Guiding Principles for Development of Effective Monitoring Programs

Prepared by MRAG Americas for Environmental Defense Fund

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1 Preface

Monitoring is an essential component of successful fisheries management. Reliable monitoring and reporting can support and improve the management of a fishery by providing verifiable information on fishing activities and assessing the performance and success of fisheries management plans. Despite the importance, fishery managers and stakeholders have often struggled in developing and implementing effective monitoring programs. The challenge is, in part, due to lack of information and peer-to-peer learning on successful monitoring programs in other fisheries.

The Monitoring Guiding Principles provide guidance for fishery managers and other stakeholders on planning, developing, and implementing monitoring programs. They draw upon the expertise of over two dozen national and international monitoring experts, including government employees, fishing industry representatives, academics and 3rd party monitoring company employees. By outlining key components to consider and providing concise recommendations, the Guiding Principles can expedite and improve the design of monitoring programs.

This document is the result of two workshops convened by MRAG Americas and Environmental Defense Fund (EDF) in 2010. Participants recognized the importance of summarizing lessons learned, as well as the individuality of each fishery and its goals. The Guiding Principles should be a point of departure for fishery managers and stakeholders in developing, reviewing, and improving fishery monitoring programs.

2 Participants

May 2010 workshop

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July 2010 workshop

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3 Introduction

Monitoring programs are essential in all fisheries to ensure effective fisheries management. Many fisheries have struggled to achieve effective monitoring programs, and many monitoring programs that are in place today have evolved over time to meet the needs of the fishery and its management framework. This paper draws on the experience of over 25 experts from fisheries around the world and reflects the most important lessons learned regarding the development and implementation of effective monitoring programs, as identified by the experts. The goal of the document is to provide fishery managers and stakeholders with cumulative knowledge and references so they can more easily develop comprehensive, appropriate monitoring approaches that will be successful. The paper outlines a series of Guiding Principles based on the collective experience of the participants and incorporates four case studies to demonstrate monitoring programs in action.

There are various stages to the design and development of an effective and comprehensive monitoring program including planning, development, and implementation. Managers and stakeholders must make decisions at each of these stages, including:

- how to involve stakeholders,
- understanding fishery-specific characteristics,
- establishing goals of the monitoring program,
- interaction with enforcement to support the program,
- methods of collecting data and use of the data,
- use of at-sea and/or dockside monitors,
- appropriate level of monitoring coverage,
- building a cost-effective programs, and
- ensuring a comprehensive and adaptive approach.

The Guiding Principles described here are intended to assist fishery managers in designing effective monitoring programs for all fisheries. While the most appropriate tools and techniques will vary on a case by case basis depending on the needs and characteristics of a fishery, the Guiding Principles provide recommendations based on significant experience across fisheries of all types. The workshop discussions largely focused on fisheries managed by catch shares as the workshop participants had significant experience with monitoring in catch share fisheries. Furthermore, many fisheries use the transition to catch shares as an opportunity to implement, modify or improve their monitoring programs. This document, including the case studies and examples, represents this reality. The Guiding Principles focus primarily on the monitoring of catch and landings to support fisheries management efforts. It should be noted that monitoring programs often include collection of information to achieve other goals such as collection of biological information, encounters with endangered species, and more. Ideally, all monitoring activities should be coordinated to avoid duplication of effort.

The Guiding Principles discussed in this paper are inter-related, meaning they should not be considered in isolation but instead simultaneously (Figure 1). For instance, fishery

managers determine the appropriate monitoring techniques and coverage levels, but these choices are dependent on the input from stakeholders, characteristics of the fishery, goals of the program, and availability of funds. Thus, when utilizing the Guiding Principles, fishery managers should consider that the principles work collaboratively to inform monitoring programs. In addition, monitoring programs are not static and may evolve or adapt as needs or circumstances change. A feedback system should be used to evaluate the program to make sure it is achieving its goals and to identify needed changes.

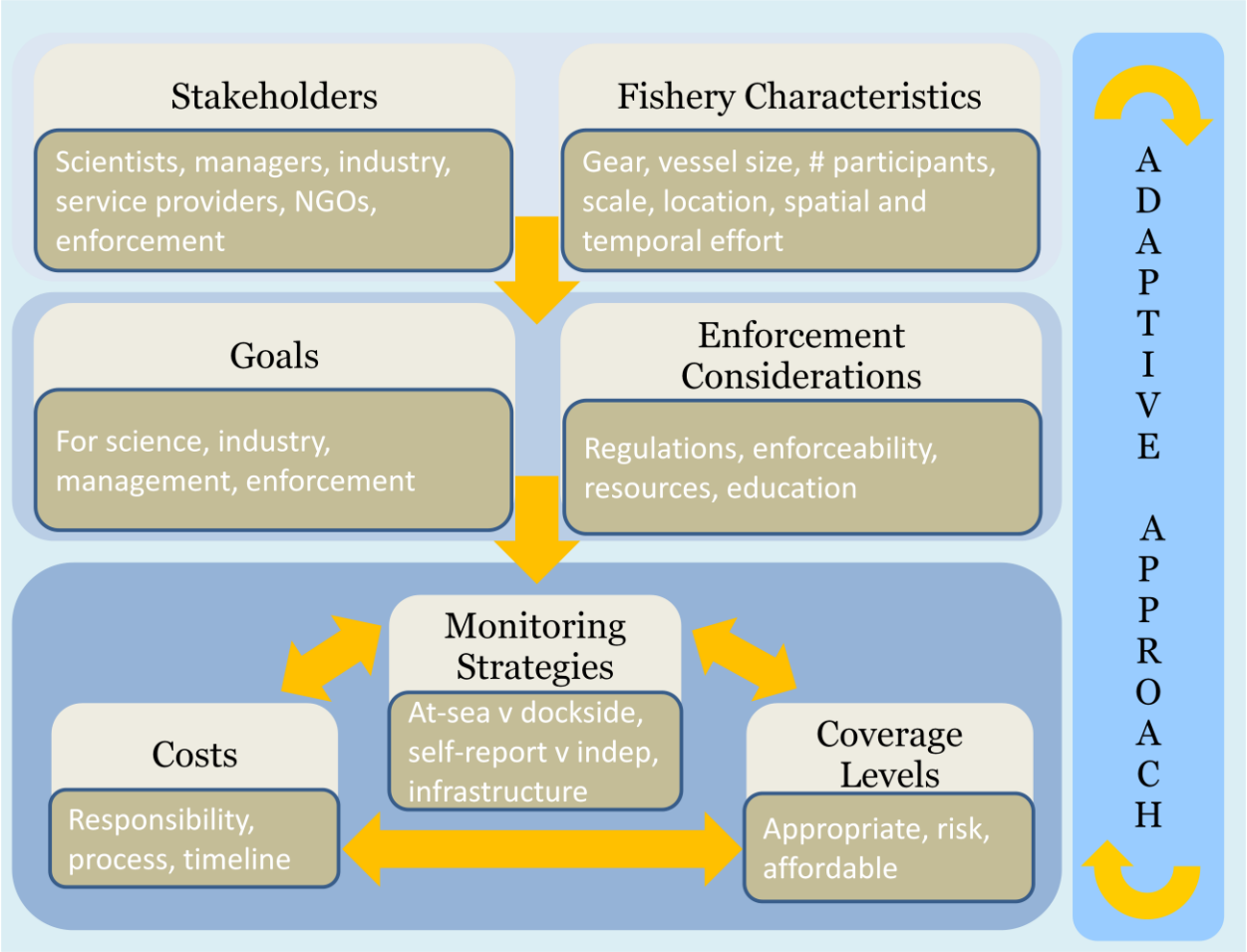

Figure 1. The Guiding Principles are inter-related and should be considered simultaneously. The monitoring program should be continually reviewed to ensure it is achieving the goals of management and of the monitoring program itself.

The second half of the document consists of four case studies of existing fishery monitoring programs in the U.S. and abroad to highlight the process and rationale behind their development (See Appendix). The case studies describe the monitoring approach and development and provide information on the trade-offs managers in these fisheries considered while weighing the costs of the monitoring strategies with the value they added to the fisheries. The Guiding Principles and case studies have been developed to be used together by fishery managers to learn from existing monitoring programs to develop comprehensive, effective, and cost efficient programs that will successfully monitor catch and landings and support management goals in a fishery.

4 Guiding Principles Overview

Stakeholder Engagement: From the outset of planning a monitoring program stakeholder engagement is crucial in effectively garnering support from diverse constituents to work towards common goals, avoid redundancies, and utilize knowledge within the fishery.

- *Involve stakeholders in the design process.*
- *Consult with appropriate stakeholders to ensure the program is enforceable.*

Fishery Characteristics: Fishermen, fishing communities, and the resource itself have different needs and requirements of a monitoring program; therefore, managers must consider the characteristics and complexity of the fishery and the existing management regime.

- *Consider the spatial and temporal scale and characteristics of each fishery before developing a monitoring program.*

Goal Setting: Establishing goals is an important step in planning for a good monitoring program and allows fishery managers, scientists, enforcement, and industry to identify what the program aims to achieve, including the desired state of the fishery or of the marine ecosystem.

- *Identify goals of monitoring programs for science, management, industry, and enforcement.*
- *Review the monitoring program to assess if it is meeting the goals and adjust as needed.*

Enforcement Considerations: Development of a monitoring program should consider strong and effective enforcement efforts to support accurate data collection that results from a properly designed monitoring program.

- *Develop a strong enforcement program in support of the monitoring program, and identify enforcement standards at the outset of the program in a clear and transparent manner.*

Monitoring Strategies: Monitoring strategies should be used to collect data essential for managing a fishery, such as catch information and biological data. There are advantages and disadvantages to employing at-sea and dockside monitors and differing uses of the type of information each collects. In some fisheries, the use of both types of monitors is appropriate for adequate coverage, while in other fisheries, one method is more appropriate than the other.

- *Identify goals for data collection programs, which will inform the appropriate data collection techniques.*
- *Effectively plan for complexity, cost, and time requirements of the supporting data infrastructure.*
- *Identify which aspects, if any, of a monitoring plan should be conducted by the government, industry, or a certified third party. When using third parties, develop consistent performance standards and consider whether single or multiple providers are preferable.*

- *Develop consistent, standardized formats for collecting data.*
- *Eliminate redundancies in data entry and reporting systems.*
- *Consider at-sea monitoring for fisheries where protected species bycatch or discards at-sea are significant management concerns or where they occur in a large portion of the fishery.*
- *Consider dockside monitors in circumstances when the landings information is of interest.*

Coverage Levels: The level of at-sea monitoring coverage chosen must address management needs and will depend in part on the fishery characteristics; coverage levels should be set to achieve the goals of the program, rather than set at arbitrary levels.

- *Consider monitoring coverage levels for fisheries on a case by case basis.*
- *Consider a formal threat assessment and/or a cost-benefit analysis to determine the levels of monitoring that are needed to achieve the goals and objectives.*
- *Consider the needs of industry when setting coverage levels, and develop incentives for fishermen to adopt higher levels of observer coverage.*

Cost Considerations: Monitoring programs are necessary to support effective fisheries management, but it is important to consider costs, who will be paying for the various aspects of the program, and if data confidentiality issues exist when planning a monitoring program.

- *Determine who will have the financial responsibility for various aspects of a monitoring program. Consider a program that requires fishermen to fund at least a portion of the management and monitoring costs.*
- *Develop a process and a timeline at the outset of a monitoring program for shifting the burden of responsibility to industry, both for cost and for data reporting.*
- *Consider a program that allows for the resource to fund its own management by scaling the monitoring approach to the value of the fishery.*
- *Develop an efficient method for collecting money to cover costs of the monitoring program.*
- *Evaluate actual funding against the proposed design.*

Comprehensive and Adaptive Approach: Fisheries management should be coupled with a comprehensive suite of monitoring options and should be as thorough as possible at the outset of the program. Review of a monitoring program will allow for improvement in the system and adaptability with changing needs.

- *Review existing programs to learn from their advantages and disadvantages.*
- *Develop a comprehensive, flexible monitoring plan at the outset of the program.*
- *Consider a dynamic system which provides stability while also adapting as circumstances change.*
- *Allow sufficient time for management and program implementation.*

5 Guiding Principles

5.1 Stakeholder Engagement

Stakeholder involvement from the outset of planning a monitoring program is crucial in effectively garnering support from diverse constituents. Stakeholders are not likely to support a program they do not understand or that their own observations do not support. Furthermore, agreement on goals and buy-in of the program can lead to fishermen and fishery representatives taking responsibility for various aspects of the monitoring programs. Managers must be mindful to consider the needs of all participants and keep them involved. Additionally, resource users can provide valuable insights that managers or scientists have not considered. The first step in this process should be coordinating efforts between stakeholders, including fishery managers, enforcement officers, industry, scientists, third party providers, and others with a vested interest in the fishery, to work towards common goals, avoid redundancies, and utilize knowledge within the fishery.

