determine the circumstances under which a combination of monitoring methods may be optimal.

Two categories of monitoring tools are highlighted in the Matrix: Independent Monitoring Tools and Self-Reporting Tools. A brief description of the tools included in each of these categories is provided below. Additionally, a further discussion of the distinction between independent and self-reporting tools, as well as an evaluation of each of these tools, is included in Section 3: Evaluation and Comparison of Fishery Monitoring Tools.

Description of Monitoring Tools

Independent

- **Vessel Monitoring Systems** (VMS) are used to track the location of a vessel. This information is useful in determining if a vessel is operating in a restricted area.
- **Camera-based Systems** usually also include GPS and gear sensors in addition to multiple cameras. These systems are designed to record gear deployment and retrieval, catch handling, fishing location and document discard events.
- **At-sea Observers** are trained individuals placed on the fishing vessel to record catch, discards, information on protected species and collect biological data/samples. At-sea monitors, which typically only record catch data are also deployed in some fisheries, and for the purposes of this document, fall under the category of at-sea observers.
- **Dockside Monitors** are trained individuals deployed to landing locations to monitor and verify landed weights and species.

Self-Reporting

- **Logbooks** are the captain's accounts of total catch by species, discarded catch, information on protected species interactions, location of fishing activities and gear used. Logbooks are traditionally submitted in paper form, but fisheries are increasingly transitioning to electronic logbooks.
- **Hailing/Notifications** include many forms of communication between the vessel and fishery managers or enforcement officials, but most often entail hailing in and out of fishing areas or ports, and notifying managers of intended target stocks or approximate amounts of catch.

DECODING THE MATRIX

The Matrix has been color coded according to the average ability of a monitoring tool to meet a given data need. The ratings range from white (highly applicable) to dark grey (limited ability to meet data needs). Because the type and format of data differs among tools, some tools are not appropriate for meeting specific data needs. In those cases the cell associated with that tool is black.

Instructions For Using the Matrix

Objective: To determine how monitoring tools can be combined in the most effective and efficient manner to achieve established fishery management goals.

Step 1: Fill out the matrix according to the characteristic of the fishery in question and the purpose of the monitoring tools currently used.

Step 2: Evaluate whether current monitoring tools are meeting objectives and identify any conditions or circumstances where they are not.

Step 3: Identify monitoring tools not currently used and that may be appropriate for a given data or management need.

Step 4: Assess the applicability of unused tools and identify any necessary changes to the management or monitoring program to optimize monitoring resources. The following "Questions for Consideration" are provided to help initiate the assessment.

Questions for Consideration:

1. What is your monitoring and/or data priority?
2. Is the transfer of monitoring data efficient (time and cost) and are data getting to the right people?
3. Is there a new tool or a different combination of monitoring tools that could be employed to meet monitoring needs?
4. Are there modifications to the current management structure and/or monitoring goals that would allow for more effective use of the monitoring tools presently used?

Decoding the Matrix:

The Matrix has been color coded according to the average ability of a monitoring tool to meet a given data need. The ratings range from white (highly applicable) to dark grey (limited ability to meet data needs). Because the type and format of data differs among tools, some tools are not appropriate for meeting specific data needs. In those cases the cell associated with that tool is black. Considerations, such as catch handling techniques, reporting frequency, or other operational recommendations are included in some cells, indicating additional steps needed to ensure the tool is able to perform at the rating shown.

Fishery Monitoring Matrix

Ability To Meet Data Needs: High / Medium / Low / Not Applicable

Data Needs	Fishery Characteristics		Independent Monitoring: Vessel Monitoring System	Independent Monitoring: Camera-based System	Independent Monitoring: At-sea Observers	Independent Monitoring: Dockside Monitoring	Self-Reporting: Logbooks	Self-Reporting: Hailing or Notifications
confirm if any catch was discarded	full retention			Requires appropriate camera coverage. Cameras must stay on once catch is onboard.	Requires observer to be present during all catch handling events		Can upgrade this rating if there is incentive to report discards	Ability to notify if any catch was discarded is high. Need incentives to ensure accuracy of data.
Discards: species and amount (count, length or weight)	serial or low volume catch handling			Discards released one at a time in a dedicated location	requires access to catch handling areas		Given experience with the vessel and fishing gear, vessel operators can estimate amount of catch discarded	Logistically, it may be difficult to notify discards for every event.
	high volume catch handling	single target species		Can use bins to approximate volume of catch				Not optimal as a standalone reporting mechanism.
		multi-species		Requires discards to get sorted into bins by species	Speciation is facilitated if the observer can take samples for catch composition or for later identification			
	species difficult to differentiate							
Retained catch: species and amount (count, length or weight)	serial or low volume catch handling			High ability as long as camera is not obstructed			Can upgrade this rating if incentives to report are high.	Not optimal as a standalone reporting mechanism.
	high volume catch handling	single target species		Can use bins to approximate volume of catch				
		multi-species		requires modified catch handling procedures	requires access to catch han-dling areas			
	species difficult to differentiate			requires modified catch handling procedures				

Fishery Monitoring Matrix

Ability To Meet Data Needs: High | Medium | Low | Not Applicable

Data Needs	Fishery Characteristics	Independent Monitoring: Vessel Monitoring System	Independent Monitoring: Camera-based System	Independent Monitoring: At-sea Observers	Independent Monitoring: Dockside Monitoring	Self-Reporting: Logbooks	Self-Reporting: Hailing or Notifications
spatial information for fishing trip	single management area	will depend upon reporting frequency	Usually integrated with GPS- can show location of gear deployment and retrieval				Stock area fished often declared upon departing and returning to port.
spatial information by fishing event	multiple manage-ment zones	can show areas fished, but no catch attribution data		Record fishing location based on vessels GPS			can notify changes in fishing location- catch attribution difficult
details on interactions with protected species	species encountered			Are trained to identify, assess condition, properly handle and release and collect any necessary samples from protected			
	handling method						
	condition at release						
	discarded or retained				Species retained can be identified and sampled		
	other interactions						
operational details	gear used						
	amount and type of bait						
	economic data						
biological data from catch	length frequency		only for low volume batch with dissimilar species				
	age						
	reproductive condition						

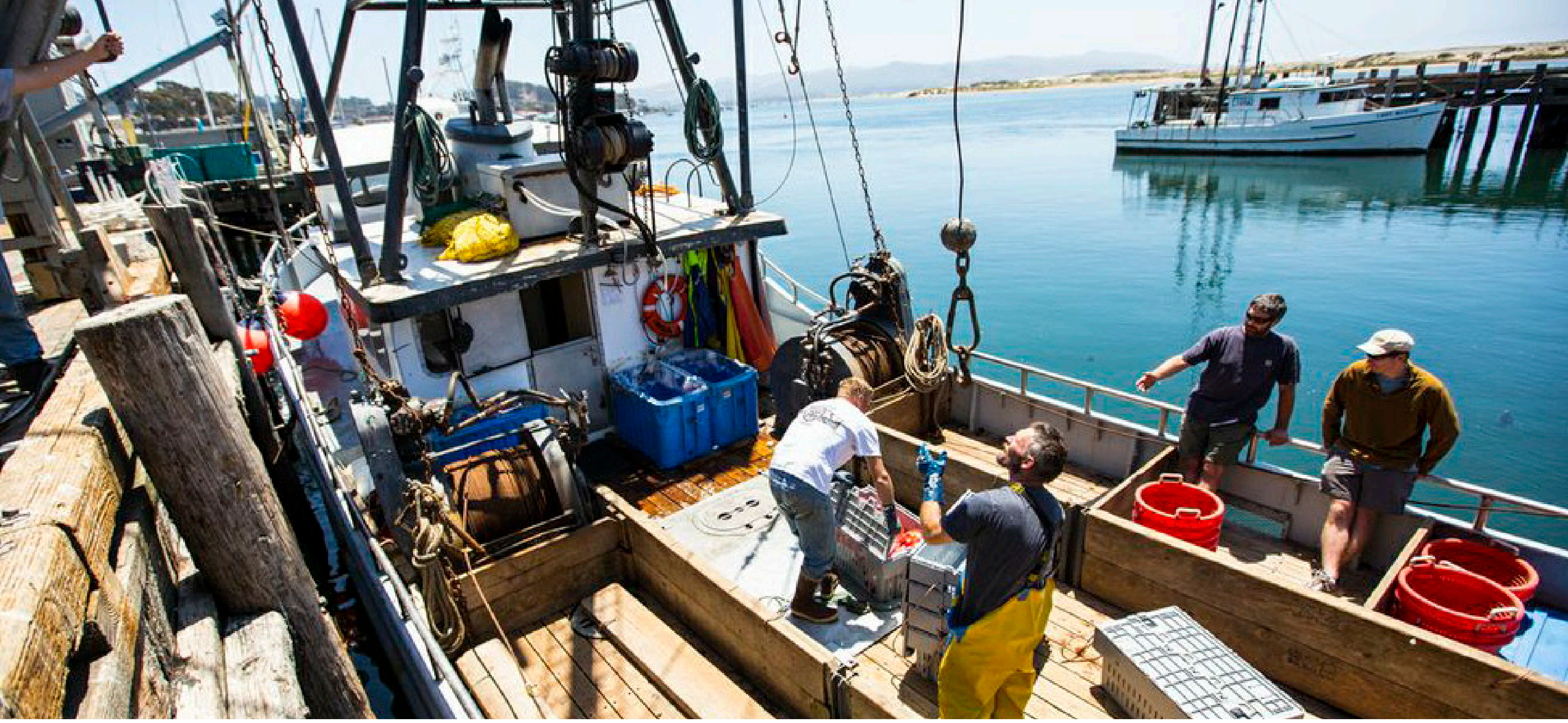


Photo credit: John Rae

SECTION 3: Evaluation and Comparison of Fishery Monitoring Tools

Overview

Although the specific monitoring goals and data requirements of individual Fishery Management Plans will be the driving force behind the tools selected for a given monitoring program, there are other considerations, such as cost, data quality and enforceability that should be considered during the development and refinement of fishery monitoring programs. The following evaluation attempts to round out the discussion of tradeoffs by comparing and contrasting different monitoring tools against practical criteria that are important to stakeholders when designing a monitoring program.

In considering the suite of monitoring tools available, self-reporting and independent monitoring tools are handled separately, with the main focus being a comparison of four types of independent monitoring tools. Examples of self-reporting tools include paper or electronic logbooks, hailing in and out of fishing areas or ports, and any other form of communication between the vessel and fishery managers or enforcement officials. Self- reported data can be audited with data from other self-reporting mechanisms or from independent monitoring tools. Independent monitoring tools discussed herein include: Vessel Monitoring Systems (VMS), camera-based systems, at-sea observers and dockside monitors. Both self-reported and independent monitoring techniques are commonly used in U.S. commercial fisheries, often in combination with each other. EM and ER tools, such as camera-based systems and electronic logbooks are continually evolving and are of growing interest due to the potential for increased cost efficiency and operational practicality.