Guiding Principles

- *Involve stakeholders in the design process.*
- *Consult with appropriate stakeholders to ensure the program is enforceable.*

Enforcement officers should also be included at the outset of a program design to ensure the implemented program is enforceable and to verify the data collected are consistent with the legal requirements for prosecution.

To involve stakeholders when planning for a monitoring program, fishery managers should:

- Initiate early two-way communication, education, and outreach of all stakeholders to ensure the development of goals and the understanding of program regulations by all participants, including fishery managers.
- Consider allocating responsibility of self-enforcement to defined groups or associations of fishermen.
- Develop incentives to encourage fishermen to adopt more responsibility and to achieve conservation objectives.

Fishery managers can also ensure an inclusive process by developing a responsible body comprised of stakeholders, such as an advisory panel, *ad hoc* monitoring committee, or board, which will remain active throughout the design, development, implementation, and review of the monitoring program. Industry members should be selected who are objective and who represent the diverse interests of the fishery. Managers should also identify explicit roles for each stakeholder group. Technical advisors, including

appropriate third party providers, can help ground-truth aspects of the program. Terms of reference should be developed for all members to know what is expected of them.

It is also important to provide outreach to stakeholders who did not participate in the planning process. This outreach should encourage industry understanding of the decisions that were made and the process and rationale behind these decisions. Stakeholder support and understanding will lead to support for the monitoring program and likely require lower enforcement intensity for fishery participants.

Examples

During development of the Gulf of Alaska rockfish rationalization program, the National Marine Fisheries Service (NMFS) consulted with the North Pacific Fisheries Management Council, members of industry, NMFS Office of Law Enforcement, National Oceanic and Atmospheric Administration's (NOAA) General Counsel, and the United States Coast Guard to design a monitoring program to increase data quality for total catch reporting (NPFMC and NMFS 2006). This multi-stakeholder effort resulted in a pilot allocation to rockfish vessels (with considerations for new entrants) with recognition of the need for a comprehensive monitoring program for the rockfish fisheries.

During development of the British Columbia groundfish fishery's monitoring program, the declaration by the Canadian Department of Fisheries and Oceans (DFO) that the fishery would be held accountable for all catch raised concerns for several sectors of the commercial fishing industry. Specifically, these sectors were worried increased monitoring responsibility would decrease their profitability, potentially to the point of making them not viable as businesses. All sectors worked with DFO to develop monitoring strategies that met the new DFO requirements but still allowed economic viability (Stebbins et al. 2009). For instance, hook and line and trap vessels became subject to 100% at-sea coverage through the use of lower cost at-sea electronic monitoring instead of at-sea observers. While this has been largely successful, a comprehensive evaluation in 2009 showed that some fishermen are still concerned about the costs of monitoring (DFO 2009). The evaluation provides an opportunity for managers to further incorporate stakeholder opinions into the monitoring program or to provide additional outreach to industry.

5.2 Fishery Characteristics

Each fishery encompasses its own suite of biological, operational, and socioeconomic characteristics. Fishermen, fishing communities, and the resource will thus have different needs and requirements of a monitoring program. When planning a monitoring program, managers must consider the characteristics and complexity of the fishery and the existing management regime. A balance must be found between designing a program that is effective for a given fishery while avoiding unmanageable complexity and maintaining integrity.

Guiding Principles

- *Consider the spatial and temporal scale and characteristics of each fishery before developing a monitoring program.*

The appropriate temporal and spatial scale of a monitoring program will depend on the goals of the program, the needs of the fishery, the vulnerability or health of stocks, the type of monitoring program (already in place and proposed), penalties in the fishery, and needs of fishermen and managers.

A review of these fishery-specific factors and an assessment of risk can help determine the appropriate scales for monitoring programs. For instance, in a fishery where stocks are low in abundance, more frequent monitoring may be necessary. Fisheries managed by catch share allocations will require timely and effective reporting and monitoring of catch and landings data. In a multi-species fishery, fishery managers may be able to identify trigger species that determine the scale of monitoring that is employed.

Examples

In the U.S. Southwest region, the drift gillnet fishery targets swordfish and thresher sharks. The National Marine Fisheries Service (NMFS) attempts to randomly observe 20% of the trips in this fishery each year; however, all of the boats are not large enough to accommodate observers. As a result, NMFS is investigating using electronic monitoring for these vessels to achieve 20% coverage and include vessels that are too small to carry at-sea observers (M. Helvey, pers. comm., August 2010).

In eastern Canada, the scale of the monitoring program in the groundfish fishery was influenced by the various landing locations of fishermen throughout the Maritimes region. In order to address the needs of industry, fishery managers did not designate landings sites and instead allowed fishermen to land their catch at any port, recognizing that this would increase costs of the program (C. Annand, pers. comm., August 2010). They formed a dockside monitoring system that could monitor landings at over 500 possible landing sites utilized by fishermen (DFO 2010a). While the program can accommodate a number of landing sites, monitoring is more costly to fishermen who land at remote locations. As a result, over 80% of landings occur in approximately 20% of the available ports (C. Annand, pers. comm., August 2010).

Conversely, the British Columbia groundfish monitoring program developed with a limited number of landing sites (DFO 2010b). This area has a long coastline with many islands, bays, and inlets that could provide for landing sites. However, the logistic difficulties in servicing many remote sites and the additional costs required led to the decision to limit the number of authorized locations. The locations are set as a condition of the permit and so can change as conditions and needs of the fishery change (DFO 2010b).

5.3 Goal Setting

Establishing effective goals, or goal setting, are important steps in planning for a successful monitoring program and should be set early and reviewed often to align the strategies available with the objectives. Transparency and participation are essential in goal setting, ensuring the interests of stakeholders are heard and considered. Goal setting allows fishery managers to identify what the program aims to achieve, including the desired state of the fishery or of the marine ecosystem. Goals must be clearly defined to avoid problems and conflicts in any monitoring program. When goals are unclear, strategies can be perceived as subjective by stakeholders.

Guiding Principles

- *Identify goals of monitoring programs for science, management, industry, and enforcement.*
- *Review the monitoring program to assess if it is meeting the goals and adjust as needed.*

Monitoring program goals can be established for a variety of reasons, including:

- science (conservation initiatives or stock assessment needs),
- management (assessing catch and landings),
- industry (community sustainability or value-added processing or marketing), and
- enforcement (enforcing regulations).

The goals of a monitoring program should be consistent with and support existing legal mandates and the current management framework of a fishery. For example, where a fishery management council adopts a catch share program to ensure catch limit compliance in a fishery, the goals set forth for a monitoring program need to be crafted to support and ensure attainment of that goal.

Goal setting should be adaptive and include regular evaluation and revision of the monitoring program. Immediately after goal setting, strategies and/or tasks to achieve those goals should be identified and implemented. Simultaneously, an evaluation framework must be established to assess the effectiveness of such strategies or activities in achieving the goals of the program. A review of the monitoring program should be designed when planning the program, conducted during the development phase, and repeatedly carried out once the program is implemented. Internal and external reviews, audits, and evaluations can also be conducted to assess the program's effectiveness at meeting the goals and objectives. Adjustments should be made as necessary.

Examples

During the planning and development of the Bering Sea/Aleutian Islands (BS/AI) crab rationalization program, goals for the monitoring and data collection program were established to obtain accurate catch and effort information, provide consistent dockside sampling effort, accurately measure bycatch, describe fishing practices, and develop timely entry of crab data into searchable databases. The monitoring program also considered enforcement needs but focused on the collection of biological data to account for bycatch and to understand fishing practices. To achieve the identified goals, the program implemented at-sea observers to accurately monitor catch and port samplers at every major port to account for every offload, with an enforcement presence on the dock. (NOAA 2008; F. Bowers, pers. comm., May 2010). Although there is no evaluation of the monitoring program, a review program is in place to assess the effectiveness of the rationalization program. The North Pacific Fishery Management Council has identified metrics used in 18 month, three-year, and five-year program reviews, with data collected in the monitoring program intended to support such a review (Garber-Yonts 2009).

A number of management goals were identified for the British Columbia groundfish fishery in transitioning to an Individual Vessel Quota system. Many of these goals directly affected the design of the monitoring program, including having individual accountability, gathering verifiable data on all catch and discards, documenting discarded catch as legal or sub-legal in size, tracking individual vessel and fleet quotas, and verifying that catch stays within the catch limit (DFO 2009; Stebbins et al. 2009). In 2003, the Department of Fisheries and Oceans Canada (DFO) announced the British Columbia groundfish fishery would be held fully accountable for all catch by 2006 (Stebbins et al. 2009). The declaration led to the adoption of monitoring strategies to support this standard and the identified goals. The monitoring program ensures at-sea and dockside activities are fully and accurately monitored and documented. A comprehensive evaluation conducted in 2009 concluded that the management and monitoring programs were achieving conservation objectives and satisfied social concerns and economic performance (DFO 2009). Halibut and sablefish fleets have continued to fully harvest their directed total allowable catch and feature stronger profitability levels. Expected reduction occurred in the smaller-scale fleets (rockfish, lingcod, dogfish), and the landings per trip for the remaining vessels has increased. Implementation of the CGIPP Plan changed the way the fishery was managed and established a substantial degree of stability for the fishery.

5.4 Enforcement Considerations

Enforcement standards for fishery participants should be developed through clear and transparent communication during the planning phase of a monitoring program. Transparency will aid in developing trust and support with industry and other stakeholder groups. The effectiveness of enforcement will depend in part on the ability of enforcement officers to adapt to development of or changes in the monitoring program. An education program for enforcement officers, fishermen, and fishery participants should be developed and implemented to ensure they understand the regulations.

Guiding Principles

- *Develop a strong enforcement program in support of the monitoring program, and identify enforcement standards at the outset of the program in a clear and transparent manner.*

Appropriate levels of enforcement coverage should be determined on a case by case basis, similar to other aspects of a monitoring program (see coverage levels, section 5.7). A formal threat assessment can inform the appropriate level of enforcement needed for a fishery. There may be instances where enforcement can be reduced based on an appropriate incentive or disincentive structure that promotes compliance within the fishery.

The costs of enforcement efforts need to be considered as well, and can be effectively managed by considering the most appropriate use of enforcement resources. Additionally, existing enforcement resources should be fully utilized to help minimize costs and avoid redundancies. It is also important to consider how the enforcement will be funded. In some fisheries, it may be feasible to use penalties incurred from non-compliance to partially fund enforcement efforts or other aspects of monitoring programs. Penalties can also improve accountability. It is in the interest of stakeholders to have effective enforcement to deter activities that would potentially undermine the sustainable use of the resource.

Examples

In the BS/AI crab rationalization program, considerable enforcement needs exist due to regulations in the fishery that limit catch to males of certain sizes. Periodic audits of offloads by enforcement officers are conducted to ensure compliance with catch monitoring plans (DOC 2004; NOAA 2008). The management program also requires at-sea sorting of catch; thus, monitoring and enforcement are needed to ensure these requirements are being met. Because the enforcement presence in this fishery was high prior to the implementation of the rationalization program, managers were able to adapt the existing enforcement framework and resources to the new needs of the rationalized program (F. Bowers, pers. comm., May 2010).

In the eastern Canada Maritimes region, an automated hail out system helps monitor fishery effort in terms of the number of vessels and their locations. The hail out information coupled with at-sea observer coverage, air surveillance, and vessel monitoring systems allows enforcement efforts to be distributed spatially and temporally and cost effectiveness of enforcement to be achieved (Genesys 2008; C. Annand, pers. comm., August 2010).

During development of the British Columbia groundfish monitoring program, energy was initially directed at building the infrastructure of enforcement to support the monitoring program. However, the increased levels of at-sea and dockside coverage coupled with an audit program effectively changed behavior, produced a more compliant fishery, and reduced the need for enforcement. As a result, enforcement efforts can be directed at other issues, such as illegal fishing (S. Stebbins, pers. comm., July 2010).

5.5 Monitoring Strategies

Monitoring strategies are a fundamental aspect of a monitoring program. Monitoring strategies can be used to collect data on catch, landings, or another measure of fishing effort; species identification, composition, or health; bycatch; discards; and fishing areas. There are also components of data collection that may be separate from the intent of a monitoring program, such as the collection of biological data. The information that is gleaned from collected data may be used in management decisions, stock assessments, enforcement operations, and/or economic valuations. This section considers data collection as a general topic (section 5.5.1) and then considers tradeoffs of using at-sea monitoring and dockside monitoring for collecting data (section 5.5.2).

5.5.1 Data Collection

In many U.S. regions, the majority of stocks lack sufficient data for even basic assumptions regarding stock health. Minimum data collection levels should be set and applied to both commercial and recreational fisheries; in this regard, program designers should consider the risk of errors in estimating total mortality. Overfished or keystone species, for example, may require higher levels of monitoring even if the catch or value is low. Monitoring programs should consider means to collect even basic data on catch and effort from fisheries, ranging from low to high value. Fisheries with the lowest value or limited catch may be restricted to collection of only the most basic catch records. Justification for fisheries without monitoring programs should be explicit.

Since collected data can produce a broad spectrum of types of information, with varying uses, it is important to identify the goals of a data collection program at the outset of a program before adopting techniques for collecting data. The goals of data collection should align with the overarching goals of the monitoring program. These goals, in addition to an understanding of how data will be used, will inform managers on which data are needed and the appropriate technique(s) for collecting data for a given situation. The goals and uses will also assist in determining the levels of confidence in the data that are needed or acceptable.

Guiding Principles

- *Identify goals for data collection programs, which will inform the appropriate data collection techniques.*
- *Effectively plan for complexity, cost, and time requirements of the supporting data infrastructure.*
- *Identify which aspects, if any, of a monitoring plan should be conducted by the government, industry, or a certified third party. When using third parties, develop consistent performance standards and consider whether single or multiple providers are preferable.*
- *Develop consistent, standardized formats for collecting data.*
- *Eliminate redundancies in data entry and reporting systems.*

Data collection will be more successful with stakeholder support. For transparency, it is important for stakeholders to understand what data are collected and why. Additionally, it is advisable to develop a data collection program that can later be adapted to fit the changing needs of the fishery and stakeholders. A cost/benefit analysis may help determine which aspects of a data collection program are best suited for a given fishery. Costs of any data collection program will likely be substantial and need to be considered throughout the development process, particularly when a shift in financial burden to industry is planned.

The appropriate temporal and spatial scale of data collection efforts will depend on the goals of the program, the needs and characteristics of the fishery, the vulnerability or health of stocks, the type of monitoring program, and needs of fishermen and managers. A review of these criteria in addition to an assessment of risk can help determine the appropriate scales for data collection and reporting programs. Where vessels conduct at-sea processing, 100% observer coverage should be the standard, as this is the only opportunity to monitor catch or landings.

The importance of the data infrastructure in supporting a monitoring program should not be minimized and needs to be considered at the planning phase of the monitoring program. The complexity, costs, and time requirements for development and implementation need to be carefully considered and planned for. It is important to consider how data can be collected and incorporated into stock assessments and management in a timely manner.

The use of third party suppliers may be appropriate with certain program designs, such as for data collection or observation. For programs that use multiple third party providers, program designers should find a balance between competition, which allows for innovation, and competitive prices with the need for stability for service providers.

Experience indicates a single provider with a long-term contract has more incentive to innovate and improve services than multiple providers who compete against each other in the short term.

Consistent, standardized formats, certification systems, and established standards for collecting data are especially important for multi-provider scenarios to ensure quality and consistency from all providers. Such systems and standards eliminate a "race for the bottom" where companies compete for the lowest prices and may compromise quality as a result. Technical requirements, specifications (functional and non-functional), and minimum standards should be developed at the outset of the program to promote cost effectiveness and data quality. Data needs should be integrated across data sources and platforms to avoid redundancies in data entry and reporting systems. This integration will also reduce costs and confusion and streamline the process for collecting data.

Just as fishery resources do not confine themselves to regulatory boundaries, data should be collected to allow for comparison and use across regions. Monitoring efforts are often designed for individual fisheries, with data collection programs differing between regions. In many cases, data collection on basic fishery landings or vessel activities relies on paper systems including trip tickets, logbooks, and other forms of reporting that are slow, costly, and error prone. While the appropriate monitoring programs and data collection will vary on a case by case basis, communication between regions sharing resources should occur in an effort to manage data collectively and efficiently. Cross-regional outreach and education on existing data collection systems is encouraged to prevent unnecessary duplication of efforts.

Examples

In the BS/AI crab fishery, a need existed for a strategy to easily and quickly submit data to allow for quotas to be accurately tracked in close to real time (NOAA 2009). Data collection aspects of the monitoring program were designed to include electronic submission of fish tickets and a requirement for fishermen to land catch at designated processing facilities. This design allowed for catch to be tracked in near real time, leading to an extension of the fishing season to several months.

Data collection and integration into management may extend beyond traditional boundaries, specifically in the case of trans-boundary fishery resources. For example, on the Pacific Coast, the International Halibut Commission is a partner in a multiagency program designed to collect and share commercial landings data on the shared (U.S. and Canadian) resource. They utilize various monitoring strategies such as elandings and an Interagency Electronic Reporting System (eLandings 2010).

Consistent standards were adopted in eastern Canada where independent suppliers, such as those that provide dockside monitoring services, must be certified according to standards developed by DFO and adhere to regular audits (DFO 2010a). In Atlantic Canada, DFO has developed a Dockside Observer Checks System that sets standards against which

third party providers are audited (DFO 2006). Such standards encourage consistency and a level of quality from service providers.

5.5.2 At-sea versus Dockside Monitors

Data can be collected using a variety of techniques, usually built around at-sea and dockside strategies, which can gather self-reported or independently collected data and include technologies and methods such as hails, electronic records, cameras, paper systems, at-sea observers, and dockside monitors (Figure 2).

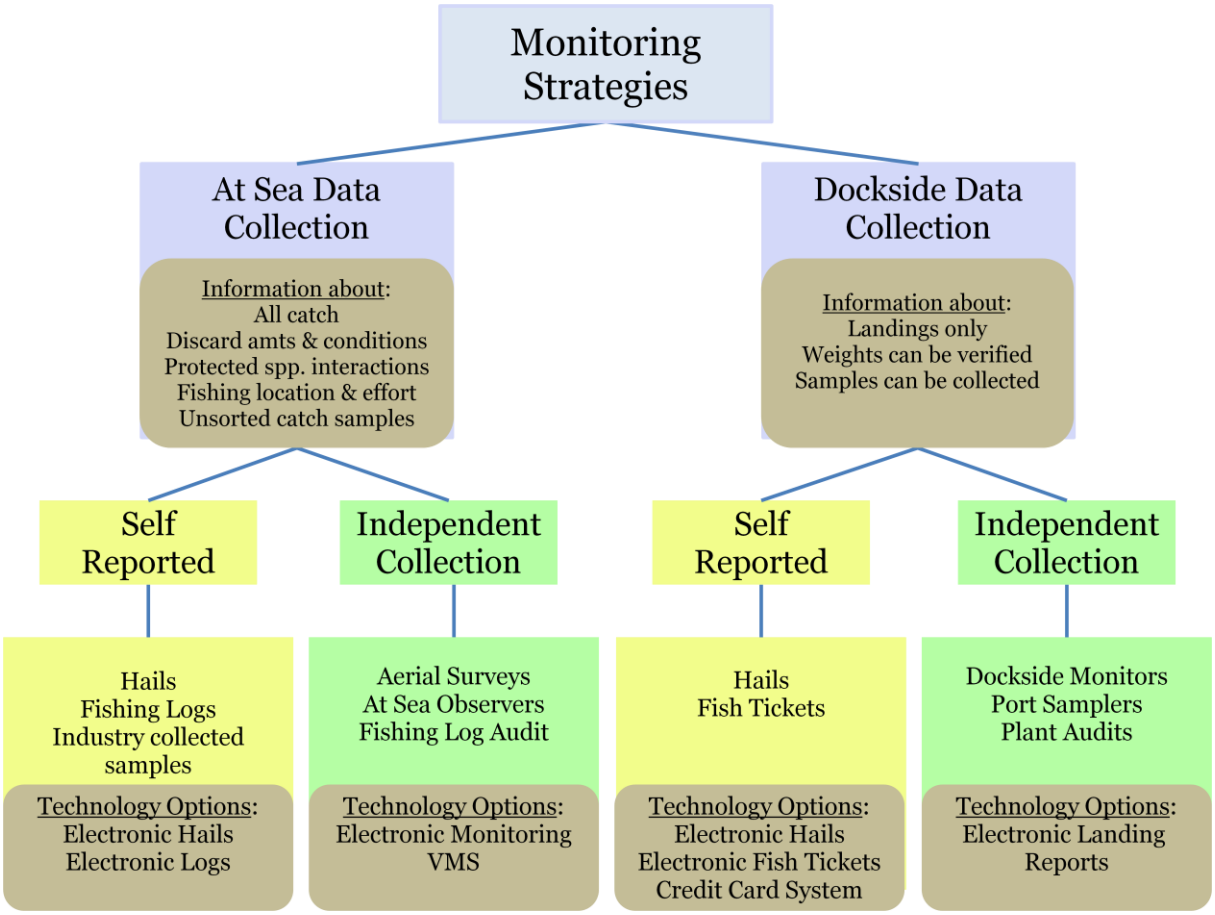

Figure 2. Data collection strategies vary from at-sea to dockside and include those that gather self-reported and independently collected data.

Both at-sea and dockside monitors[1] provide critical information that can inform fisheries management and/or stock assessments, and these systems should be designed effectively and with cooperation from all involved parties. There are advantages and disadvantages of each type of monitoring and differing uses for the type of information each collects. Many factors will play a role in determining the need and feasibility of using at-sea or dockside

[1] We use monitoring in a generic sense, without distinguishing between observers and monitors.

monitors for a given fishery. Certain approaches will also lead to predictable bias in the data that should be factored in. For example, where at-sea monitoring is not employed, it is often believed that discards increase due to high-grading of catch or misreported/underreported catch of legal discards.

In some fisheries, the use of both at-sea and dockside monitors is appropriate for adequate coverage, depending on the goals and needs of the monitoring program and the characteristics of the fishery. In other fisheries, one method is more appropriate than the other.

Guiding Principles

- *Consider at-sea monitoring for fisheries where protected species bycatch or discards at-sea are significant management concerns or where they occur in a large portion of the fishery.*
- *Consider dockside monitors in circumstances when the landings information is of interest.*

Useful information can be attained through dockside monitoring of landings and at-sea monitoring of catches and other activities such as gear use. Dockside monitoring of landings and dealer reports are often paper systems, though in many instances are now evolving to electronic systems, with much of the data collection requiring cooperation between jurisdictions (i.e. states or states and federal). For some fisheries, it is difficult to obtain even basic fishing effort and landings data given the complications that arise when dealing with a paper system and multiple ports.

At-sea monitoring should be used in situations where self-reporting of data cannot be considered to be reliable, i.e., where bycatch of protected species occurs, where tracking quantities of discards is a significant management requirement, or where regulations require 100% retention of catch. Where 100% retention of catch is required, at-sea monitoring may be less complicated and more easily accomplished through the use of technology (e.g., a camera system). To address discards, managers can consider allowing quota transfers within the regulatory regime between fisheries instead of requiring portions of catch to be discarded.

Dockside monitors can be utilized when fishery managers are interested in accurately reported landings data. 100% coverage should be employed where feasible to ensure all landings data are accurate. When 100% dockside monitoring is not possible, appropriate penalties and audits should be developed and implemented to encourage honest landings reports.

Costs of employing dockside and at-sea monitors vary considerably due to the level of education and training required for each method and vessel expenses for at-sea monitors.

Fishery managers need to assess costs when determining acceptable levels of monitoring coverage. Electronic monitoring or other technologies may be considered as alternatives to at-sea monitors. Trade-offs are likely to occur when weighing the costs and benefits of various monitoring strategies. Sampling analysis can be used to determine acceptable levels of precision and the levels of at-sea monitoring, dockside monitoring, and self reporting needed to achieve overall monitoring goals. Sampling designs should also be used to ensure the needs of the management, science, and enforcement programs are addressed.

Examples

The American lobster fishery is composed of both inshore and offshore components which cross multiple state boundaries. It is one of the most valuable fisheries in the U.S. However, because of the lack of coordinated systems, lack of an effective monitoring program, issues regarding data confidentiality, and other barriers to effective communication, even basic landings data are difficult to obtain for this fishery (MRAG Americas 2008). Landings data are the primary source of information that is needed to assess the impact of fishing on lobster populations, yet this information has not been consistently collected either spatially or temporally (Kerns et al. 2010). At-sea and port sampling would provide a useful record of the biological characteristics of the lobster being caught and harvested. Recent gains due to improvements in landing reporting systems, which are essential for accurate lobster assessments, are now threatened by a lack of funding (Kerns et al. 2010).

On the other hand, the eastern Canada mobile groundfish fishery in the Maritimes region and the British Columbia groundfish fishery employ 100% dockside monitoring coverage in order to gather complete records of landings (O'Boyle et al. 1994; DFO 2010a, b). The British Columbia groundfish fishery also utilizes 100% at-sea monitoring, either through an at-sea monitor or an electronic monitoring system, to track catch and discards. The electronic monitoring system is used to audit fishery logbook data.