Regardless of the self-reporting tool implemented, the main limitation with self-reported data is the need for an independent means of validation, especially where there are legal or economic incentives to misreport. In some cases, the time and effort required to accurately report data, rare events, or interactions with protected species, may negatively impact operations of the vessel and potentially the rest of the fleet, which creates disincentives for self-reporting. The degree of data validation and the resources necessary to implement controls will vary by type of data being collected, the risk or tolerance for misreporting, and the cost and funding available to pay for data assurance and quality controls. These trade-offs are similar to the risks-rewards analyses associated with selecting and implementing independent monitoring tools such as selecting appropriate levels of sample coverage, number and type of data elements, and frequency of reporting.

> "Integration of self-reporting tools with independent monitoring tools allows for cross-checking and audit of self-reported data and also increases incentives within the industry to provide accurate self-reported data."

Self-Reporting Tools

Self-reporting tools are valuable in that they generally have lower initial costs, are not overly complex or difficult to integrate into fishing operations, and are generally more acceptable to industry as they give the fishing vessel and crew increased responsibility for reported data. Integration of self-reporting tools with independent monitoring tools allows for cross-checking and audit of self-reported data and also increases incentives within the industry to provide accurate self-reported data.

The Evolution of Logbooks

Although upfront costs are low, paper logbooks have proven to create logistical challenges in some fisheries. Paper logs require personnel to manually input catch data, which can be burdensome, introduces additional opportunities for data entry errors, and often results in significant temporal lags in catch accounting.

Given that timely catch accounting is important to managing fishing effort, especially in fisheries where quota is allocated seasonally or among individual vessels, moving toward the use of electronic logbooks may be of great benefit. Electronic logbooks not only reduce overall time, personnel and resources required to input data, thus improving data quality and timeliness, but can be submitted in a format that allows for integration with other data sources to monitor fleet catches in close to real-time. There are potentially multiple applications of electronic logbooks, which may contribute to increasing the effectiveness of catch accounting and reduce monitoring costs.

The transition from existing paper logbooks to electronic logbooks seems opportune for consideration. The existing data infrastructure, databases and repositories of States and Federal governments provides an existing investment that may not require extensive revisions or replacement if logbooks are designed to be compatible/consistent with their data format. However it is likely that software and mechanisms to integrate data are needed. Software that meets government requirements for fiduciary and evidentiary use can be supplied in multiple ways: government-furnished, partnerships, or through third-party developers. Each will have a different cost and budget implication for managers and stakeholders that will need to be evaluated.

Electronic logbooks that are capable of capturing data to satisfy the business and fishing data needs of fishermen, as well as the regulatory/compliance needs of managers have obvious efficiency and cost-effectiveness advantages. Electronic logbooks, on their own or coupled with sensors to capture geospatial position, sea water temperature, depth of gear, or other environmental parameters, can provide scientific insights into the biology and ecology of the managed species. Several fisheries have deployed such electronic technologies in pilot studies and cooperative research efforts, demonstrating their potential capability for management, compliance/enforcement and science purposes.

Comparison of Independent Monitoring Tools

In addition to meeting data needs for management purposes, other practical considerations are often prioritized when developing a fishery monitoring program. Some of the most common priorities include cost, ability to meet enforcement needs and data quality issues. Each of the independent monitoring tools is discussed below in the context of these and other considerations.

Cost Considerations

Initial Set-up Costs

These are the costs borne by the industry and relevant management entities to purchase and install equipment, and to establish infrastructure necessary to properly implement each monitoring tool.

NOTE: Accurate and complete cost data on existing data collection programs are difficult to come by, even though these are the most frequently cited determinants of a choice between EM and ER versus other data collection methodologies. Currently, there is no universally "cheapest" data collection methodology as costs vary widely for EM, ER, observers, logbooks and other methods depending on the specifics of the fishery and the overall program design. Therefore, it is imperative that cost templates be developed and completed for each particular fishery and program design under consideration to ensure fair and relevant cost comparisons of future policy options. For example, a template would ensure initial capital, installation and other one- time costs for hardware and software development associated with EM, ER and other methods are amortized over the useful life of the inputs. Operations and long term maintenance costs would be identified separately. Overhead costs (e.g., support personnel, travel, training, facilities, IT infrastructure) would be uniformly accounted for if a template were used to compare the costs of alternatives.

Vessel Monitoring Systems:

In many U.S. fisheries the National Marine Fisheries Service (NMFS) has offset the purchase price of VMS units for vessel owners. Currently, VMS reimbursements are approximately $3,000 per vessel. As with other monitoring tools, total initial costs will depend on the complexity of the VMS program established. The specific design of the program will affect the type and frequency of reporting, software and hardware requirements, and personnel required to process and maintain VMS data. VMS infrastructure requirements include software to process data, a database to store and access formatted data, a communications module to pull position data from satellites, and an interface to display VMS position data on a map. Upper estimates for initial set up costs are in the tens of thousands of dollars. In U.S. fisheries, NMFS runs a consolidated data center that handles VMS for a number of fisheries, distributing these costs across regions and a number of fleets.

Camera-based Systems:

These systems can include digital or analog cameras, gear sensors, data storage, and integrated GPS units. Initial set-up costs are primarily associated with the purchase and installation of equipment, and the training of technicians. Program planning and design can also be a substantial cost. The process of developing the program components (i.e., vessel monitoring plans and training curriculum for vessel crew) can involve many stakeholders and substantial outreach/coordination. The capital cost of the hardware for a typical multi-camera system and gear sensors can be significant ($8,000 or more), but this cost is often amortized over the expected life of the equipment (five or more years) and fishing vessels often have the option of leasing camera systems. Other initial costs include training of qualified staff for both field and data services, and the purchase of related goods, such as hard drives and capacity for long-term data storage. Due to the large quantity of data produced via camera-based monitoring, computers dedicated to data processing are usually required.

At-Sea Observers/Monitors:

The most significant initial cost for establishing an observer program will be associated with hiring and training enough observers to cover a fishery's needs. Training expenses will include travel to the training location, training materials such as fish identification, safety protocols, methods for collecting biological samples and appropriate sampling techniques. At-sea monitors may require less training as they usually only record catch and discards and are not responsible for collecting biological data.

In addition to the observers themselves, personnel costs will include operations staff associated with coordinating observer placement, travel and training, data analysts, data processing and quality assurance staff, gear technicians, and program management personnel. Following the recruitment of staff, an at-sea monitoring program will also require a secure database (with an appropriate backup system) for generated data. Field equipment can range in price from the cost of acquiring foul weather gear to issuing individual laptop computers. Other examples of gear to be purchased include fish picks, sampling gear, and zero gravity scales. There will also be costs associated with developing sampling methods based on the specific needs and priorities of the fishery, and resources required to develop, duplicate and distribute data collection forms.

Dockside Monitors:

Like at-sea observers, dockside monitors require training in sampling and reporting protocols, as well as species identification. Training requirements however are usually less extensive for dockside monitors than at-sea observers.

> "The most obvious ongoing costs associated with the use of VMS are transmission fees."

Some dockside monitoring programs require the purchase of scales and other equipment to independently measure/weigh fish, while others allow monitors to observe and verify the fish buyer's catch accounting. Purchase of electronic reporting equipment (e.g., netbooks or other electronic devices) may increase initial costs, but can provide long-term or ongoing cost savings by reducing costs associated with printing, finding and correcting duplicative data entry, and may also increase the timeliness of data availability. Infrastructure required for dockside monitors includes software and telecommunications hardware associated with data transmittal and processing. Fish buyers may also need to make some up-front investments if modifications to fish handling sites and practices are required to create adequate and appropriate space for a monitor to work.

Ongoing Operational Costs:

These costs are distinct from the initial investment needed to acquire and establish the infrastructure to use a monitoring tool. Ongoing costs represent the recurring costs that cover maintenance, deployment, system upgrades, as well as data processing and transfer. Costs to industry and managers will vary by region and fishery.

Vessel Monitoring System:

The most obvious ongoing costs associated with the use of VMS are transmission fees. For some fisheries that report hourly, transmissions fees are approximately $50/month. These fees will increase as the frequency of reporting and complexity of data transmitted increases. The type of data required, geography of the fishery, size and number of area closures, and fishing gear deployed will affect how frequently vessels must transmit data. Depending on the fishery, VMS units may also have to undergo periodic inspection and certification.

> "Ongoing operational costs of camera-based monitoring programs are dependent on the program design, and can be flexible according to management needs and resources available. "

Camera-based Systems:

Ongoing operational costs of camera-based monitoring programs are dependent on the program design, and can be flexible according to management needs and resources available. Fishery characteristics, including duration of fishing seasons and trips, frequency of trips, and port distribution can have a significant impact on the cost of providing field services and retrieving video data. Data can be retrieved from the vessels between each trip, or after several trips depending on the need for quick turnaround of the data. Work is currently underway to develop ways to transmit video data through high-speed broadband connections, which would eliminate the need to pick up the hard drives manually. Such technology would reduce a substantial portion of the ongoing operational costs of camera-based systems.

The required speed of the data review and percent of data reviewed (100% census versus partial review or "audit") are also an important component of the ongoing costs of deploying a camera-based system. If trip data are required immediately, additional data processing staff will likely be required. In the British Columbia groundfish fishery, 10% of the data are reviewed and processed within five days of the end of a trip. Data storage will also affect ongoing operational costs, with cost increasing as the quantity of data and the duration of time required to store data increase.

Case Study 1: West Coast Whiting Fishery (2010) – Camera-based System

Table 1. *Total annual costs and cost per sea day to deploy a camera-based EM system in the U.S. West coast whiting EFP fishery during 2010 for 35 fishing vessels, 728 trips and 1,269 sea days. Industry covered the majority of monitoring costs for this program. See Section 5: Case Study #1, for additional information on the characteristics of this fishery. Source: Archipelago Marine Research unpublished data.*

	Cost per Sea Day	Total Annual Costs		
		Total	Industry Portion	Government Portion
Logistical Planning	$17	$22,000	$0	$22,000
Project Manager	$20	$25,472	$14,231	$11,241
Equipment Lease Costs* (26 F/V)	$132	$129,045	$129,045	$0
Equipment Purchase Cost* (9 F/V)	$52	$15,291	$15,291	$0
Field Services	$81	$102,494	$102,494	$0
Travel Expenses	$42	$53,463	$53,463	$0
Data Services	$45	$56,480	$0	$56,480
Data Reporting	$13	$16,384	$0	$16,384
TOTAL COST - LEASED EQUIPMENT	$350	$405,338	$299,233	$106,105
TOTAL COST - PURCHASED EQUIPMENT	$270			
Proportion of total cost			74%	26%

** Equipment purchase costs were amortized over five years.*

At-Sea Observers/Monitors:

Ongoing programmatic costs of at-sea observer programs usually vary between fisheries, which is largely due to differences in the percentage of trips or total sea-days observers cover. The extent of biological sampling required (at-sea monitors versus observers) and the entity administering the at-sea program can also affect ongoing operation costs. Even within a given fishery, per vessel costs can vary significantly based on duration of fishing trips and how geographically isolated the vessel's home port is. Costs of observers traveling to ports that are geographically isolated will be higher and in some instances may require placing an observer/monitor in temporary housing so they can be on-call during the fishing season. Trips of longer duration distribute the costs associated with travel across more observed days at sea. There can also be difference in costs per day observed between large and small vessels, as large vessels are able to make longer trips that are pre-planned, while smaller vessels take shorter trips that are more likely to be weather dependent.