In the New England groundfish fishery, both at-sea and dockside monitors are being employed. Due to the multispecies nature of the fishery, at-sea monitors are necessary to track bycatch of undersized or overfished stocks (NOAA 2010). To reduce bycatch, managers can also encourage gear innovations by fishermen that reduce these incidental takes.

5.6 Coverage Levels

The level of monitoring coverage chosen must address management needs and will depend in part on the fishery characteristics, including management areas, gear types, involved stocks, and species interactions, in addition to fishery goals, enforcement considerations, and costs. To the degree practicable, coverage levels should be set to achieve the goals of the program, rather than at arbitrary levels. Additionally, it is valuable to assess priorities in determining needed or acceptable coverage levels as a way to ensure cost-effectiveness.

At-sea monitoring is often thought of as onboard observers but can apply to other at-sea methods as well, such as Vessel Monitoring Systems (VMS), electronic logbooks, and camera systems. Development of a strong, independent dockside monitoring program with 100% coverage may be appropriate in some fisheries. Without 100% dockside monitoring coverage, identify and implement appropriate penalties and audits.

Guiding Principles

- *Consider monitoring coverage levels for fisheries on a case by case basis.*
- *Consider a formal threat assessment and/or a cost-benefit analysis to determine the levels of monitoring that are needed to achieve the goals and objectives.*
- *Consider the needs of industry when setting coverage levels, and develop incentives for fishermen to adopt higher levels of observer coverage.*

It is important to consider the stratification of the fleet, biases in observer coverage, minimum requirements for data, level of desired precision, degree of acceptable uncertainty, and vulnerability of stocks when setting monitoring coverage levels or a level to serve as a reference point. In fisheries with low coverage levels, managers should consider adopting a precautionary total allowable catch (TAC) of targeted species.

High levels of at-sea coverage are warranted in fisheries that meet certain criteria. Fisheries that have at-sea processing, utilize high impact gear types, have interactions with endangered species, have significant discards, have vulnerable stocks, or are data-poor should consider high levels of monitoring coverage. Babcock et al. (2003) demonstrated that for fisheries where there are no endangered or threatened species, coverage of at least 20% is required to generate meaningful information. For fisheries that involve endangered or threatened species, the study recommends at least 50% observer coverage.

A formal threat assessment may also be used to inform levels of monitoring coverage. For fisheries or stocks identified with a higher threat levels, more comprehensive programs will be needed. Fisheries that interact with protected species may warrant higher coverage levels even if the economic value of the fishery is lower than other fisheries, based on the results of a threat assessment. A cost-benefit analysis can also be used to inform the levels of coverage that are appropriate in a given fishery.

The needs of industry should also be considered when setting coverage levels. Higher levels of coverage may be needed to warrant an increased price of seafood or development of an eco-labeling scheme. Incentives should be considered for fishermen to adopt higher levels of coverage. These incentives can take the form of increased quotas, financial

benefits, and/or access to fishing areas only with observers. Disincentives of a loss of quota without observers or the implementation of a high penalty for improperly documented catch can also be considered.

Examples

In the U.S., monitoring coverage varies between regions and fisheries, ranging from coverage levels of less than 1% to full coverage, which makes for great inconsistencies in monitoring across regions. For instance, the California pelagic longline fishery, the Hawaii shallow-set (swordfish) fishery, and the Bering Sea pollock fleet require observers on all vessels. The Alaska groundfish fishery requires large vessels to have 100% or 200% observer coverage and smaller vessels to have 30% coverage requirements (NOAA 2007). In other regions, observer coverage often fluctuates between only 1% and 2% while in the Caribbean, no fishing trips are covered by fishery observers. It should be noted that these coverage levels include observers from biological data collection and sampling programs in addition to those that monitor catch and landings.

A number of approaches have been adopted to increase coverage levels in diverse fisheries. In the British Columbia groundfish fishery, 100% dockside and at-sea monitoring levels are required as part of the catch share program. In eastern Canada, fishery managers used an incentive in the Maritimes region to encourage fishermen to support the monitoring program and to reduce bycatch. If fishermen carry an observer while fishing, their actual cod bycatch is counted against their quota instead of a pre-established maximum allowable discard rate, based on a cod to haddock ratio (C. Annand, pers. comm., May 2010). Thus, without an observer, an assumed bycatch rate will more likely lead to closure of the fishery for the season with lower cod catch than would occur with observers. Under this regulation, fishermen adopted higher than required levels of observer coverage if the additional coverage led to lower actual bycatch rates.

In the Pacific Northwest whiting fishery, eco-certification has been a driver for 100% at-sea observer coverage. Industry wanted to ensure that all fishermen would be facing the same regulations, particularly with respect to discards. Eco-labeling of Alaska salmon has illustrated that there is substantial consumer demand for certified sustainable products (Alaska Department of Fish and Game 2007), which can be used to motivate fishermen to adopt higher levels of monitoring coverage.

5.7 Cost Considerations

When planning a monitoring program, it is important to consider ways to find cost-efficiency, as well as who will pay for various program aspects. Social and economic goals of the fishery or the monitoring program should also be considered when choosing the appropriate fee structure.

Through careful design and thoughtful consideration of who pays for different program components, it is possible to have an effective, efficient system. Different stakeholders will have incentives to keep certain costs down. Upfront, managers will need to identify if data

confidentiality issues exist, as well as the effectiveness, costs, and quality of provider services. A process and a timeline should be developed and communicated with stakeholders at the outset of a monitoring program to ensure enough time to develop the program, to garner trust among stakeholders, and to determine who covers the costs (whether part or all) where necessary. A phased in monitoring program may allow for the fishermen to pay more of the monitoring costs over time as it allows the value of the fishery to increase before implementing a full suite of monitoring strategies.

Guiding Principles

- *Determine who will have the financial responsibility for various aspects of a monitoring program. Consider a program that requires fishermen to fund at least a portion of the management and monitoring costs.*
- *Develop a process and a timeline at the outset of a monitoring program for shifting the burden of responsibility to industry, both for cost and for data reporting.*
- *Consider a program that allows for the resource to fund its own management by scaling the monitoring approach to the value of the fishery.*
- *Develop an efficient method for collecting money to cover costs of the monitoring program.*
- *Evaluate actual funding against the proposed design.*

During the development of a monitoring program, managers should determine if industry will be responsible for any costs of management. This will depend largely on the goals for a program and fishery characteristics. The ability of industry to cover aspects of a monitoring program will also depend, in part, on the value of the fishery, the health of the stocks, the level of coverage, and the type of monitoring approach. For example, high monitoring coverage in low value fisheries may depend on the government to pay a higher portion of the costs. Similarly, it may make sense for the government to pick up costs of management for depleted or overfished fisheries until they have recovered to a level where they are economically viable. In general, profitable fishermen, whether they fish from large or small boats, are more often able to pay for part or all aspects of a monitoring program.

Incentives can also be used to encourage fishermen to share the responsibility of cost. Incentives such as eco-certifications or labeling programs create business opportunities for fishermen and encourage cost sharing of monitoring by providing external market incentives to demonstrate a level of sustainability. Acceptance of monitoring programs by fishermen increases as the benefits to fishermen increase.

Managers can also consider developing a means for the resource to fund its own management. Such a strategy could entail setting aside a portion of the allowable catch for data collection For example, in the U.S., several regional fishery management councils have used research set-asides of total allowable catch to help fund the monitoring programs.

Since costs are such an important concern of monitoring programs, a number of other factors should be considered during the development of these programs. For instance, during program development, managers should prioritize elements of the plan and evaluate tradeoffs of value per dollar of each. In some cases, eliminating select elements to maintain others is better than cutting back on all. How the program will be funded in actuality should be considered as the program is being designed.

Managers and third party providers can also assist industry in identifying cost-effective approaches to monitoring programs. Reducing redundancies and improving communications can lead to cost savings that will be beneficial to industry and can be used to fund the monitoring program. For instance, some fisheries utilize both at-sea observers that collect biological samples and record bycatch incidents as well as monitors that account for catch and discards. In some cases, it may be feasible to reduce costs by reducing redundancies of duplicate programs. In other instances, industry may be able to work together to share observers and reduce costs by paying a monthly fee instead of a daily fee. Managers and third party providers may be able to help industry in identifying cost savings opportunities. In FY 2009, the National Observer Program stated that at-sea observer programs cost $51.113 million, with $35.441 million from government funding and $15.672 million from the industry (NOAA 2010b).

Examples

In U.S. fisheries management, NMFS often incurs the costs for data collection programs, including at-sea observer programs, though these funds are limited typically by time and/or value (NOAA 2007). In many cases, these funds help initiate but not sustain a program. Several fisheries in the U.S. also collect fees from industry to fund management and monitoring programs. Groundfish fishermen in Alaska were willing to accept self-funding of observers as a necessary means of obtaining data to refute erroneous claims of ecosystem damage. In the Alaska halibut and sablefish individual fishing quota (IFQ) programs in the North Pacific, a fee is collected to recover the costs of management, data collection, and enforcement. In this program, IFQ permit holders pay a cost recovery fee for every pound of IFQ halibut and IFQ sablefish landed under the permit (Federal Register 2009). This program, however, demonstrated the importance of allowing enough time for funds to be generated from landings to fund a monitoring program (C. Rilling, pers. comm., July 2010). Thus, fee structures must be in place and funding generated before government funding is eliminated for these programs.

In the British Columbia groundfish fishery, electronic monitoring coupled with an audit system is used to defray costs and to eliminate the need for an at-sea monitor on every vessel. On hook and line and trap vessels, an electronic monitoring system audits

fishermen's self-reported data on effort, catch, and catch disposition in fishing logbooks (Stebbins et al. 2009). Since the data that is collected and self-reported in fishing logs is utilized for science and management, a high level of confidence is needed in this data. As a result, 10% of the landings on these vessels are independently monitored on a random basis. This level of coverage was chosen since more frequent audits would have been cost prohibitive to industry. Yet, a low level of agreement between the self-reported data and the audit can lead to additional audits (up to 100% of each set) that are funded by the fishermen (S. Stebbins, pers. comm., July 2010). The cross-reference of data between required hails, self-reporting, and electronic monitoring provides a high level of confidence in the information, and the high costs of funding additional audits encourages honest reporting.

New Zealand has historically tried several methods for paying for fisheries management and monitoring programs, including resource rental fees and transaction fees. Current regulations require individuals to pay for services such as research, management, and enforcement operations. The cost recovery system has successfully provided high quality research funded largely by those that benefit from it; however, progress has been limited in increasing efficiency and accountability and devolving responsibility to stakeholders (Stokes et al. 2006).

5.8 Comprehensive and Adaptive Approach

Fisheries management should be coupled with extensive monitoring of fishing activities on a continuing basis. Monitoring programs should consider a comprehensive suite of monitoring options and should be as thorough as possible at the outset of the program. Review of a monitoring program will allow for improvement in the system and adaptability with changing needs.

Guiding Principles

- *Review existing programs to learn from their advantages and disadvantages.*
- *Develop a comprehensive, flexible monitoring plan at the outset of the program.*
- *Consider a dynamic system which provides stability while also adapting as circumstances change.*
- *Allow sufficient time for management and program implementation.*

Although developing comprehensive and adaptive monitoring programs can be difficult given the resource strains of management authorities, a number of existing fisheries have effective monitoring programs, and many demonstrate how these programs have evolved over time to fit the needs of the respective fisheries. Learning across regions should be

encouraged as existing monitoring programs and their methodologies provide fishery managers with a comprehensive overview of the types of technologies that are available, when dockside and at-sea monitors are used, the types of data that are collected, when and how those data are used, coverage levels that have been achieved in other fisheries, and other useful information such as the advantages and disadvantages of each approach.

The lessons learned from existing monitoring programs should be used by fishery managers to develop comprehensive, flexible monitoring programs for their fisheries that can adapt to the changing needs of a fishery and/or resource. This flexibility needs to be balanced with stability as a stable program will be more likely to solicit trust, confidence, and support from stakeholders groups. A monitoring program should also utilize the existing elements to the extent feasible to avoid redundancies. Additionally, an adaptable program allows for flexibility and innovation in responding to technical needs and promoting technological advances. Third party providers, gear engineers, or industry should be encouraged to facilitate efficiencies in technologies and be innovative in solving conservation challenges.

Finally, it is important to allow sufficient time from the development of management regulations through to the implementation of an appropriate monitoring program. This time will allow for stakeholder involvement and for the development of a comprehensive program.