Ongoing operational costs will in part depend on how the at-sea program evolves over time. As coverage rates, data collected, extent of biological sampling and reports/analyses increase so do the overall costs of the program. In addition to maintaining associated staff and infrastructure, at-sea programs usually require annual briefings to review safety procedures, fish identification and update sampling protocols. Using a third party provider for observers, compared to a government entity, can reduce some administrative burden and costs, and provide additional flexibility with respect to employment requirements.

Case Study #2. New England Groundfish Fishery

Table 2. *Average costs associated with deploying at-sea monitors and observers in the New England groundfish fishery during 2011. Dollar values shown are approximate total annual costs and cost per sea day, assuming 6,474 sea-days with monitors and 2,699 sea-days with vessels carrying an observer. During 2011 there were approximately 301 vessels in this fishery. All costs are currently covered by the National Marine Fisheries Service. See Section 5: Case Study #2, for additional information on the characteristics of this fishery. Source: Personal Communication: Amy Van Atten, NMFS Fishery Sampling Branch, March 27, 2013.*

	At-Sea Monitors (21% of trips)		At-Sea Observers (7% of trips)	
	Cost per Sea Day	Total Annual Cost	Cost per Sea Day	Total Annual Cost
Observer/Monitor Cost	$508	$3,288,792	$568	$1,533,032
Travel	$31	$200,694	$35	$94,465
Training	$41	$265,434	$45	$121,455
Other Costs	$267	$1,728,558	$269	$726,031
TOTAL COST	$847	$5,483,478	$917	$2,474,983

Dockside Monitors:

Costs associated with deploying dockside monitors will vary depending on a number of factors, including: the number of offloading sites, the distance monitors travel to reach offloading sites; the number and frequency of fish deliveries; a buyer's ability to coordinate offloadings from multiple vessels; and other fishery-specific characteristics and regulatory requirements. In some programs, at-sea observers serve as the dockside monitor during offloading which can reduce travel costs, but may not be appropriate if monitors are intended to verify or cross-check at-sea retained catch estimates. Dockside monitors may be paid on an hourly or daily basis, or can be included as part of the daily at-sea observer rate if one person is performing both duties. Other ongoing costs include personnel needed to process data, periodic debriefing of monitors, ongoing training of new dockside monitors as needed, and site checks of buying stations.

Summary of Case Studies and Costs Associated with Monitoring – Costs per Sea Day

Table 3. *Summary of costs associated with the implementation of monitoring tools in four different fisheries. Values displayed are costs per sea day. See Section 5: Case Studies, for more details on each of the monitoring programs and for additional information on the characteristics of these fisheries. The level of observer coverage and amount of EM data auditing differs among these fisheries, which should be taken into consideration when comparing program costs. Empty cells do not represent zero cost, but highlight monitoring expenses we were unable to get more detailed data for.*

Fishery	West Coast Whiting	New England Groundfish	Pacific Groundfish	B.C. Groundfish
Fishing Year	2010	2011	2011	2009-2010
Number of Sea Days	1,269	28,922	5,225	11,545
Number of Trips	728	13,642	1,604	1,023
Number of Fishing Vessels	35	301	108	202
VMS	$89	$11	$59	n/a
Camera-based Systems	$350	n/a	n/a	$149
At-sea Observers	n/a	$917*	$337**	n/a
Dockside Monitors		n/a	$47**	$51
Logbooks		$10		$5
TOTAL MONITORING COSTS	$439	$938	$514	$205

** The term "at-sea observer" in this fishery refers to observers placed under the Northeast Fisheries Observer Program (NEFOP). The cost per sea day for an at-sea monitor (ASM) in this fishery during 2011 was $847. Total monitoring costs per sea day for vessels carrying an ASM was $868.*
*** These values do not include an additional $70 per sea day of shared costs associated with administration, travel and training, which are included in the total cost $514.*

NOTE ON TABLE 3

The above table contains examples of costs from existing monitoring programs, each of which are included in Section 5: Case Studies. Care should be exercised in comparing the relative costs among these fisheries as complete data were not available and conditions affecting costs vary considerably across fisheries. While informative, these relative costs should not be considered authoritative of what deployment costs would be in every fishery. Moreover, costs should always be viewed in the context of the relative benefits they accrue, and should not be the sole determinant of a data collection methodology choice.

Data Considerations

Data Processing and Timeliness

Each monitoring tool described herein collects a combination of similar and unique data. The type and complexity of data collected will determine the system and type of infrastructure needed to transfer, process and store data. Additionally, the format and volume of data collected may affect how long it takes to process information into a format that is meaningful for management, science and enforcement purposes.

Vessel Monitoring Systems

Data formats may vary among satellite providers. Generally, VMS data are received in a text format that is transcribed before it is placed in the VMS database. Despite these steps, data are viewed in almost real-time. As long as there is no interruption in data flow, VMS data can be viewed within 10 minutes of transmission. Given the automatic nature of data transmission from vessel, to satellite, to land station, to network, only one person is needed to administer a program for a fleet of 350 vessels. Newer VMS units have a computer unit associated with them that enable fishermen to send and receive email, access and submit fisheries forms, and send declarations. For these new VMS units, which transmit more than just positional data, additional staff would be required to monitor and manage data.

Camera-based Systems

These systems provide independent, archival, electronic data. Camera-based EM tools can generate significant amounts of data, presenting challenges for analysis. Concerns regarding the amount of time necessary to process, review, and provide catch data have undoubtedly hindered the adoption and implementation of this technology. Despite the large volume of data generated, video footage (data) of interest can be reviewed in a fraction of real-time operations. Depending on the application of the system, data needs and program design, camera-based catch data can have a turn- around time ranging from hours to many weeks. Well-planned data systems, training of data analysts and managers, and adequate storage infrastructure are highly recommended. Data processing can also be facilitated with specialized software, adoption of fishery-appropriate audit rates, and integration with data from other fishery monitoring tools.

At-Sea Observer

Currently, at-sea observer programs (with some exceptions) generally collect data on paper forms, which are then entered into a computer once the fishing vessel returns to port. Physical and electronic data storage is required for at-sea programs, as both the original hard copy reports and electronic submissions are archived. This is in addition to any biological samples that must be processed and stored. Although data quality assurance procedures may result in revisions to some of the catch or discard data, at-sea observer or monitor data can be uploaded and submitted to the relevant fisheries authorities within 48 hours. Some at-sea programs are starting to explore the use of an online database that observers access once they return to port to upload data collected at sea. This would reduce data turn-around and processing times.

"VMS data contain information regarding the location and duration of fishing and transiting activities and are generally very accurate and reliable. VMS provides locational information within 100m of accuracy, and because data are transmitted real-time via satellite, there is little concern regarding corruption of data."

Dockside Monitors

If dockside monitors have the ability to transmit data electronically and, particularly if the data are also recorded on an electronic device, data transmission is very timely. However, some fisheries do not have specific requirements for when landings data must be submitted, which can result in delays in data submission and processing. In fisheries where the dockside monitor is also acting as the at-sea observer, submission of landings data can be delayed if the individual is re-deployed on another fishing trip. Additionally, if dockside monitoring is used to verify other sources of data (e.g., fish tickets submitted by fish buyers, or at-sea estimates of landed catch), processing timeswill be dependent on when these sources of data become available and the extent to which there are discrepancies to resolve.

Accuracy and Reliability of Data

Fishery monitoring tools differ in the type of data collected, the manner in which it is collected and frequency of collection. Likelihood of errors and corruption or loss of data also varies among tools, with some requiring additional processing steps to ensure data are accurate. Other important considerations when evaluating accuracy and reliability of data include consistency in how data are collected, and the ability to resolve discrepancies and revisit data in the future, if necessary.

Vessel Monitoring Systems

VMS data contain information regarding the location and duration of fishing and transiting activities and are generally very accurate and reliable. VMS provides locational information within 100m of accuracy, and because data are transmitted real-time via satellite, there is little concern regarding corruption of data. Initially some fisheries experienced problems with vessels turning off units, but two-way communications has decreased incidences of deactivated units.

Camera-based Systems

This type of EM tool creates a comprehensive record of fishing activity that can be stored long-term when necessary. Overall accuracy is dependent upon crew adherence to vessel monitoring and catch handling plans as well as the training and expertise of data processors and analysts. Camera-based data quality does not degrade overtime time and can be independently audited or referenced at a later date to ensure accuracy and clarify any discrepancies. Furthermore, should a new data need arise; footage can be mined for data that may not have been required previously. Camera-based systems collect data in a consistent manner, but are currently unable in some circumstances (i.e., high volume fisheries targeting multiple species) to provide accurate and reliable data on catch composition, especially for fish discards. In those instances data from video footage should be cross-checked with another data source(s). Consequently, this tool alone may not be adequate to reliably differentiate and account for discards of species that are very similar in form and color.

At-Sea Observers

Observer programs in the United States typically include quality control and quality assurance steps to ensure accuracy and reliability of data. Part of this process includes a structured briefing and debriefing process. Debriefing occurs at the end of a trip to clarify discrepancies or problems with the data or sampling procedures and to discuss any concerns or notable events that occurred during the fishing trip. After data are finalized and submitted it may undergo an additional quality assurance process. Because at-sea observers do not always have the opportunity to weigh every fish, observers in some programs may be required to perform calculations to determine the total weight of discards and retained catch. Some variability may occur between observers in the application of sampling protocols and estimation techniques, although training, debriefing and quality control measures help to reduce this as a source of variance in data. It has been suggested that in fisheries with only partial observer coverage, fishing operations may proceed differently when an observer is not on board. This "observer effect" may affect data quality if the observer data cannot be extrapolated accurately to all vessels in the fishery. Regardless, in well-structured and well-funded programs, overall, accuracy and reliability of observer data is high.

Dockside Monitors

The accuracy and reliability of data collected by dockside monitors is high, it should be noted however, that information on discarded catch or rare events cannot be addressed with this tool. Likewise they are unable to independently confirm where catch originated. Compared to data collected at-sea, the conditions and pace of monitoring dockside is more conducive for accurately reporting retained catch by species. Dockside monitors can also collect size frequency data and biological samples, such as otoliths and gonads.

Industry Considerations

Industry acceptance and buy-in of a given monitoring tool is very important. Wide acceptance of a monitoring program and its components is expected to increase compliance and effective use, and thus the accuracy and reliability of data collected. Relative costs to industry of different monitoring tools will be the most important consideration for industry stakeholders. The ease of use and adaptability of a given tool are also high priorities. Ease of use of a given monitoring tool will affect fishing operations, morale, and consequently the economics of fishing operations. Ideally, fishery monitoring programs will allow fishing to proceed with minimal disturbance or changes to normal operations, while also maintaining accountability and confidence in data collected on a timely basis.