Examples

After years of separate catch data reporting requirements for Alaska fisheries independently implemented by NMFS, Alaska Department of Fish and Game, and the International Pacific Halibut Commission, the three agencies developed a joint system to reduce redundant reporting and to simplify the system (H. Gilroy, pers. comm., May 2010). This system begins with an electronic web-based portal for entry of landings and provides a printed fish ticket as a landing receipt, plus receipts for individual quota account debits (eLandings.alaska.gov). In addition, a backup system of paper reporting via fax directly to the NOAA Fisheries' quota management database is available for individual fishing quota (IFQ) fisheries in the event that the electronic system is temporarily unavailable. The joint system now provides a comprehensive and consistent system for IFQ and community development quota for the Pacific halibut and king and Tanner crab fisheries. The program will soon incorporate salmon and shellfish landings.

The Integrated Fisheries Management Plan for British Columbia's groundfish fishery employs a comprehensive monitoring program that ensures at-sea and dockside activities are fully and accurately monitored and documented and supports in-season management of the fishery (Stebbins et al. 2009). The monitoring program mandates 100% dockside and at-sea monitoring coverage. The 100% at-sea monitoring coverage is accomplished in the offshore trawl fleet by at-sea observers and for the hook and line and trap vessels through an electronic monitoring system that audits self-reported data fishermen collect on effort, catch, and catch disposition in fishing logbooks (Stebbins et al. 2009).

6 Conclusion

Reliable monitoring of catch and/or landings is necessary to support fishery management efforts. When planning, developing, or implementing a monitoring program, a number of decisions must be made to create a comprehensive and effective system for tracking fish caught or landed. Many fisheries have struggled to achieve effective monitoring, and monitoring programs have often evolved to meet the needs of a fishery and its management framework. While all fisheries have (or need) monitoring programs, fisheries with in-season management (and especially catch share management) often have the best and most robust monitoring, and therefore the lowest level of management uncertainty. In the current era of annual catch limits and accountability measures in U.S. fisheries, decreasing management uncertainty will become increasingly important, as will the need to apply lessons from well-monitored fisheries to those with less effective monitoring programs.

The Guiding Principles presented here draw on experiences of technical advisors and fishery managers in the U.S. and abroad in a systematic way, and are intended to serve as a starting point for fishery managers tasked with designing effective monitoring programs. The examples, case studies, and references for various monitoring programs provide information that could inform development or improvements to other programs. Given the numerous monitoring programs in the U.S. administered by NMFS, with different goals, objectives, and designs, an ongoing discussion and consultation among administrators, managers, fishery stakeholders, and experts from abroad would provide the best opportunity to develop and implement best practices across the U.S. system.

Stakeholder involvement from the outset of planning a monitoring program is crucial in effectively garnering support from diverse constituents and in learning what is feasible and enforceable in a fishery. The design of a monitoring plan will have major impacts on fishermen and buyers; allowing industry to have a key role in determining the strategies that support the goals or requirements of the program will achieve the maximum buy-in from industry while still achieving scientific, management, and enforcement needs. Establishing and implementing effective goals are also necessary in planning for an effective monitoring program. The established goals will inform strategy development and the chosen monitoring techniques, which will depend on the needs and characteristics of a fishery. Monitoring programs should consider a comprehensive suite of monitoring options and should be as thorough as possible at the outset of the program.

The high costs of various aspects of a monitoring program, in the form of both time and money, have presented challenges to the implementation of comprehensive monitoring programs. Fishery managers are often faced with difficult decisions and must weigh the inherent value of monitoring techniques with the costs associated to implement them. A process and a timeline should be developed and communicated with stakeholders at the outset of a monitoring program to ensure enough time to develop the program, to garner trust among stakeholders, and to shift the cost burden (whether part or all) where necessary. A phased in monitoring program may allow for the fishermen to pay more of

the monitoring costs over time as it allows the value of the fishery to increase before implementing a full suite of monitoring strategies.

Monitoring programs are not static and may evolve or adapt as needs or circumstances change. A feedback system should be used to evaluate the program to make sure it is achieving its goals and to identify areas where changes are needed. In general, the monitoring programs employed by the fisheries highlighted in the case studies evolved as the management changed. As the fisheries changed to an IFQ (or other forms of catch share), managers and industry recognized the need for a higher level of accuracy in the landings data, which led to enhanced monitoring. In some cases, the management system also recognized the need for better at-sea data, and improvements to these data go hand-in-hand with an improvement in landings data.

The Guiding Principles laid out here describe guidelines for designing, implementing, and tracking such programs to monitor catch and landings in all fisheries. Coupled with lessons learned from existing monitoring programs, the proper design, implementation, and review of a monitoring program will allow for the development of an effective program, improvement in the system, and adaptability with changing needs.

7 Appendix – Case Studies

The Guiding Principles were developed by studying lessons learned from existing monitoring programs and with guidance of experts who have been involved in the development of these programs. The following four case studies, which represent the British Columbia groundfish fishery, Gulf of Mexico reef fish fishery, Bering Sea and Aleutian Islands crab rationalization program, and the Icelandic groundfish fishery, demonstrate the how elements of the Guiding Principles have been utilized in these four regions.

The British Columbia (BC) groundfish monitoring program was developed by establishing clearly articulated goals and involving stakeholders in the process of developing not only the monitoring strategies but also the management plan itself. The program was established to meet the fishery characteristics and utilizes both at-sea and dockside monitors at higher coverage levels. Costs are shared between industry and government. The program has been reviewed since its implementation to ensure the goals are being achieved.

The Gulf of Mexico reef fish fishery also identified explicit monitoring goals. In development of the program, enforcement needs were considered. Programmatic costs are shared between industry and government with a cost recovery program in place to collect fees from fishermen to help cover the costs of administering and enforcing the monitoring program. Data collected from the program are intended to be used to ensure that the monitoring program is achieving its objectives. A five year review of the program is scheduled to occur before 2012.

The Bering Sea and Aleutian Island crab rationalization program's monitoring efforts were established without explicit goals; however, a partnership between various organizations ensures that the program is enforced. Data collection systems were developed based on the specific needs of the fishery, and involved both a third party contractor and government staff. Observer coverage levels for the monitoring program are also based on the fishery's characteristics and needs. All landings made by vessels without an observer are monitored dockside. Aspects of the monitoring program are covered in part by fees recovered from industry through a cost recovery program. The fee percentage has adapted over the years based on the value and management needs of the fishery.

The Icelandic groundfish fishery employs a comprehensive monitoring program that utilizes both at-sea and dockside monitoring strategies to gather weight data for all catch. Discards are prohibited as all catch must also be landed. Iceland uses severe penalties such as fines or revocation of fishing rights to increase compliance of fishery regulations, regardless of whether the actionable offense was done by intent or negligence. Fishermen pay an annual resource fee to participate in the fishery, which can be used to help fund the monitoring program.

7.1 British Columbia Groundfish Fishery

Fishery Background and Management

The British Columbia (BC) groundfish fleet consists of over 300 vessels, varying in size from 20-175 feet in length, though most range between 45 and 80 feet (Stebbins et al. 2009). The groundfish fleet uses trawl, demersal longline, hand line, troll, and trap gear to target multiple species. The trawl fleet targets numerous species while the other gear types target one species or group of species (i.e., halibut, sablefish, rockfish, lingcod, and dogfish), but all gear types incur bycatch of non-target species. There are several components of the trawl fleet, with the offshore groundfish component making up the majority of the fishery. There is also a small inshore component, consisting of less than ten fishermen with extremely limited landings, as well as a hake mid-water trawl component with low bycatch.

Fishing occurs six to twelve months out of the year, depending on the gear used and the species targeted. Approximately 3,500 landings occur each year, combined, at six high volume and twenty low volume landing ports (Stebbins et al. 2009). Overall, the fishery accounts for 230 million pounds landed annually (Stebbins et al. 2009). The BC groundfish fishery is managed by the Canadian Department of Fisheries and Oceans (DFO), under the Groundfish Integrated Fishery Management Plan, which was developed in consultation with the commercial fishing industry.[2]

Since the 1990s, management and monitoring programs co-evolved to address biological and socio-economic concerns. Understanding the current monitoring program requires an understanding of the changes in management over the years. Beginning in 1990 and 1991, the sablefish and halibut longline fisheries, respectively, were placed under individual quota management and were subject to 100% dockside monitoring. These management measures were implemented as a result of the annual quota being caught in a limited number of fishing days. Safety and management issues existed in the fishery, and managers and industry wanted to lengthen the fishing season.

Beginning in 1997, an Individual Transferable Quota (ITQ) system was adopted for the groundfish trawl fishery. Prior to the adoption of the ITQ system, the trawl had been managed by limited entry licensing since 1976; however, several factors led to the adoption of the ITQ system in 1997. Before 1997, many of the multiple species caught by the trawl fleet were managed without a total allowable catch (TAC) limit, and for those with a TAC, many of the limits were not grounded with a sound scientific basis. TACs were often exceeded by the fishery. For instance, the Pacific Ocean perch TAC was exceeded each year from 1988 to 1995, often by more than 40% of the allowable catch (Clark & Munro 2007). The fishery experienced decreasing trip limits and increasing discards to avoid exceeding TACs. Incentives to misreport on logbooks and sales transactions were

[2] Pacific Region Integrated Fisheries Management Plan, Groundfish, February 21, 2009 to February 20, 2010. http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/plans09/2009_Groundfish_IFMP.pdf

high, prices were unstable, and the fishery was unable to meet the quality demands of the market. The fleet was overcapitalized in terms of vessels, crew, and gear.

As a result of these factors, the groundfish trawl fishery was closed in September 1995 when the TACs of over half of the species had been exceeded. An industry advisory committee met regularly to decide how to move forward in light of overfishing. They wanted to increase the value of their catch, increase flexibility and efficiency in their fishing strategy, retain more of their catch, and be able to acquire additional quota if necessary (Shawn Stebbins, pers. comm., July 2010). By 1996, the fishing season was characterized by trip limit restrictions and fishing closures (areas and periods). During that year, a requirement that all bottom trawlers carry an on-board observer was implemented. The next year, the ITQ system was adopted.

Ongoing concerns about rockfish bycatch and discards and the lack of comprehensive at-sea monitoring to account for the at-sea discards of rockfish and groundfish in the non-trawl fisheries led the DFO to begin conversations in 2003 with the commercial groundfish industry about ways to address the conservation and management issues (DFO 2009). After having determined that the existing groundfish management was no longer sufficient, the DFO established five Guiding Principles to inform a new management framework. These principles included that:

- All groundfish must be accounted for
- Groundfish catch will be managed according to the established rockfish management areas
- Fishermen will be held individually accountable for their catch
- New at-sea monitoring standards will be established
- Species and stocks of concern will be closely managed using a precautionary approach (DFO 2009)

The outcome of these discussions and Guiding Principles was the introduction of a three year pilot program known as the Commercial Groundfish Integration Pilot Program (CGIPP), which took effect in April 2006 (DFO 2009).

The CGIPP implemented ITQs for the remaining aspects of the groundfish fleet and brought all five groundfish fleets, including the groundfish trawl, halibut, sablefish, rockfish, lingcod, and dogfish, under the same management program (Trumble et al. 2010). Prior to the CGIPP, the five fleets operated independently and discards of one fleet could be the target catch of another. The CGIPP now streamlines management, reduces bycatch, and accounts for discards. It does this by mandating retention of rockfish, and deducts discards of all catch from individual ITQ. It also considers discards when TACs are set. Furthermore, transfers are permitted between willing participants to address bycatch concerns (DFO 2009; Trumble et al. 2010). When the trawl ITQ program was developed, only permanent quota transfers were allowed, subject to vessel and species caps in order to avoid quota and fleet consolidation (Turris 2000). Beginning in 2000 and continuing through the development of the CGIPP, both temporary and permanent transfers have been allowed

(DFO 2009). Transferability of quota as an option provides fishermen with flexibility for gaining quota to cover their catch.

The CGIPP has made quota holders responsible for catch regardless of whether it is retained or discarded (DFO 2009) which is accomplished by managing all fleets under ITQs and having 100% at-sea monitoring. The program has led to better science, more appropriate, stock-specific TAC, and reduced bycatch and discards (Trumble et al. 2010).

Monitoring Program Development and Methodologies

Background and Goals

The management goals of the BC groundfish fishery have been identified as requiring individual accountability, gathering verifiable data on all catch and discards, documenting discarded catch as legal or sub-legal in size, tracking individual vessel and fleet quotas, and verifying that catch stays within the TAC (DFO 2009; Stebbins et al. 2009). The monitoring program associated with the BC groundfish fishery was originally developed to track the trawl fishery to ensure TACs were not exceeded. It has evolved over time to be comprehensive in nature to respond to intense fishing effort and concerns about stock health, to support the evolving management approach towards the integrated ITQ system, and to achieve the identified management goals (Stebbins et al. 2009). The current monitoring program ensures that the BC groundfish fishery is fully documented, meaning that at-sea and dockside activities are fully and accurately monitored and recorded. The program uses independently verifiable systems to support real-time, in-season management of the fishery (Stebbins et al. 2009).

Before these management and monitoring goals were explicitly defined, dealer reports and fishing logs were the only monitoring strategies utilized in the BC fishery. When ITQ management began in the 1990s, an independent dockside monitoring program was developed to augment the existing tools. Due to overfishing and fishing closures for the trawl fishery in 1996, 100% at-sea observer coverage became mandatory for this component of the fishery (Stebbins et al. 2009).[3]

Further changes to the BC groundfish management and monitoring program occurred in 2003 when the DFO announced that the fishery would be held fully accountable for all catch by 2006 (Stebbins et al. 2009). This declaration included all catch at-sea regardless of whether it was targeted or bycaught, legal or sub-legal size, covered by quota or not, or marketable or not. Even though only legal size, quota-managed catch would be subtracted from a vessel or fleet's quota, all catch still needed to be accounted for. In response to this declaration, several sectors expressed concern that they would no longer be profitable enough to remain viable. All sectors worked with the DFO to develop monitoring strategies that met the new DFO requirements but still allowed economic viability (Stebbins et al.

[3] References to the trawl portion of the BC groundfish fishery apply to the offshore portion of the fleet, which uses 100% at-sea observers. A small inshore component of the fleet uses 100% electronic monitoring, and a small mid-water trawl fishery for hake has 10% coverage of at-sea observers and 100% dockside monitoring (Shawn Stebbins, pers. comm., July 2010).

2009). For instance, the hook and line and trap vessels became subject to 100% at-sea coverage through the use of electronic monitoring instead of at-sea observers. In addition to the adoption of management strategies including individual quotas and quota transferability, the BC groundfish fisheries initiated individual accountability that supported in-season management of all quota species.

Monitoring Strategies

A monitoring program to account for all catch in a multi-sector, multi-species fishery such as the BC groundfish fishery must be extensive and tailor-made to meet the fishery's objectives and industry's needs. The declaration by the DFO that the BC groundfish fishery would be held fully accountable for all catch by 2006 led to the adoption of monitoring strategies to support this standard.

Monitoring Strategy: Hail in/Hail out
Fishery: All groundfish vessels

Monitoring Strategy: Dockside
Fishery: All groundfish vessels
Method: 100% independent verification of all weights for all species for every landing made by the groundfish fleet. In the trawl fishery the landed weights are used to verify at-sea observer estimates and subsequently to make area allocations of at-sea estimates proportionate to landed weights. In the hook and line fisheries the verified landed piece counts are used to verify skippers' logbook piece counts as part of the audit process (Shawn Stebbins, pers. comm., November 2010). This forms part of their rating to determine the necessary level of video review. The cross-reference of data between the hails, self-reporting, and electronic monitoring provides a high level of confidence in the information for a relatively low cost, and the high costs of funding additional audits encourages honest reporting.

Monitoring Strategy: At-sea observers
Fishery: Offshore trawl vessels
Method: 100% at-sea observer coverage

Fishery: Hook and line and trap vessels
Method: 100% as-sea coverage is accomplished through an electronic monitoring system that audits the self-reported data fishermen collect on effort, catch, and catch disposition in logbooks (Stebbins et al. 2009). Since the data that are collected and self-reported in fishing logs are utilized for science and management, a high level of confidence is needed in these data. As a result, 10% of landings on hook and line and trap vessels are randomly audited against the fishermen's self-reported logs to ensure accuracy. This level of coverage was chosen since more frequent audits would have been cost prohibitive to industry. If self-reported data and the audit have a low level of agreement, then additional audits (up to 100% of sets) are conducted and paid for by the fisherman (Shawn Stebbins, pers. comm., July 2010).

Monitoring Strategy: Video
Fishery: Hook and line and trap vessels
Method: Fish sizes of some species are independently verified as being either legal or sublegal through the use of video, using a ruler mounted on the vessel. At-sea discards of legal size catch are assessed so they can be accounted for in individual quotas (Stebbins et al. 2009).

Funding

Aspects of the monitoring program are primarily funded through industry, yet the DFO still contributes to the program. At the outset of the program, DFO planned to cover 30% of the cost of the electronic monitor program for the first two years of operation. This level of contribution has continued beyond the initial two years. The government also pays for 33% of the annual costs of the at-sea observer program for the offshore trawl fleet, and 30% of the observer costs for the small inshore trawl fleet (Stebbins et al. 2009). The remaining costs are entirely funded by industry.

Program Evaluation

The three year pilot program was extended for an additional year to provide extra time for a comprehensive evaluation of the program in 2009 (DFO 2009). The evaluation, which included comments from a broad range of stakeholders, was conducted to determine if the CGIPP had achieved its identified goals and to conduct an assessment of socio-economic impacts (DFO 2009). Since the impetus for the pilot program focused on rockfish bycatch and discard reduction, the evaluation focused on whether or not the CGIPP achieved its objectives of reducing rockfish fishing mortality and providing full accountability for rockfish catch. Three key themes emerged regarding monitoring costs, sector accountability, and quota accessibility from stakeholders that participated in the review (DFO 2009). Discussions with stakeholders identified greater certainty and flexibility of fishing associated with the CGIPP; however, fishermen were concerned about the costs of monitoring. Some fishermen felt that small vessel owners were most heavily impacted by the high monitoring costs while others felt the DFO should contribute a greater amount of funding, given the level of benefit they receive from the data (see DFO 2009 for more stakeholder perspectives). They urged the government to continue funding the program to be consistent with the level of funding received by other groundfish fisheries in Canada (DFO 2009). Regarding sector accountability, fishermen also felt that the recreational sector was not being held to the same catch monitoring standards as the commercial sector (see DFO 2009).

In addition to stakeholder perspectives, the comprehensive evaluation of the pilot program found that the monitoring program was collecting valuable information on which to base bycatch estimates for yelloweye rockfish, which is necessary for rebuilding the stock. After an initial learning period, fishermen are now passing their audit checks. Groundfish and rockfish catch are not exceeding TACs, and it is expected that as the program continues to evolve, additional species will be tested through the audit process (DFO 2009).

Results of the evaluation suggest that the CGIPP is achieving its conservation objectives and satisfies social and economic concerns. After initial adjustments in the groundfish fishery, stability was observed during the pilot period. Other benefits of the CGIPP included financial gains from the sale of non-directed catch; improved data for research, assessment, and management; and improved monitoring of rockfish conservation areas (DFO 2009). Department of Fisheries and Oceans identified high monitoring and quota leasing costs, quota availability, and small boat fleet rationalization as issues needing further consideration, yet it is believed that permanent implementation of the CGIPP will alleviate some of these issues (DFO 2009).

Lessons Learned

A key lesson learned from the BC groundfish fishery monitoring program is how adaptable industry was in adjusting to new regulations. This is especially noteworthy as the fishing industry had a major part in the development of this monitoring program. Quota transferability is also important if 100% accountability is a goal of the program. Transferability has the benefit of allowing sectors to acquire quota for species they previously discarded but may be more valuable than other species they land. Cost sharing is also an important consideration in developing monitoring programs. For instance, managers should consider economic impact at the vessel level. Fixed costs, such as for the program's infrastructure, should be funded proportionally based on quota to lessen the impact on smaller vessels (Shawn Stebbins, pers. comm., August 2010).

Finally, outreach should also be considered during development of a monitoring program. While it is important to involve as many stakeholders as feasible in the development of a program, not all perspectives will be represented. It is important to provide outreach to the entire fishing fleet to make sure industry understands the decisions that were made and the process and rationale behind these decisions. Stakeholder support and understanding will lead to a monitoring program that is better supported and requires fewer enforcement efforts to uphold. In the BC groundfish fishery, various outreach mechanisms were employed. In the case of the trawl fishery, the Groundfish Trawl Advisory Committee, which includes license holders, processors, government, union, and more recently coastal communities and others, was an active part of the process to decide how dockside, at-sea, and vessel shares were to be implemented. In the case of the hook and line fisheries, government organized a commercial Industry Caucus with representation from all involved fisheries to develop the integrated fishery plan and associated monitoring component (Shawn Stebbins, pers. comm., November 2010).

7.2 Gulf of Mexico Reef Fish Fishery

Fishery Background and Management

The Gulf of Mexico (GOM) commercial reef fish fishery consists of approximately 1,000 permitted vessels. In 2008, about 800 vessels reported commercial landings of reef fish through the Southeast Fishery Science Center (SEFSC) logbook program; however, 90% of the commercial landings from 2006-2008 could be attributed to only 330 vessels (Stebbins et al. 2009). The majority of reef fish catch is caught with longline and vertical line gear while a very small portion of commercial harvest is done with spears. Historically, there were around 100 core vessels constituting the longline fleet. Longline vessels range from 50-70 feet in length and carry a crew of 3-4, including the captain. Vertical gear used in the fishery includes bandit gear and rod and reel/hand line. These vessels are smaller, ranging from 30-40 feet in length, and carry a crew of 1-2 individuals.

The complex of reef fish that constitutes the GOM reef fish fishery consists of forty-two species, including groupers, snappers, and tilefish species among other co-existing species. A number of species are caught in the fishery including red, yellowtail, vermilion, silk, queen, dog, mutton, blackfin, schoolmaster, cubera, lane, wenchman, mahogany, and gray snappers; a shallow water grouper complex, consisting of red, gag, black, scamp, yellowfin, and yellowmouth groupers and rock and red hind; a deep-water grouper complex, including snowy, yellowedge, speckled hind, Warsaw, and misty groupers; tilefish; jacks; hogfish; and triggerfish (Stebbins et al. 2009). In general, the GOM reef fish fishery targets red snapper in the northern and western GOM and groupers in the eastern GOM. Yellowtail and mangrove snappers are caught also in the eastern GOM, either by directed efforts or incidentally in the grouper fishery. The red snapper fishery also targets vermilion snapper. Almost half of the value of the commercial reef fish fishery comes from the shallow-water grouper fishery (GMFMC 2008). Eleven of the forty-two species have stock assessments, and twenty-one are managed by a commercial quota or annual catch limit, including red snapper, gray triggerfish, greater amberjack, and eighteen species of groupers and tilefishes. Greater amberjack, gag, red snapper, and gray triggerfish are considered overfished while catch of goliath and Nassau grouper is prohibited as a result of severe depletion in the past (Stebbins et al. 2009). Four of these species (red snapper, greater amberjack, gray triggerfish, and gag grouper) are experiencing overfishing (NOAA 2009b).

Snappers, primarily red and vermilion, are caught with longline and bandit gear; the latter being more prevalent. Longline catch accounts for less than 5% of the total landings and are prohibited from certain areas in Florida. Additional longline gear restrictions occur throughout the GOM. Sixty-two vessels meet new restrictions implemented in 2010 to reduce sea turtle bycatch in longline gear and have qualified for an endorsement based on landings histories between 1999 and 2007 (A. Strelcheck, pers. comm., Sept. 2010). Fishing for snappers is often done in association with natural or artificial structures with high relief from the bottom (Stebbins et al. 2009). Fishing mortality rates of red snapper are highest in the western GOM shrimp fishery, followed by the eastern GOM recreational red snapper fishery, and then by the western GOM commercial red snapper directed fishery. These sectors select for different age classes of red snapper with the shrimp fishery affecting age-

zero and age-one fish while the commercial and recreational fisheries impact fish of ages older than two. (GMFMC 2007). The eastern and western red snapper fisheries are separated spatially by the Mississippi River delta (Stebbins et al. 2009).

Grouper is generally caught with bottom longlines and bandit rigs. Longline catches account for the majority (~60%) of grouper landings each year (Stebbins et al. 2009). Grouper were also caught by fish traps until February 7, 2007 when they became prohibited within the GOM EEZ. A large deep water grouper fishery is based in the western GOM. The shallow-water grouper fishery is almost exclusively based out of Florida. For the shallow-water grouper fishery, which accounts for 43% of all reef fish landings, 95.9% of all landings were attributed to Florida, particularly the west-central region (Stebbins et al. 2009).