Vessel Monitoring Systems

VMS does not impact the ability of the crew to operate as usual. Very little space is required for VMS systems, and other than testing the unit prior to leaving port, no additional attention or effort is generally required during fishing operations. VMS does require access to vessel power, and some VMS monitoring re-

"Depending on the vessel, and characteristics of the fishery (high volume, multi species, etc.) use of camera-based systems may require changes to fishing behavior or operations to ensure that all catch handling is captured on video."

gimes are coupled with hailing requirements when leaving or returning to port. These are usually automated, resulting in minimal impact on timing of fishing trips, or ability to change fishing strategies and adjust to changing conditions. Some fisheries require periodic certification of VMS, which may necessitate having the vessel at a designated port during a specific time.

Camera-based Systems

Somewhat more complex to install, camera systems require additional support from vessel personnel compared to other monitoring tools. Gear sensors and video-cameras require custom placement and deployment for each fishing vessel. Depending on the vessel, and characteristics of the fishery (high volume, multi species, etc.) use of camera-based systems may require changes to fishing behavior or operations to ensure that all catch handling is captured on video. In some cases, the crew must modify where they stand and how they handle catch to ensure video cameras capture necessary footage. Camera windows/enclosures should also be periodically checked to ensure that they are clean and unobstructed. Like VMS, these systems require reliable vessel-supplied power to operate.

Some potential advantages to the industry are that camera-based systems take up very little space on board a vessel, and can provide additional flexibility in timing of fishing trips. Camera-based systems can monitor multiple areas of the vessel at once, and are highly customizable to specific boat and fishery characteristics. However, the ability to use multiple gears within one trip may be limited if different camera positions are needed to effectively monitor the catch and/or discards.

At-Sea Observers/Monitors:

Managing the costs and availability of human observers requires advance scheduling of trips, which can be challenging in unpredictable weather conditions as changing the location and timing of fishing trips may result in a significant cost increase. At-sea observers have the potential to impact regular fishing operations as they must be provided with a sleeping area, food, and work space, which can be particularly challenging on small vessels where bunk space is at a premium and may require displacing a needed crew member. Despite these considerations, in fisheries where observer coverage is evenly distributed, industry has expressed support for use of observers as they "level the playing field" by ensuring all fishery participants are playing by the same rules. This is also true for the deployment of camera-based systems and other monitoring tools. If costs for carrying an at-sea observer could be reduced, industry participants would likely be supportive of including observers as part of a monitoring program.

Dockside Monitors:

Dockside monitors can provide assurance to offloading vessels that the species and weight of fish they are offloading and selling is accurate. In some fisheries where dockside monitors are not required, industry members pay for a "weigh master" to document fish weights as they are being landed and sold. In some fisheries, at-sea observers also act as the dockside monitor for the fishing vessel. One advantage to this approach is that the dockside monitors will already be familiar with the crew, vessel, and type of catch retained during a given trip. The dual role also eliminates the need to coordinate or schedule the deployment of a catch monitor to the dock. Some industry members suggested having someone associated with the fishery, such as a retired fisherman, fulfill dockside monitoring duties. This could reduce overall monitoring costs and provide part-time employment opportunities for an important sector of the fishing community.

Ability to Meet Enforcement Needs

Among other responsibilities and duties, fisheries enforcement officials are responsible for enforcing laws and carrying out statutes to help fishing communities and other stakeholders benefit from marine resources to the greatest extent possible. Monitoring programs must therefore be designed to detect potential violations of fishery regulations. Furthermore, the data collected must be from a reliable source of high quality and conform to numerous evidentiary standards when used in the prosecution of alleged violations.

Vessel Monitoring System:

While there were initial challenges to using VMS as a tool in the prosecution of fishing violations, case law has now been developed allowing the introduction of VMS track data as credible information to support allegations of fishing in a closed area or time. However, refinement of case law and the use of VMS as a "sole source" of evidence is an ongoing process. This is especially true in State court jurisdictions where the burden of proof required is "beyond a reasonable doubt" for most offenses, versus the Federal system where the burden can be less. While VMS can only provide information on spatial and temporal vessel movements, its value as a monitoring and investigative tool should not be underestimated. For example, VMS can track vessels and determine when and where gear is being deployed. VMS data may also contribute to enforcement goals and objectives by allowing enforcement officials to identify when and where fishing activity is concentrated, allowing for efficient use of limited patrol resources.

"(C)ase law has now been developed allowing the introduction of VMS track data as credible information to support allegations of fishing in a closed area or time."

Camera-based Systems:

Camera set ups can monitor multiple areas of the vessel at once, but are unable to provide information on intent, or other situational evidence that may be useful in charging cases. The use of camera-based or video data for enforcement purposes is expected to increase as this technology advances. For example, other gear/vessel sensors that may provide information on vessel activities, such as the state of a vessel's hydraulic systems, engines or the status of a vessel's net are being developed by fishery type, with the intention that this data would be captured and recorded (or be transmitted) electronically as part of a camera-based or VMS system. With increased confidence in camera-based data, these tools are likely to become more main stream and increasingly useful for enforcement purposes. Currently, there is limited case law in which video data has been used as evidence; however, a private association and the Crown in British Columbia have used EM data to support settlements in fisheries litigation. In these cases, the video evidence led to timely resolution of claims.

"Determining the abundance and productivity of fish stocks, species distribution, abundance, growth, maturity, size and age, and catch per unit effort are all key to fulfilling scientific objectives."

At-Sea Observers:

Given the ability to have a live witness testify regarding the intention, actions and circumstances around a potential fishery violation, human observers are often the standard against which other monitoring tools are compared considering enforcement needs. Human observers however often have many tasks, in addition tomonitoring compliance with fishery regulations. Some consideration should be given to the extent to which observers are required to multi-task, as the relationship between the observer and vessel crew, and thereby the quality of scientific data collected, can be compromised if observers are perceived as compliance officers. While human observers remain the best source of evidentiary-quality information, they have on occasion been subjected to bribes or threats. From a practical standpoint, a single observer is limited in the physical amount of the vessel and fishing operations they can observe at any given time.

Dockside Monitors:

Similar to at-sea observers, dockside monitors as their presence serves as a deterrent and witness to any illegal activities taking place in port, and are able to provide a first-hand account of the quantity and species of fish landed. As with the at-sea observer program, how of the dockside monitor is perceived will affect how they are viewed and treated by the fishermen and/or buyers they are monitoring during offloads. Oftentimes the monitor is tasked with both biological sampling and compliance monitoring.

Ability to Meet Science Needs

Scientific data are an important component of the ongoing evaluation and sustainable management of fisheries. Determining the abundance and productivity of fish stocks, species distribution, abundance, growth, maturity, size and age, and catch per unit effort are all key to fulfilling scientific objectives. Additionally, monitoring activities need to document interactions with protected species to ensure interactions remain within accepted biological limits. Such information can also contribute to the development of modified fishing gear and fishing behaviors to minimize impacts on protected or overfished species.

Vessel Monitoring System:

VMS does not capture biological data directly but it supports meeting biological data needs of fisheries when its position data are used in conjunction with other monitoring tools. VMS can provide spatial data regarding locations where fishing effort may or may not be concentrated. Additionally, distributional data coupled with oceanographic information can contribute to understanding fish-habitat relationships and the ecology of target and bycatch species.

Camera-based Systems:

Video data can remain available for independent audit, verification, or subsequent review, offering both science and management the opportunity for truly random subsampling of data. Protected species interactions have been documented with cameras, including providing an index of sea bird abundance and monitoring for use of required mitigation gear/practices. It should be noted that image quality is not always sufficient for species identification, although emerging use of digital technology will improve this. Additionally, cooperation with the vessel's crew is an important component of effectively using cameras to document interactions with protected species and other rare events. The ability to detect rare events will decline as the amount of video data reviewed decreases. Audit rates (e.g. 100%, 25%, 10%) therefore should be informed by the need to and probability of documenting rare events in a particular fishery.

At-Sea Observers:

At-sea observers are most commonly employed to collect data relevant for meeting scientific goals and objectives. A significant advantage of observers is their ability to collect complex biological data and to collect and manage physical samples. In some fisheries, small vessels and limited space to accommodate an additional person have reduced the ability to deploy at-sea observers to collect scientific data.

Dockside Monitors:

In addition to confirming quantities and species of landed catch, dockside monitors can serve a useful role in collecting biological or genetic samples, as well as age and growth data. However, dockside monitors are unable to provide scientific data on discarded catch, rare events, protected species interactions, or samples from unsorted (pre-sorted) catch.

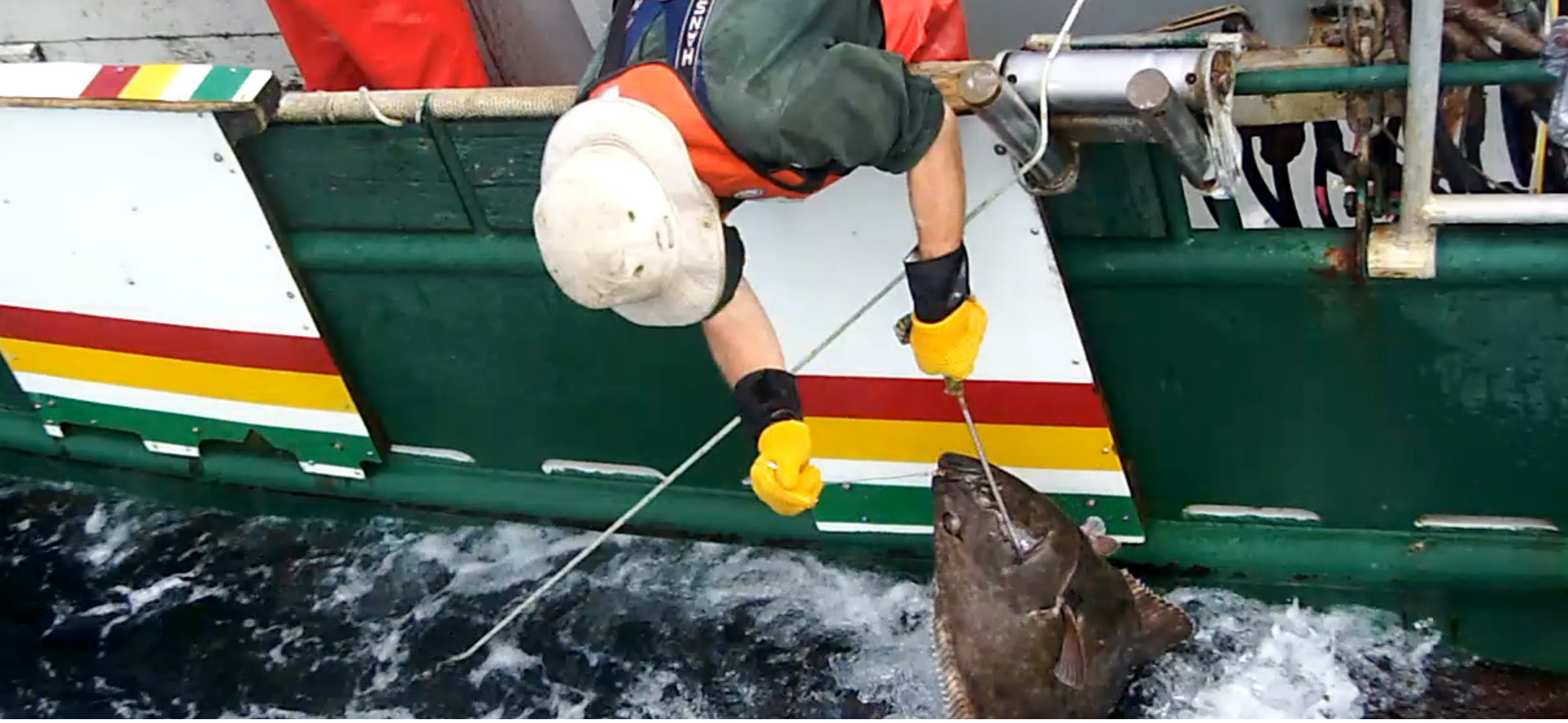


Photo credit: Archipelago Marine Research – EM footage

SECTION 4: Electronic Monitoring Resources

Table 4. *Studies, conference and workshop proceedings, documents from meetings of Regional Fishery Management Councils and other reports related to the use of electronic monitoring and electronic reporting tools in fisheries. To aid in the evaluation of monitoring tools and consideration of tradeoffs, relevant phases of the Roadmap (see Section 1) are identified.*