The GOM commercial reef fish fishery is managed by the Reef Fish Fishery Management Plan (FMP), which was implemented in November 1984. The red snapper fishery, in particular, was characterized by overcapacity and derby-style fishing conditions from 1992 through 2006. Amendment 26, which was implemented in 2007, established an individual quota (IFQ) system for the commercial red snapper fishery and eliminated the restrictive seasons and trip limits that were previously used. The IFQ program was designed to allow fishermen to take their commercial quota during times, in places, and with methods that best suited their business. As a result, the program increased efficiency, profitability, compliance, and safety of fishermen, and it has provided consumers the ability to purchase fresh fish more often during the year (Stebbins et al. 2009). The program allows transfer of quota between fishermen, requires electronic monitoring of landing transactions, requires hail ins/outs by fishermen, restricts offloading of landings to certain hours, and allows for a collection of a fee (Stebbins et al. 2009). As a result, overfishing of red snapper is no longer believed to be occurring. Amendment 27 of the FMP was designed to address overfishing and bycatch in the directed red snapper and shrimp fisheries. It revised the rebuilding plan for red snapper and reduced the commercial quota in 2008 and 2009 to 2.55 million pounds whole weight (GMFMC 2007). In 2010, the GMFMC passed a regulatory amendment increasing the commercial quota to 3.54 million pounds whole weight for the 2010 fishing season (GMFMC 2007). Amendment 29 to the Reef Fish FMP introduced an IFQ program for the grouper and tilefish fisheries, which was implemented in January 2010, in an effort to reduce overcapacity and bycatch. This Amendment brought the grouper and tilefish fisheries under the same management regime as the red snapper fishery. The extension of the IFQ program was initiated by the GMFMC in an effort to end derby fishing and to maintain a longer fishing season. Amendment 29 also created an advisory panel made up of appointed fishermen and others to develop management options and report back to the GMFMC.

NMFS has developed an online system for maintaining all aspects of the IFQ program. IFQ fishermen are charged a cost recovery fee (3% of the ex-vessel value of the landed fish for the first year, re-evaluated every year) to administer and enforce the program. This fee is collected by the IFQ dealer at the time of sales transaction (GMFMC 2010). The IFQ dealer then submits fees online on a quarterly basis to NOAA Fisheries Service.

In addition to management measures to address overfishing, measures were put in place to address bycatch of loggerhead sea turtles in the reef fish fishery. Bottom longline gear used in a portion of the fishery was found to exceed sea turtle take levels authorized by the 2005 Biological Opinion (NOAA 2009a). Effective June 1, 2008, regulations required both commercial and recreational reef fish fishermen in the GOM to use circle hooks, dehooking devices, and venting tools (FFWCC 2010). Additional management actions were implemented by Amendment 31 in 2010, including measures that require a longline gear endorsement, restrict areas where longlines can be fished during June-August in the eastern GOM, and limit the number of hooks used on a longline (NOAA 2009a).

Monitoring Program Development and Methodologies

Background and Goals

Several goals were developed for the GOM reef fish fishery monitoring program. Both general and specific goals were identified. The general goals included:

- To account for all fishery-related mortality including landings, at-sea discards, and unreported catch mortality
- To collect biological and fishery-related data to inform stock assessments, including vessels characteristics, gear type, gear details, total catch, species composition, fishing effort (i.e., set location, soak time, number of hooks), biological samples, and sea conditions
- To collect information on vessel location, activity, and permits to support program compliance and enforcement
- To provide accurate data in a timely way to support in-season management and annual planning needs (Stebbins et al. 2009)

Specific goals were also identified for the management plan including to develop an accurate logbook reporting system for all vessels that are active in the GOM reef fish fishery. The aim was to collect information by statistical area on catch that was retained and released, species that were consumed onboard or used as bait, and gear that was lost at sea. The program also aimed to gather information from dealers on all landed catch, also by statistical area, that was received from vessels permitted to catch reef fish in the GOM (Stebbins et al. 2009).

Monitoring Strategies

Several strategies have been employed in the GOM reef fish fishery to achieve the objectives of the monitoring program and to collect biological information that can be used to assess the health of fish stocks.

Monitoring Strategy: Logbooks
Fishery: All permitted reef fish vessels
Method: Fishermen are required to complete a logbook documenting catch and effort for each fishing trip. The logbook must be submitted to the SEFSC within seven days of a fishing trip. These data are supposed to be available within two weeks of being submitted, yet 50% of logbooks are received more than two weeks after a fishing trip ends (Stebbins et al. 2009). Many logbooks are either not thoroughly or properly completed. NMFS audits logbooks and returns about 10% of the vessel reports for completion or correction. When requested, fishermen must also complete a logbook that details their discards. These discard logbooks are based on a 20% random sample of the fleet.

Monitoring Strategy: Electronic reporting
Fishery: IFQ vessels
Method: The system tracks IFQ shares and allocations in addition to the pounds and value of landed red snapper and other IFQ species (Stebbins et al. 2009). Both dealers and fishermen enter data jointly during landing using personal identification codes. To make a transaction complete, both parties have to submit the required data, including number of pounds sold and average price of landings. This allows managers and law enforcement to monitor IFQ accounts in real time, ensure sales and purchases balance, and have a complete picture of what was purchased in the past 24 hours (D. McKinney, pers. comm., Sept. 2010). This information was available through the paper fish ticket process that was used previously; however, the information was not available in real time.

Monitoring Strategy: Hail in/Hail out and VMS
Fishery: IFQ Vessels
Method: Fishermen are required to notify NOAA Fisheries three hours before landing. This, combined with a vessel monitoring system (VMS) requirement, allows the NOAA Fisheries Office of Law Enforcement to decide whether to monitor the IFQ landing (Stebbins et al. 2009). VMS is used to monitor compliance with fishing regulations such as restricting fishing in closed areas. All vessels are required to carry an operating VMS on board that transmits hourly signals (Stebbins et al. 2009). Each vessel must notify NOAA Fisheries prior to departure which fishery the vessel will participate in and which gear will be carried and used.

Monitoring Strategy: Designated/approved landings ports
Fishery: IFQ vessels
Method: The strategy was designed to facilitate enforcement and dockside monitoring efforts. An approval code is needed to move IFQ species from a designated landing site; the code shows that the landing has been reported by the fisherman and dealer (GMFMC 2010). Fishermen can land their vessels anytime during the day and night, given that they have provided their hail-in or landing notification; however, offloading is restricted to the hours of 6 am to 6 pm (GMFMC 2010).

Monitoring Strategy: At-sea observers
Fishery: Commercial reef fish vessels
Method: The long term goal of the observer program is to provide more accurate data of finfish and protected species interactions (Stebbins et al. 2009). Vessels are randomly selected by NOAA Fisheries and are stratified by season, gear type, and geographic location. The observer program data are available about four weeks after a trip, and are used in stock assessments and as part of the National Bycatch Report. While the program targets 5% of trips, it achieves only around 1% (Stebbins et al. 2009).

Monitoring Strategy: Dockside
Fishery: Commercial reef fish vessels
Method: Dockside monitors collect landings information in addition to economic and biological data as part of a trip interview program. Interviews collect information on species age at length, size frequency data, catch per unit effort, and composition of species caught and landed (Stebbins et al. 2009). These data are available in several months for age-related data and within several weeks for fishery or socio-economic data (Stebbins et al. 2009). This information is dependent on interviews, and it is not independently verified. It is also not used to ground-truth other sources of data such as dealer reports or fishing logbooks though it could be possibly used in this way.

Funding

Information on price paid is necessary so that the NMFS can obtain a 3% cost recovery fee for the IFQ species. This fee is used by NMFS to cover costs of administering and enforcing the program. While IFQ shareholders are actually paying the fee, it is the responsibility of the dealers to collect the fees and submit them to NMFS (Stebbins et al. 2009).

Program Evaluation

The IFQ electronic reporting system was designed to require mandatory reporting by all fishermen and dealers in the IFQ fishery and to track consolidation of share and allocation. Data are used to monitor the program against its objectives, and landings data are used in stock assessments. The program to date has been achieving most of these goals since the reporting is mandatory and penalties are strict for non-compliance. The GMFMC plans to conduct a formal five year review of the program by 2012.

Lessons Learned

Each of the data collection systems were developed independently for specific purposes, resulting in overlap in some of the types of data that are collected. Specifically, landings data are collected by several monitoring methodologies. There is also overlap in the collection of vessel characteristics, socio-economic information, and trip summary data, yet coverage levels of the various monitoring techniques are often low. If the collection of data was integrated and duplication of effort reduced, costs could be decreased and coverage levels and data confidence increased.

Currently, there is no comprehensive auditing of fishermen and dealer records in place to confirm accurate reporting, though some states do conduct audits. A number of measures including the 3-hour hail in, VMS, and dockside monitoring may work to deter dealers and fishermen from jointly underreporting. Yet, inherent incentives to underreport still exist.

Additionally, the IFQ quota monitoring system was designed to account for landed catch, but it does not account for total fishery-related mortality. Without an accurate assessment of total catch mortality, the monitoring program cannot effectively prevent overfishing or restore depleted populations (Stebbins et al. 2009). It is important to know the total fishery-related mortality to support in-season management and prevent annual catch limits from being exceeded. Information on discards is available from logbooks from about 20% of fishermen, yet the number of discards is often underreported, compared to observer based estimates. Since observers only cover about 1% of the reef fish fishery, these data may not be representative of fleet-wide fishing activities. In order to meet the goal of the monitoring program of accounting for total catch mortality, additional measures are still needed.

Precision estimates of sea turtle bycatch would also be greatly enhanced by higher levels of observer coverage. More observations are necessary in the longline fishery to determine if mitigation measures of the fleet are successful. The NOAA SERO has conducted a pilot project for longline vessels in the GOM using an electronic monitoring system to evaluate whether it could be used to supplement the existing monitoring efforts (Pria et al. 2008). Such an electronic monitoring system could also provide valuable information on discards of fish species. In the meantime, in the absence of discard and bycatch data, extreme precaution is necessary in setting catch limits to prevent overfishing.

The current IFQ program's online system is a step forward for the GOM reef fish fishery with regard to reporting catch data. Real time data reporting can ensure quotas are not exceeded. However, the system relies to a large degree on fishermen and dealer reports, without much independent verification while at-sea data are largely ignored. Additional recommendations to improve the monitoring program of the fishery include improvements to fishing logbooks, an integrated data system, a data collection training and outreach program, electronic monitoring, and a roving and more robust dockside monitoring program (Stebbins et al. 2009).

7.3 Bering Sea and Aleutian Islands Crab Rationalization Program

Fishery Background and Management

In the Bering Sea and Aleutian Islands (BS/AI), nine King and Tanner crab fisheries are presently managed under a Crab Rationalization Program (CRP), including (1) Bristol Bay red king crab (*Paralithodes camtschaticus*); (2) Western Aleutian Islands (Adak) golden king crab (*Lithodes aequispinus*) — west of 174° W longitude; (3) Eastern Aleutian Islands (Dutch Harbor) golden king crab — east of 174° W longitude; (4) Western Aleutian Islands (Adak) red king crab — west of 179° W longitude; (5) Pribilof Islands blue king crab (*P. platypus*) and red king crab; (6) St. Matthew Island blue king crab; (7) Bering Sea snow crab (*Chionoecetes opilio*); (8) Eastern Bering Sea Tanner crab (*C. bairdi*) — east of 166° W longitude; and (9) Western Bering Sea Tanner crab — west of 166° W longitude (NOAA Fisheries 2010a). The original Bering Sea Tanner crab fishery was divided after the first CRP year into Eastern and Western Bering Sea Tanner fisheries, so the CRP now manages nine fisheries. BS/AI crab fisheries are managed through a cooperative management regime between the National Oceanic and Atmospheric Administration (NOAA) Fisheries and the Alaska Department of Fish and Game (ADF&G).

Crabs are benthic species caught by pots. Pots are considered an environmentally responsible method of fishing, and the majority of bycatch in crab fisheries are of non-target crab species, female crabs, and sub-legal males. Interaction with endangered, threatened, or protected species is of limited concern. King and Tanner crabs exhibit life history characteristics that make them somewhat vulnerable to fishing pressure as they have moderate age at first maturity, a fairly long life span, and high fecundity. Stock productivity alters with environmental perturbations.

Prior to 2005, major BS/AI crab fisheries were managed under the License Limitation Program (LLP), a limited entry program under which licenses were allocated based on historic participation. Licenses were endorsed for one or more area and species, and issued by vessel type: catcher vessel or catcher/processor (Fina 2005). Despite the limit on entry, there was substantial overcapacity in the fisheries, and derby-style fishing was prevelant. Most participants could actively fish in several fisheries since most crab fishery seasons did not conflict, yet equipment was often idle for several months of the year. The majority of fishing effort was focused on the three largest fisheries: the Bristol Bay red king crab, the Bering Sea snow crab (*C. opilio*), and the Bering Sea Tanner crab (*C. bairdi*) fisheries. Stock declines occurred in the Bristol Bay red king crab and the Bering Sea snow crab fisheries while excess capacity led to short seasons lasting only a few days or weeks as harvesters raced to catch the annual quota, compromising safety of the fishermen (Fina 2005).

In addition to the LLP program, fisheries were previously managed by a target catch known as the guideline harvest level (GHL). Initially, these GHLs were ranges of acceptable total catch, but later they became fixed amounts. Harvests were monitored by voluntary in-season reports, and managers attempted to coordinate the closure of a fishery with anticipated completion of the GHL. In-season monitoring could not always keep pace with

harvests during the short seasons, and harvests exceeded the GHLs in some years. For example, in the Bering Sea snow crab fishery, the harvest exceeded the GHL each year from 1995 to 2000 (Fina 2005). In the years immediately preceding implementation of the CRP, managers improved in-season catch monitoring, thus limiting the extent of these GHL overages (NPFMC 2008).