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
1	Bvaker Jr MS, et al	2012	NMFS Cooperative Research Program Award # NA06-NMF4540059.	Evaluation of electronic monitoring (EM) as a tool to characterize the snapper grouper bandit fishery	Phase I: step 4 Phase II: step 2 Phase II: step 3	Pilot Study - General	Bandit Gear
2	Brady C	2012	NOAA Fisheries	2012 Electronic Monitoring Feasibility Plan	Phase II	Pilot Study - General	Trawl
3	McElderry H	2012	Archipelago	Technology-based monitoring options for commercial fisheries	Phase I: step 3 Phase II: step 2	Monitoring Program Design	Not specific to a type of fishing gear

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
4	McElderry H	2012	Archipelago	Moving Towards an Operational EM Program	Phase I: step 3	Monitoring Program Design	Not specific to a type of fishing gear
5	McTee S	2012	PFMC Apr 2012 I.4.d Supp. Public Comment 2	Electronic Monitoring: Lessons Learned and Recommendations for Further Development	Phase I: step 3 Phase II: step 2	Information Gathering	Longline, Gillnet, Trawl, Fixed Gear
6		2012	NOAA Technical Memorandum NMFS-F/SPO-123	National Observer Program FY 2011 Annual Report	Phase I: step 3 Phase II: step 2	Observer Coverage	Not specific to a type of fishing gear
7		2012	PFMC Apr 2012 I.4.b Supp. PSMFC Report	Pacific States Marine Fisheries Commission Report on Electronic Monitoring	Phase II	Pilot Study - General	Trawl, Fixed Gear
8		2012	PFMC Jun 2012 D.6.a Supp. Attachment 2	Electronic Monitoring Update	Phase II	Pilot Study - General	Trawl, Fixed Gear
9		2012	PFMC Jun 2012 G.7.a Attachment 6	Possible Regulation Amendment Process for Consideration of Electronic Monitoring as a Replacement for the 100% Observer Coverage Requirement	Phase III	Monitoring Program Design	Trawl, Fixed Gear
10		2012	Marine Management Organization	Catch Quota Trials 2011 Final Report: April 2012	Phase II	Pilot Study - General	Trawl, Gillnet, Longline
11	Bryan J, Ramos MJP, McElderry H	2011	Archipelago; The Nature Conservancy	Use of an electronic monitoring system to estimate catch on groundfish fixed gear vessels in Morro Bay California -- Phase II	Phase II: step 2 Phase III: step 2	Pilot Study - Catch Estimates	Fixed Gear
12	Evans R, Molony B	2011	Department of Fisheries, Western Australia	Pilot evaluation of the efficacy of electronic monitoring on a demersal gillnet vessel as an alternative to human observers	Phase II: step 2 Phase III: step 2	Pilot Study - Observers vs. EM	Gillnet

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
13	Faunce CH	2011	ICES Journal of Marine Science	A comparison between industry and observer catch compositions within the Gulf of Alaska rockfish fishery	Phase I: step 3 Phase I: step 4	Research - Catch Estimates	Trawl
14	Faunce CH, Barbeaux SJ	2011	ICES Journal of Marine Science	A comparison between industry and observer catch compositions within the Gulf of Alaska rockfish fishery	Phase I: step 3 Phase I: step 4	Research - Catch Estimates	Trawl
15	Hartley, M.L. et al.	2011	Northern Economics, Inc.	A Review of Observer Monitoring Programs in the Northeast, the West Coast and Alaska	Phase II: step 2	Information Gathering	Trawl, Fixed Gear
16	Kindt-Larsen L, Kirkegaard E, Dalskov J	2011	ICES Journal of Marine Science	Fully documented fishery: A tool to support a catch quota management system	Phase II	Pilot Study - General	Trawl, Gillnet, Seine
17	Kubiak CJ	2011	Central Coast Sustainable Groundfish Association	Electronic Monitoring Proposal for the IFQ Trawl Rationalization Program	Phase II	Pilot Study - General	Trawl
18	Lanning JM	2011	NOAA Fisheries	Sector ASM Coverage Requirements	Phase II: step 2 Phase III: step 3	Observer Coverage	Not specific to a type of fishing gear
19	Stebbin S, et al.	2011	MRAG Americas	Development of Effective Monitoring Programs	Phase II	Monitoring Program Design	Not specific to a type of fishing gear
20	Pria MJ, Bryan J, McElderry H	2011	Northeast Fisheries Science Center Contract EA133F-10-SE-0949	New England Electronic Monitoring Project 2010 Annual Report	Phase II	Pilot Study - General	Trawl, Gillnet, Longline
21	Stanley, RD et al.	2011	ICES Journal of Marine Science	The Advantages of an Audit Over Census Approach to the Review of Video Imagery in Fisheries Monitoring	Phase I: step 5 Phase III: step 1 and 2	Video Analysis	Fixed Gear

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
22		2011	NPFMC Feb 2012 B-2	The Use of Electronic Monitoring (EM) Technologies in Alaskan Fisheries	Phase I: step 4 Phase II: step 2	Information Gathering	Trawl, Longline
23	Aggarwal M, Lautz C	2010	Mamigo	Final Report Trainable Video Analytic Software (HA133F10SE1558)	Phase III: step 2	Video Analysis	Trawl
24	Bonzon K, et al.	2010	Environmental Defense Fund	Catch Share Design Manual. Appendix A: Monitoring and Data Collection Approaches	Phase I: step 3	Monitoring Program Design	not specific to a gear type
25	Calahan JA, et al.	2010	NOAA Tech. Memo. NMFS-AFSC-213	Bycatch characterization in the Pacific halibut fishery: A field test of electronic monitoring technology	Phase II	Pilot Study - Discard Estimates, Observers vs. EM	Longline
26	McElderry H, et al.	2010	Archipelago	Electronic monitoring in the New Zealand inshore trawl fishery: A pilot study	Phase II	Pilot Study - Protected Species	Trawl
27	McElderry H, et al.	2010	Archipelago	A pilot study using EM in the Hawaiian Longline Fishery	Phase II	Pilot Study - General	Longline
28	Rienecke S, et al.	2010	Archipelago; The Nature Conservancy	Morro Bay/Port San Luis Exempted Fishing Permit Electronic Monitoring Pilot Project Progress Report for the Pacific Fisheries Management Council	Phase II	Pilot Study - General	Fixed Gear
29	Benoit HP, Allard J	2009	Canadian Journal of Fisheries and Aquatic Sciences	Can the data from at-sea observer surveys be used to make general inferences about catch composition and discards?	Phase I: step 3 Phase I: step 4	Research - Observer Effect	Trawl, Seine, Longline, Gillnet

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
30	Bonney J, Kinsolving A, McGauley K	2009	Alaska Groundfish Data Bank; NMFS	Continued Assessment of an Electronic Monitoring System for Quantifying At-sea Halibut Discards in the Central Gulf of Alaska Rockfish Fishery	Phase II	Pilot Study - General	Trawl
31	Conners ME, et al.	2009	NOAA Technical Memorandum NMFS-AFSC-199	Sampling for Estimation of Catch Composition in Bering Sea Trawl Fisheries	Phase II: step 2 Phase III: step 2	Pilot Study - Observers vs. EM	Trawl
32	Dalskov J, Kindt-Larsen L	2009	DTU Aqua report no. 204-2009	Final Report of Fully Documented Fishery	Phase II	Pilot Study - General	Trawl, Gillnet, Seine
33	Stanley RD, Olsen N, Fedoruk A	2009	Marine and Coastal Fisheries	Independent validation of the accuracy of yelloweye rockfish catch estimates from the Canadian Groundfish Integration Pilot Project	Phase II: step 2	Research - Catch Estimates	Fixed Gear
34	Bonney J, McGauley K	2008	Alaska Groundfish Data Bank; EFP 07-02 Final Report	Testing the Use of Electronic Monitoring to Quantify At-sea Halibut Discards in the Central Gulf of Alaska Rockfish Fishery	Phase II	Pilot Study - Discard Estimates	Trawl
35	McElderry HI, Reidy RD, Pahti DF	2008	Archipelago; IPHC Tech Report 51	A pilot study to evaluate the use of electronic monitoring on a Bering Sea groundfish factory trawler	Phase II	Pilot Study - General	Trawl
36	Pria MJ, et al.	2008	Archipelago	Using electronic monitoring to estimate reef fish catch on bottom longline vessels in the Gulf of Mexico: A pilot study	Phase II	Pilot Study - Catch Estimates	Longline
37	Pria MJ, et al.	2008	Archipelago	Use of a Video Electronic Monitoring System to Estimate Catch on Groundfish Fixed Gear Vessels in California: A pilot study	Phase II	Pilot Study - Catch Estimates	Fixed Gear

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
38		2008	Alaska Fisheries Science Center	Electronic Fisheries Monitoring Workshop Proceedings	Phase I: step 3 Phase II: step 2	Conference Proceedings	Not speci!c to a type of !shing gear
39	Ames RT, Leaman BM, Ames KL	2007	North American Journal of Fisheries Management	Evaluation of Video Technology for Monitoring of Multispecies Longline Catches	Phase III: step 2	Video Analysis	Longline
40	McElderry H, et al.	2007	DOC Research & Development Series 264	Pilot study to test the effectiveness of electronic monitoring in Canterbury fisheries	Phase II	Pilot Study - Protected Species	Trawl, Seine
41	Kinsolving A	2006	National Marine Fisheries Service	Discussion Paper on Issues Associated with Large Scale Implementation of Video Monitoring	Phase III	Information Gathering	Not specific to a type of fishing gear
42	McElderry H	2006	ICES Annual Science Conference 2006 Session CM 2006/N:14	At-Sea Observing Using Video-Based Electronic Monitoring	Phase II	Pilot Study - General	Longline, Trawl
43	Ames RT	2005	IPHC Scientific Report No. 80	The efficacy of electronic monitoring systems: a case study on the applicability of video technology for longline fisheries management	Phase II	Pilot Study - General	Longline
44	McElderry H, et al.	2005	Archipelago	Electronic Monitoring of the Cape Cod Haddock Fishery in the United States A Pilot Study	Phase II	Pilot Study - General	Longline
45	McElderry H, Reidy R, Illingworth J, Buckley M	2005	Archipelago	Electronic Monitoring of the Kodiak Alaska Rockfish Fishery A Pilot Study	Phase II	Pilot Study - General	Trawl

	Author(s)	Year	Source	Title	Phases in Roadmap	Focus Area	Gear Type
46	McElderry H, et al.	2004	NOAA Tech. Memo. NMFS-AFSC-147	Electronic Monitoring of Seabird Interactions with Trawl Third-wire Cables on Trawl Vessels - A Pilot Study	Phase II	Pilot Study - Protected Species	Trawl
47	Cusick J, LaFargue J, Parkes G	2003		NMFS Small Boats Workshop	Phase I: step 3 Phase I: step 4 Phase II: step 2	Conference Proceedings	Longline
48	McElderry H, Schrader J, Illingworth J	2003	Research Document 2003/042	The Efficacy of Video-Based Electronic Monitoring for the Halibut Longline Fishery	Phase II	Pilot Study - General	Longline

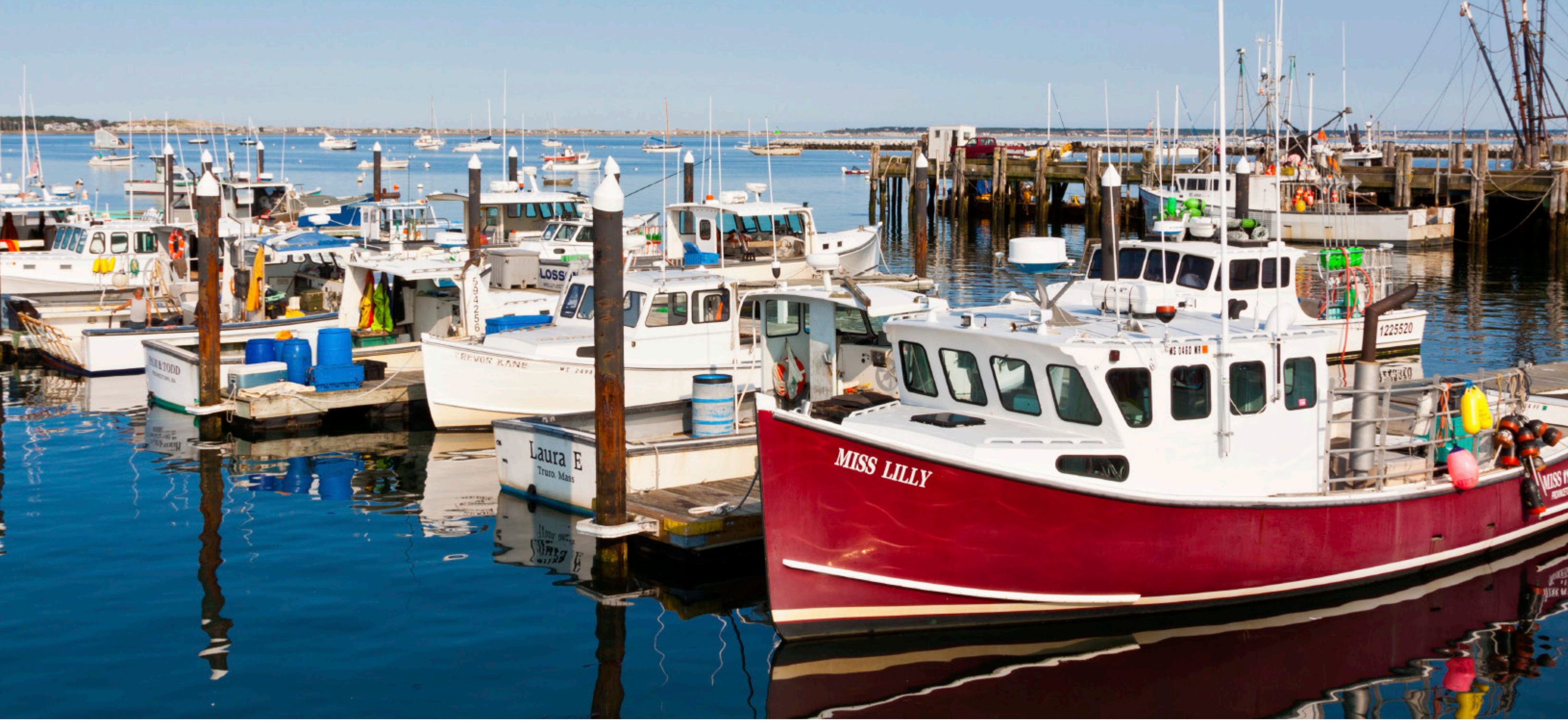


Photo credit: Oleg Albinsky

SECTION 5: Case Studies

The following four case studies are intended to help illustrate how the Fishery Monitoring Matrix (see Section 2) can be tailored to a given fishery. Additionally, the case studies demonstrate how similar fisheries have tailored the use of a given monitoring tool and have elected to deploy different combinations of monitoring tools. Understanding that monitoring costs are of particular interest to stakeholders, the case studies provide an outline some of the costs associated with implementing each monitoring tool. Some costs such as administration/overhead and training costs for some fisheries were not readily available. Additionally, because VMS is implemented as a national program identifying costs for individual fleets was not possible in some instances. Care should therefore be exercised in comparing the relative costs among these fisheries as complete data were not available and factors affecting costs vary considerably across fisheries. Although the cost information presented herein is limited, the case studies help demonstrate and how the details of the monitoring program, such as coverage level, audit rates and the number of monitoring tools used can affect the cost of a monitoring program. Additionally, the case studies can be used as guidance, outlining the different categories of costs to be considered for implementing a specific monitoring tool.

Case Study #1:

West Coast Shoreside Whiting EFP Fishery (2010)

Gear Used

- Midwater trawl

Fisheries Characteristics

- Multiple stock areas can be fished in a single trip
- Single target species fishery
- Multispecies rockfish bycatch, some of which are challenging to differentiate from each other
- Discards of salmon prohibited
- Fleet-wide limits for overfished rockfish species
- Maximum retention standard for all of the rockfish species
- Vessels stop fishing for the year once the fleet-wide limits are reached
- Approximately 35 vessels

Main Monitoring Objective

To document at-sea fishing activities, ensure no discards of salmon occurred and that overfished rockfish species were retained.

Monitoring Tools Used

1. VMS

- Document stock areas fished

2. Logbooks

- Document gear used
- Record stock areas fished and approximate catch, by species, for each area
- Record quantity and size of discarded "sector" species

3. Hailing/Notifications

- Notify when vessel is leaving port
- Notify intention to fish in specific stock areas
- Upon return to port, indicate approximate catch from each stock area

4. Camera-Based Systems

- Monitor fishing handling and ensure all salmon are retained and that overfished rockfish species were retained to the greatest extent possible.

Monitoring Tools Not Used

1. Observers

Monitoring Program Details

Initially this fleet also deployed at-sea observers, covering 10% of trips. Electronic monitoring (camera-based) systems were deployed initially to examine observer-biases in data, i.e. the presence of an observer altering fishing behavior and to test accuracy of speciation with cameras. Eventually, the fleet went to 100% EM to monitoring for full retention of catch, with all catch accounting and speciation taking place dockside.

Ongoing Monitoring Research

The overall fishery monitoring program was revised as the fleet began fishing under an Individual Transferable Quota (ITQ) during 2011. A handful of vessels are deploying camera-based systems (along with required observers) to help refine the components of Vessel Monitoring Plans for this fleet and also identify audit rates for video footage that produce comparable results to observer data. Additional details on this monitoring project can be found on the Pacific Fishery Management Council's website.

Monitoring Costs

Table 5. *Monitoring costs for the West coast shoreside whiting EFP fishery during 2010 for 35 fishing vessels making 728 trips for a total of 1,269 sea days. Starting January 2011, this fishery was incorporated into the Pacific groundfish IFQ fishery. Empty cells do not represent zero cost, but highlight monitoring expenses we were unable to get more detailed data for. Source: Personal communication Archipelago Marine Research; September 4, 2012.*

	Cost per Sea Day	Annual Monitoring Costs		
		Total	Industry	Government
VMS Costs				
Purchase Price	$75	$390,600		$390,600
Transmission	$14	$75,600	$75,600	
Monitoring Software				
Monitoring Technicians				
VMS SUBTOTAL	$89	$466,200	$75,600	$390,600
Dockside Monitor Costs				
(Compliance) Monitors				
Training				
Travel				
Administration / Overhead				
DOCKSIDE MONITOR SUBTOTAL				
Camera-Based System Costs				
Logistical Planning	$17	$22,000	$0	$22,000
Project Manager	$20	$25,472	$14,231	$11,241
equipment lease costs* (26 F/V)	$132	$129,045	$129,045	$0
equipment purchase costs* (9 F/V)	$52	$15,291	$15,291	$0
field services	$81	$102,494	$102,494	$0
travel expenses	$42	$53,463	$53,463	$0
data services and review	$45	$56,480	$0	$56,480
data reporting	$13	$16,384	$0	$16,384
CAMERA-BASED SUBTOTAL (LEASE)	$350	$405,338	$299,233	$106,105
CAMERA-BASED SUBTOTAL (PURCHASE)	$270			
Logbook Costs				
Printing				
Handling / Data Entry				
Quality Assurance				
LOGBOOK SUBTOTAL				
TOTAL MONITORING COSTS	$439	$871,538	$374,833 43%	$496,705 57%

* *Equipment purchase costs were amortized over five years. The total monitoring cost of $439 is estimated based on the cost of leasing EM equipment.*

Fishery Monitoring Matrix

Ability To Meet Data Needs: High | Medium | Low | Not Applicable

Data Needs	Fishery Characteristics and Requrements		Independent Monitoring: Vessel Monitoring System	Independent Monitoring: Camera-based System	Independent Monitoring: Dockside Monitoring	Self-Reporting: Logbooks	Self-Reporting: Hailing or Other Notifications	Tools Not Used: At-sea Observers
Discards: species and amount (count, length or weight)	high volume catch handling	single target species		Monitored haul back and fish handling. Reviewed to detect presence/absence of discard events and the magnitude (based on approx. weight) of discards				The fleet initially started out with 10% observer coverage, but there we no observer coverage required during 2010
		multi-species						
	species difficult to differentiate			Some of the groundfish "bycatch" were difficult to differentiate. Documented any circumstances under which rockfish species were discarded		Required to record all discard events if any		
Retained catch: species and amount (count, length or weight)	high volume catch handling	single target species						
		multi-species				Species and approximate pounds of catch were reported in paper logbooks		
	species difficult to differentiate							

Fishery Monitoring Matrix

Ability To Meet Data Needs: High | Medium | Low | Not Applicable

Data Needs	Fishery Characteristics and Requrements	Independent Monitoring: Vessel Monitoring System	Independent Monitoring: Camera-based System	Independent Monitoring: Dockside Monitoring	Self-Reporting: Logbooks	Self-Reporting: Hailing or Other Notifications	Tools Not Used: At-sea Observers
spatial information for fishing trip	single management area	All vessels were required to operate VMS outside of port			Paper logbooks required- used to record fishing locations among other data.		The fleet initially started out with 10% observer coverage, but there we no observer coverage required during 2010
details on interactions with protected species	species encountered						
	handling method						
	condition at release						
	discarded or retained		Monitored fish haul back and fish handling to ensure salmon were not discarded.				
	other non-gear interactions						
operational details	gear used						
	amount and type of bait used						
	economic data						
biological data from catch	length frequency						10% of trips with observers collecting biological samples for scientific purposes.
	age						
	reproductive condition						

Case Study #2:

New England Multi-species Sector Fishery (2010)

Gear Used

- Bottom trawl
- Gillnet
- Hook and line

Fisheries Characteristics

- Multispecies fishery
- Approximately 300 vessels
- Revenue for 2011 was just over $89 million for 61.1 million pounds landed.
- Fish are allocated on an area basis with four broad stock areas
- Multiple stock areas can be fished in a single trip
- Minimum size limits for 9 species
- Mandatory discard requirements for 6 non-allocated species
- Some species, such as flounder species are difficult to differentiate

Main Monitoring Objective

To monitor discards and landings to ensure catch does not exceed allocated amounts, to enforce area-specific management measures, and determine fishing effort and fishing mortality.

Monitoring Tools Currenctly Used

1. VMS

- Document stock areas fished

2. At-sea Monitors and Observers (Northeast Fishery Observer Program)

- Collect biological samples (NEFOP only)
- Document amount and species of fish discarded
- Document amount and species of retained catch
- Document interactions with protected species

3. Logbooks (paper or electronic)

- Document gear used
- Record stock areas fished and approximate catch, by species, for each area
- Record quantity and size of discarded "sector" species

4. Hailing/Notifications

- Notify when vessel is leaving port
- Notify intention to fish in specific stock areas
- Upon return to port, indicate approximate catch from each stock area

Monitoring Tools Not Used

1. Camera-based Systems

2. Dockside Monitors

Monitoring Program Details

- The coverage of both the at-sea Observers and at-sea Monitors is decided on an annual basis.
- Currently vessels may submit either paper or electronic logbooks, referred to in this fishery as Vessel Trip Reports (VTRs). Logbooks are submitted to both the Sector manager as well as NMFS. When paper logbooks are used, both the Sector manager and NMFS must input this data manually into an electronic form. Furthermore, a separate logbook (VTR) must be completed for each area fished on a single trip.
- All discarded catch of undersized sector species counts against that vessel's quota. For vessels not carrying an observer, a sector, area and gear-specific discard rate is applied to that vessels quota account.
- Information on retained catch comes from logbooks, dealer reports and in some instances at-sea monitors (21% of trips), or observers (7% of trips).
- Landings are not currently monitored. Dealers submit reports, but no other data are currently used to verify landings. State enforcement officials, through the Joint Enforcement Agreement (JEA) perform spot checks at the docks.

Ongoing Monitoring Research

The fishery is currently testing the ability of electronic monitoring (EM) tools to record the size, number and species of retained and discarded catch. Preliminary results of this research can be found at: http://www.nefsc.noaa.gov/fsb/ems/

Monitoring Costs

Table 6. *Monitoring costs for the New England multi-species sector fishery, comprised of approximately 301 fishing vessels, which made 13,642 trips, for a total of 28,922 sea days during 2011. Level of at-sea observer and at-sea monitoring coverage is variable each year. Sources: OMB Paperwork Reduction Act, Revision of Currently Approved Collection, 201o. Personal communication: Amy Van Atten, NMFS Fisheries Sampling Branch, March 27, 2013.*

	Costs per Sea Day	Annual Monitoring Costs		
		Total	Industry	Government
VMS Costs				
Salary etc	$8	$230,000	$0	$230,000
Equipment and Supplies	$1	$31,000	$0	$31,000
Internet Connection and Backup	$2	$46,460	$0	$46,460
Software and Licensing	$0	$3,500	$0	$3,500
Training and Travel	$0	$8,000	$0	$8,000
VMS SUBTOTAL	$11	$318,960	$0	$318,960
At-sea Monitor Costs (ASM) (21% of trips)				
Monitor Cost	$508	$3,288,792	$0	$3,288,792
Travel	$31	$200,694	$0	$200,694
Training	$41	$265,434	$0	$265,434
Other Costs	$267	$1,728,558	$0	$1,728,558
AT-SEA MONITOR SUBTOTAL	$847	$5,483,478	$0	$5,483,478

Monitoring Costs (continued)

	Costs per Sea Day	Annual Monitoring Costs		
		Total	Industry	Government
Northeast Fishery Observer Program (NEFOP) Costs (7% of trips)				
Observer Cost	$568	$1,533,032	$0	$1,533,032
Travel	$35	$94,465	$0	$94,465
Training	$45	$121,455	$0	$121,455
Other Costs	$269	$726,031	$0	$726,031
AT-SEA OBSERVER SUBTOTAL	$917	$2,474,983	$0	$2,474,983
Logbook Costs				
Printing	$2	$51,300		$51,300
Handling and Data Entry	$1	$27,600		$27,600
Quality Assurance	$7	$192,900		$192,900
LOGBOOK SUBTOTAL	$10	$271,800	$0	$271,800
TOTAL COSTS (AT-SEA MONITOR)	$868	$6,074,238	$0	$6,074,238
TOTAL COSTS (AT-SEA OBSERVER)	$938	$3,065,743	$0	$3,065,743

Fishery Monitoring Matrix

Ability To Meet Data Needs: High | Medium | Low | Not Applicable

Data Needs	Fishery Characteristics and Requirements		Independent Monitoring		Self-Reporting		Tools Not Used	
			Vessel Monitoring System	At-sea Observers	Logbooks	Hailing or other Notifications	Camera-based Systems	Dockside Monitoring
Discards: species and amount (count, length or weight)	high volume catch handling	multi-species		ITQ species are not required to be retained. 5-6 non-ITQ species must be discarded. There are also minimum size restrictions for some species that must be discarded.	Discards from each stock area are reported by species.			
	species difficult to differentiate							
Retained catch: species and amount (count, length or weight)	high volume catch handling	multi-species		At-sea monitors and observers estimate amount of each allocated species. Do not verify quantity and species of landed catch.	All vessels required to submit logbooks (vessel trip reports VTRs) for each stock area to NMFS and the Sector manager. Can be either paper or electronic logbooks.	Must notify type and approximate amount of catch from each stock area prior to landing.		
	species difficult to differentiate			Flounder species are difficult to differentiate from each other.				

Fishery Monitoring Matrix

Ability To Meet Data Needs: High · Medium · Low · Not Applicable

Data Needs	Fishery Characteristics and Requirements	Independent Monitoring: Vessel Monitoring System	Independent Monitoring: At-sea Observers	Self-Reporting: Logbooks	Self-Reporting: Hailing or Notifications	Tools Not Used: Camera-based Systems	Tools Not Used: Dockside Monitoring
spatial information by fishing event	multiple management zones	all vessels required to operate VMS	12% of trips covered by at-sea monitors. 8% of trips covered by at-sea observers.	All vessels required to submit logbooks (vessel trip reports VTRs) for each stock area to NMFS and the Sector manager. Have the option of submitting either paper or electronic logbooks.	Prior to leaving port vessels must notify which stock areas they will be fishing in.	High	Not Applicable
details on interactions with protected species	species encountered	Not Applicable	High	Medium	Medium	High	Not Applicable
	handling method	Not Applicable	High	Medium	Medium	Medium	Not Applicable
	condition at release	Not Applicable	High	Medium	Medium	Low	Not Applicable
	discarded or retained	Not Applicable	Medium	Medium	Medium	Medium	Low
	other non-gear interactions	Not Applicable	High	Medium	Medium	Medium	Not Applicable
operational details	gear used	Not Applicable	High	High	High	High	Medium
	amount and type of bait used	Not Applicable	High	High	High	High	Medium
	economic data	Not Applicable	Medium	High	High	Not Applicable	Medium
biological data from catch	length frequency	Not Applicable	High	Not Applicable	Not Applicable	Medium	Medium
	age	Not Applicable	High	Not Applicable	Not Applicable	Not Applicable	Medium
	reproductive condition	Not Applicable	High	Not Applicable	Not Applicable	Not Applicable	Medium

Case Study #3:

Pacific Groundfish IFQ Shore-Based non-whiting Trawl Fishery (2011)

Gear Used

- Bottom trawl
- Fixed gear (bottom longlines, pots and traps)

Fisheries Characteristics

- Multispecies fishery, including many rockfish that are difficult to differentiate and are found in similar habitats
- Individual fishing quotas (IFQ) for approximately 60 species, 22 of which are the main target species.
- Six IFQ species are overfished which constrains fishing activities
- Discards permitted, but all catch counts against quota
- Discard of halibut and salmon mandated. Halibut catch is deducted from an individual bycatch quota (IBQ)
- Limited entry trawl permit required, but vessels are permitted to "gear-switch"
- No minimum landing sizes or retention requirements.
- Approximately 126 vessels and 50 processing/landing sites. Total revenue during 2011 was near $53 million.
- Minimal interactions with protected species.

Main Monitoring Objective

- To record retained and discarded catch by species and estimate mortality rates of discarded halibut

Monitoring Tools Currently Used

1. VMS

- Documents areas fished

2. At-sea Observers

- Record fishing effort information
- Estimate retained and discarded weight of overfished IFQ species
- Estimate discard rate of non-overfished IFQ species
- Sample Pacific halibut for viability
- Biological information and collect samples from non-IFQ and protected species

3. Dockside Monitors

- Verify delivery vessels and document landings
- Observe sorting and weighing of catch
- Submit species specific catch data
- Collect biological data from salmon

4. Logbooks (paper or electronic)

- Vessels record information on time and location of fishing activities and estimates of catch composition in hard copy logbook

5. Hailing/Notifications

- Notify when vessel is leaving port
- Upon return to port, indicate approximate catch from each stock area

Monitoring Tools Not Used

1. Camera-based Systems

Monitoring Program Details

- 100% at-sea observer and shoreside monitor coverage
- Observers contracted through any of five companies
- Restricted landing hours to reduce costs
- Submission of economic information from vessels mandatory for ongoing research
- Industry portion of monitoring costs increasing on an annual basis. Expected to cover 100% of monitoring costs by 2015.
- Cost recovery from industry for program management, up to 3% of ex-vessel revenue, scheduled for 2013.

Ongoing Monitoring Research

This fishery is currently testing the ability of electronic monitoring (EM) tools to accurately document discards. Various review rates (100%; 50%; 25% and 10%) are also being tested to determine the amount of EM data that must be analyzed to achieve a high level of confidence in reported data. Details and preliminary results of this research can be found on the Pacific Council website.

Monitoring Costs

Table 7. *Monitoring costs of the Pacific groundfish (non-whiting) IFQ fishery during 2011 for approximately 108 active vessels with 1,604 trips for a total of 5,225 sea days. Monitoring costs vary by year, with the industry portion of total costs increasing each year since 2011. Empty cells do not represent zero cost, but highlight monitoring expenses we were unable to get more detailed data for. Source: Personal communication, Pacific States Marine Fisheries Commission, November 7, 2012 and March 22, 2013.*

	Costs per Sea Day	Annual Monitoring Costs Total	Industry	Government
VMS Costs				
Purchase Price	$49	$258,340		$258,340
Transmission	$10	$50,001	$50,001	
Monitoring Software				
Monitoring Technicians				
VMS SUBTOTAL	$59	$308,341	$50,001	$258,340
At-sea Observer and Dockside Monitor Costs				
Training and administration	$70	$366,730	$36,507	$330,223
Dockside (compliance) monitors	$47	$247,700	$24,769	$222,931
At-sea observers	$337	$1,763,030	$160,275	$1,602,755
DOCKSIDE AND OBSERVER SUBTOTAL*	$455	$2,377,460	$221,552	$2,155,909
Logbook Costs				
Printing				
Handling / Data Entry				
Quality Assurance				
LOGBOOK SUBTOTAL				
TOTAL MONITORING COSTS	$514	$2,685,802	$271,553) 10%	$2,414,249 90%

** In this fishery, once a trip is completed the at-sea observer usually performs dockside monitoring duties. Because the same person performs both functions the costs for training and administration are represented as a single cost.*

Fishery Monitoring Matrix

Ability To Meet Data Needs: High · Medium · Low · Not Applicable

Data Needs	Fishery Characteristics and Requirements		Independent Monitoring: Vessel Monitoring System	Independent Monitoring: At-sea Observers	Independent Monitoring: Dockside Monitoring	Self-Reporting: Logbooks	Self-Reporting: Hailing or other Notifications	Tools Not in Use: Camera-based Systems
Discards: species and amount (count, length or weight)	fixed gear = serial or low volume catch handling			100% observer coverage on all vessels. record amount and species of IFQ discards		approximate amount of IFQ species discarded	Hailing/notification of species and amount of discards not required	
	trawl = high vol. catch handling	multi-species		100% observer coverage on all vessels. Focus on discard events, but also record retained catch.		species and approximate weight of IFQ species retained		
	species difficult to differentiate							
Retained catch: species and amount (count, length or weight)	fixed gear = serial or low volume catch handling			species and approximate weight of IFQ species retained	Confirm catch is sorted to IFQ level. Record weights by species. Help link buyer reports (e-fish tickets) to landings.	Each state with different requirements. No coast-wide logbook currently in place for fixed gear vessels.		
	trawl = high vol. catch handling	multi-species				Approximate volume of retained catch recorded	Hailing/notification of species and amount of discards not required	
	species difficult to differentiate							

Fishery Monitoring Matrix

Ability To Meet Data Needs: High Medium Low Not Applicable

Data Needs	Fishery Characteristics and Requirements	Independent Monitoring			Self-Reporting		Tools Not in Use
		Vessel Monitoring System	At-sea Observers	Dockside Monitoring	Logbooks	Hailing or Notifications	Camera-based Systems
spatial information for fishing trip	single management area	records vessel location and transit pattern	100% of all fishing trips are observed.		time and location of fishing events recorded	report stock area(s) fished before returning to port	
details on interactions with protected species	species encountered		Catch and condition of halibut is recorded to estimate mortality		details on interactions with protected species recorded		
	handling method		Details for all interactions with protected species are recorded.				
	condition at release						
	discarded or retained			Based on landings and reported catch can determine if/what was discarded.			
	other, non-gear interactions						
operational details	gear used				gear is recorded, other operational details are voluntary and rarely reported.		
	amount and type of bait used						
	economic data						
biological data from catch	length frequency		collect all necessary biological samples for the fishery	Do not collect biological data. Port samplers collect samples according to State needs and requirements.			
	age						
	reproductive condition						

Case Study #4:

British Columbia Hook and Line Groundfish Fishery (2009-2010)

Gear Used

- Rod and Reel
- Troll
- Horizontal Longline

Fisheries Characteristics

- Multispecies fishery
- Approximately 200 vessels
- During the 2009-2010 fishing year, the ex-vessel value of catch from this fleet was over $75 million.
- Multiple stock/fishing areas
- Spatial restrictions to fishing activity, i.e. no fishing inside [rockfish conservation areas]
- Several species have minimum size limits.
- Required to retain all rockfish species
- Many of the rockfish species are difficult to differentiate from each other
- Some concerns about seabird interactions.

Main Monitoring Objective

To document species-specific catch within an area-specific Individual Transferable Quota (ITQ) management program.

Monitoring Tools Currently Used

1. Camera-based System

- Document amount and species of fish discarded
- Document amount and species of retained catch
- Used to audit logbooks

2. Logbooks (paper)

- Piece counts of catch by species
- Approximate weights of some species

3. Dockside Monitors

- Validate all species offloaded
- Validate piece counts of certain species

4. Hailing and other Notifications

- Indicate areas and species intended to fish when leaving port
- Notify approximate catch and species when returning to port

Monitoring Tools Not Used

1. VMS

2. At-sea Observers (optional, but not currently used)

Monitoring Program Details

- Fishers have the option of using at-sea observers instead of EM systems; however, 100% of vessels have opted for EM during recent years.
- A crucial part of the video footage is imagery of catch being released back into the water. Each fish must be held in front of a measuring board in clear view of the camera, which allows for size verification and species identification. This allows for mortality to be attributed to any catch released of legal-size.
- A minimum of 10% of EM fishing data is reviewed and used to audit logbook records. Dockside monitor reports are also compared against catch reported in the logbook.
- Data processing and comparison of data among EM, dockside monitors and logbooks is completed within 5 days.
- Fishers are currently retrieving and submitting EM directly to Archipelago Marine Research Ltd., allowing for a reduction in cost of field services. This is the first fishery to employ these data retrieval and submission protocols.

Ongoing Monitoring Research

This fishery is involved in ongoing research to refine EM data review and procedures for auditing data.

Monitoring Costs

Table 8. *Monitoring costs for the British Columbia hook and line groundfish Fishery. Costs below are for monitoring a fleet of approximately 202 vessels, which made a total of 1,323 trips for a total of 11,545 sea days. Empty cells do not represent zero cost, but highlight monitoring expenses we were unable to get more detailed data for. Source: Stanley RD, et al. 2011. ICES Journal of Marine Science. The Advantages of an Audit Over Census Approach to the Review of Video Imagery in Fisheries Monitoring. 68(8), 1621-1627 Note: based on the source of data, all costs shown are in Canadian dollars. At the time of publication (March 2011) the Canada: U.S. exchange rate was 1.02.*

	Cost per Sea Day	Annual Monitoring Costs		
		Total	Industry	Government
Camera-based System (10% audit)				
Equipment	$1	$355,520	$215,090	$140,430
Field Services	$68	$785,578	$475,275	$310,303
Data Services	$51	$583,982	$353,309	$230,673
CAMERA-BASED TOTAL	$149	$1,725,080	$1,043,673	$681,407
Dockside Monitor Costs				
Dockside (Compliance) Monitors				
Training				
Travel				
Administration				
DOCKSIDE MONITOR SUBTOTAL	$51	$583,780	$583,780	$0
Logbook Costs				
Printing				
Handling / Data Entry				
Quality Assurance				
LOGBOOK SUBTOTAL	$5	$63,024	$63,024	$0
TOTAL MONITORING COSTS	$205	$2,371,884	71% ($1,690,477)	29% ($681,407)

Fishery Monitoring Matrix

Ability To Meet Data Needs: High / Medium / Low / Not Applicable

Data Needs	Fishery Characteristics and Requirements	Independent Monitoring: Camera-based Systems	Independent Monitoring: Dockside Monitoring	Self-Reporting: Logbooks	Self-Reporting: Hailing or Other Notifications	Tools Not in Use: Vessel Monitoring System	Tools Not in Use: At-sea Observers
Discards: species and amount amount = count, length, or weight)	serial or low volume catch handling	All catch items are recorded by total piece count, species and utilizations (retained, discarded) and size (legal/sub-legal).		All catch items are recorded by total piece count, species and utiliza-tions (retained, discarded) and size (legal/sub-legal).	Discards not reported by hailing		Observ-ers are an option for this fleet, but fishing vessels have opted for EM instead.
	species difficult to dif-ferentiate						
Retained catch: spe-cies and amount (amount = count, length, or weight)	high volume catch handling multi-species	All catch items are recorded by total piece count, species and utilizations (retained, discarded) and size (legal/sub-legal).	All landed catch recorded by total piece count, and species.	All catch items are recorded by total piece count, species and utiliza-tions (retained, discarded) and size (legal/sub-legal).	Fishers report landed catch by species and weight		
	species difficult to dif-ferentiate	Rockfish are recorded to the species group level, and verified by dockside monitor		Rockfish are recorded to the species group level, and veri-fied by dockside monitor	Fishers report landed catch by species and weight		

Fishery Monitoring Matrix

Ability To Meet Data Needs: ☐ High ■ Medium ■ Low ■ Not Applicable

Data Needs	Fishery Characteristics and Requirements	Independent Monitoring		Self-Reporting		Tools Not Used	
		Camera-based Systems	Dockside Monitoring	Logbooks	Hailing or Other Notifications	Vessel Monitoring System	At-sea Observers
spatial information by trip	single management area	Records the start and end of each fishing trip		Fishers record start and end of each trip.	Hail in and out for each trip and total landed catch by species and areas fished	The camera-based EM includes GPS data	Observers are an option for this fleet, but fishing vessels have opted for EM instead.
spatial information by fishing event	multiple management zones	Records the time date and location of each fishing event.		Time, date and location of each fishing event required as well as Groundfish Management Area fished.	Fishers hail in and out for each trip and report total landed catch by species and areas fished		
details on interactions with protected species	species encountered	Recorded by EM		Recorded in logbook	Not reported during hail in or hail out		
	handling method	Visible, but not documented by reviewer unless mishandled		Not recoded in logbook			
	discarded or retained	Recorded by EM	Only when these species are landed (very uncommon)	Recorded in logbook			
	other interactions						
operational details	gear used	Recorded by EM	Recoded by dockside monitor	Recorded in logbook	Fishers report gear type during hail in and hail out.		
	amount and type of bait used	Not recorded by EM	Not recorded by dockside monitor				
biological data from catch	length frequency	Length recorded above/below specified lengths (legal, sublegal and marketable, unmarketable)	Not recorded by dockside monitor				
	age						
	reproductive condition						

Lowman, DM, R Fisher, MC Holliday, SA McTee, and S Stebbins. 2013.
Fishery Monitoring Roadmap.