In addition to the GHLs, there were minimum size limits, sex restrictions (with landings limited to males), area closures, gear restrictions, limited fishing seasons, and a community development quota program (CDQ). The CDQ program began in 1992 and allocated a share of allowable harvests of all BS/AI groundfish, prohibited species, halibut, and crab to eligible communities to promote fisheries-related economies in western Alaska (DOC and State of Alaska 2005).

The BS/AI Crab Rationalization CRP is a limited access privilege program developed by the North Pacific Fishery Management Council (NPFMC). It was implemented in 2005 to protect the interests of those that depend on these crab fisheries and specifically, to address safety, economic, and conservation concerns that resulted from excess capital, and overcapacity and the ensuing race for fish (Fina 2005; NPFMC 2008). The CRP is also intended to reduce bycatch and associated discard mortality (Fina 2005; NPFMC 2008).

The NPFMC created allocations, based on historic participation, according to a "voluntary three pie cooperative" program that intended to protect the interests of the harvest sector, the processing sector, and defined regions and communities (NPFMC 2008). As a result, the CRP governs three types of crab fisheries— the large individual fishing and processing quota fisheries, the CDQ fisheries, and the Western Aleutian Islands golden king crab fishery fished by the community of Adak. The NPFMC developed the CRP over a six-year period to accommodate the specific dynamics and needs of the BS/AI crab fisheries. NOAA Fisheries published a final rule to implement the CRP on March 2, 2005 (Federal Register 2005), and crab fishing under the CRP began when the first rationalized fisheries opened on August 15, 2005.

The CRP has transitioned the crab fisheries into individual fishing quota (IFQ) fisheries. Where the fleet would previously catch the GHL in just a few days, the CRP was designed to allow IFQ holders to fish over a longer period to catch their quota. Under the CRP, a catch limit is set and shared among participants (harvesters, processors, and communities). Crab sold or kept for personal use and all deadloss, the amount of dead crab landed at the dock, are debited against an IFQ allocation, though discards are not. (Fina 2005).

In addition to the quota management system, other management measures that continue to be used in the crab fisheries include minimum size limits, sex restrictions, area closures, gear restrictions, and limited fishing seasons. The ADF&G establishes fishing seasons to avoid sensitive periods of the crabs' life cycle, including molting (soft-shell periods) and mating (F. Bowers, pers. comm., 2010). Since inception of the CRP, of the nine crab stocks, none have experienced overfishing. Prior to the CRP, four stocks were overfished and vary today in their stock status.

Vessel consolidation has also occurred since implementation of the CRP. In 2004, the Crab Capacity Reduction Program (Buyback Program) removed 25 vessels from the fleet (NOAA Fisheries 2009b). Most notably, in the Bristol Bay red king crab fishery and the Bering Sea snow crab fishery, vessel participation reduced from 246 to 84 vessels and 229 to 70 vessels, respectively, between 2000 and 2007 (NOAA Fisheries 2008).

The CRP effectively slowed the pace of the fisheries and reduced the race to fish. The Bristol Bay red king crab seasons typically lasted less than one week between 1996 and 2004 whereas in 2005, the season stretched to an unprecedented three months. The CRP was unsuccessful at reducing bycatch, however, which actually increased under the rationalized fisheries (Barnard and Pengilly 2006).

As a result of the CRP, stock statuses have improved, fishing seasons have lengthened, and safety conditions are markedly better, yet the allocation of fishing privileges, processor quota shares, and binding price arbitration remain contentious among stakeholders. There has been one thorough review of the CRP to date. The review considered allocations, participation patterns, and distribution of activities of the sectors and changes in their operations. The results are preliminary since the review examines only three years of fishing under the CRP (NPFMC 2008).

The review also found that the CRP led to increased catch. Many of the vessels that remained active in the CRP actually fished more than the quota share allocation attributed to that vessel (while other vessels sat idle and owners collected lease royalties). As a result, most active vessels substantially increased their catch after rationalization. Under the CRP, both the median and largest harvests have been more than double their pre-rationalization levels in pounds and as a percent of the total catch (NPFMC 2008). Fewer vessels are sharing the quota so each is granted a larger share of the catch. In the Bristol Bay red king crab fishery prior to the CRP, 251 vessels each received an average per vessel harvest of 0.40% of the total allocation, or 55,335 pounds (NPFMC 2008). In the first year after the CRP was implemented (2005 – 2006 fishing year), 89 vessels each received an average per vessel harvest of 1.12% of the total allocation, or 185,120 pounds (NPFMC 2008).

The review also noted that the average number of crab deliveries from a harvester to a processor doubled or tripled in some fisheries post-rationalization, demonstrating harvesters were taking advantage of their secured allocation and taking shorter fishing trips. For example, in the Bristol Bay red king crab fishery one year before rationalization, each vessel made an average of one crab delivery (maximum number of deliveries by any one vessel was two) of 54,009 pounds (NPFMC 2008). During the first year in the CRP, each vessel in that fishery made an average of 2.6 crab deliveries (maximum number of deliveries by any one vessel was six) of about 68,366 pounds.

Monitoring Program Development and Methodologies

Background and Goals

Prior to the CRP, monitoring was insufficient to track catches against target levels; strategies employed included voluntary catch reporting and on-board observers. While no explicit goals of the monitoring program were identified with the establishment of the CRP, the transition to this new management regime highlighted the need for stringent, real-time catch accounting against individual quotas.

The CRP's monitoring program supports real-time account management and monitoring by NOAA Fisheries to ensure compliance with the regulatory requirements (NOAA Fisheries 2008). Electronic reporting is used to collect data in real-time and to attribute landings to the appropriate accounts (NPFMC 2008). NOAA Fisheries' mandatory data collection program also includes strategies to collect landings cost, revenue, ownership, and employment data regularly from the harvest and processing sectors to facilitate the study the economic and social impacts of the program.

A partnership among the NOAA Fisheries Office for Law Enforcement, the state of Alaska, and the U.S. Coast Guard ensures compliance with the regulations that govern allocation. The state of Alaska and USCG perform nearly all at-sea enforcement. Dockside enforcement is mostly conducted by the state. Alaska state troopers conduct dockside boardings focused on spot checks (rather than detailed reviews of permits and logbooks) and inspections (audits) focused on accounting for the entire catch (including deadloss and personal-use crab). Funding and direction for these duties come through Joint Enforcement Agreements (NPFMC 2008; NOAA Fisheries 2010a).

Monitoring Strategies

Biological data are necessary for fisheries management to assess stock status, target catch, and related regulations. Pre-2005, fishing effort was spatially and temporally compressed contributing to homogeneity within the fleet. Because of this homogeneity, the state of Alaska at-sea observer and dockside sampling programs were specifically designed with the knowledge that full sampling coverage would not be needed or obtained from every landing (Bowers et al. 2010). With the implementation of the CRP, the state of Alaska recognized that fishing effort was likely to be more broadly distributed in its spatial and temporal components given the previously shorter fishing seasons. To ensure each fishery was being fully characterized by participation and to ensure adequate data to assess the impacts of the new CRP were being collected, the state increased observer and dockside monitoring coverage for each fishery.

Monitoring Strategy: VMS
Fishery: All catcher and catcher/processor vessels in the CRP, including IFQ, CDQ, and Adak fisheries

Method: VMS are used to determine vessel position and activity, which is extremely important given the spatial and temporal restrictions associated with quotas in the fisheries (NOAA Fisheries 2008; NPFMC 2008).

Monitoring Strategy: At-sea observer
Fishery: Processor vessels
Method: 100% at-sea observer coverage to collect biological data on the retained and non-retained portion of the catch and document fishing practices.
Fishery: Catcher vessels
Method: Coverage varies by fishery from 20% of the fleet in the Bristol Bay red king crab fishery to 100% of the fleet in the Saint Matthew Island blue king crab fishery (Bowers et al. 2010). Observer coverage levels are based in part on the amount of available data from that fishery, data needs, potential fleet size, stock conservation concerns, and geographic and temporal distribution of the fleet. All landings made by vessels without an observer are monitored at dockside (Bowers et al. 2010).

Monitoring Strategy: Dockside
Fishery: Catcher vessels without an at-sea observer
Method: Dockside samplers collect biological data on the retained and non-retained portion of the catch and document fishing practices. When samplers note catch accounting concerns, these are transmitted to enforcement staff (Bowers et al. 2010).

Monitoring Strategy: Catch weighting system
Fishery: All catcher and catcher/processor vessels in the CRP, including IFQ, CDQ, and Adak fisheries
Method: CRP crabs are weighed on certified scales, and reports are submitted electronically. The system was designed to reduce uncertainty associated with reported catch and to decrease the likelihood of underreported harvests. Additional weighing requirements exist for shore side or floating processors taking deliveries (transfer of crab from a harvester or a processor, for catcher and catcher/processor vessels (NOAA Fisheries 2008).

In order to take deliveries from catcher vessels, a buyer must be a NMFS Registered Crab Receiver (RCR). An RCR ensures that all CRP crab are weighed (on a scale that meets NMFS specifications and that is approved by the landing state), and all offloading complies with an annually approved Catch Monitoring Plan (CMP).[4] The CMP provides an explicit description of how crab are offloaded and weighed, and vessels must remain at the offload site until required reporting is complete. There are no exceptions to the RCR regulations, such as dockside sales or tendering (NOAA Fisheries 2008, 2009b, 2010a; NPFMC 2008). Annual review of the CMP ensures that the standards continue to be met.

Catcher/processor vessels are also required to weigh all landings on an approved scale, but a CMP is not required since the weighing occurs at-sea prior to processing. Vessel

[4] See http://www.fakr.noaa.gov/sustainablefisheries/crab/rat/scales/cmp.pdf

operators that harvest and process their catch at-sea must weigh crab on NOAA Fisheries certified motion-compensated scales prior to processing. A scale-equipped printer must record the weight of each load in the weighing cycle, the total weight in the offload, and the date and time of the offload. Catcher/processors must submit an offload report including the gross and net weight of the crab product offload, along with the scale printout documenting the offload (NOAA Fisheries 2008, 2009b, 2010a; NPFMC 2008). These measures provide a robust method to track all crab landings and account for catch against individual quotas. The use of registered receivers reduces the risk that vessels misuse and underreport their catch.

Monitoring Strategy: Online reporting
Fishery: All participants in the CRP
Method: Timely reporting of catch is conducted through the Interagency Electronic Reporting System (IERS) and its online reporting component, eLandings (eLandings.alaska.gov). The IERS is a joint system developed under the partnership of NOAA Fisheries Alaska Region, ADF&G, and the International Pacific Halibut Commission. Electronic reporting of landings supports real-time account management and compliance monitoring. The data entry system allows electronic entry of crab landings and provides a printed fish ticket as a landing receipt, plus receipts for IFQ and IPQ account debits. In addition, stand-alone client software allows submission of landing reports as email attachments for clients disconnected from the web (such as catcher/processors). This electronic system and database were designed, developed, tested, implemented, and maintained jointly by a contractor and NOAA Fisheries agency staff. The services required for management of the central database are covered through fees recovered from industry. In the event that eLandings system is temporarily unavailable, a backup system of paper reporting via FAX directly to NOAA Fisheries' quota management database is available for IFQ/IPQ fisheries. For CDQ and Adak fisheries, a temporary paper fish ticket completed for ADF&G serves a similar purpose (NOAA Fisheries 2008, 2009b, 2010a; NPFMC 2008).

Monitoring Strategy: Economic reporting
Fishery: All participants in the CRP, including any owner or leaseholder of a vessel or processing plant that harvested or processed crab in specified BS/AI crab fisheries during the prior calendar year (NOAA Fisheries 2010c).
Method: Submission of historic and annual Economic Data Reports help the NPFMC and the National Marine Fisheries Service (NMFS) assess the success of the management program and develop amendments to it. Economic data quality assessments are conducted through submitted feedback by means of detailed comment logs maintained by the PSMFC, along with submitter interviews and informal meetings held by NOAA Fisheries Alaska Fisheries Science Center and the NPFMC.

Funding

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and the NPFMC motion adopting the CRP, NOAA Fisheries collects fees from CRP participants to pay for the costs of management, monitoring, and enforcement arising out of the program. Fees are limited to no more than 3% of the ex-vessel (value before processing) value of the

fishery in a crab fishing year.[5] The precise percentage is based on the previous years' ex-vessel prices and management and enforcement costs.[6] NOAA Fisheries determines the annual fee percentage at the start of each season (published in the Federal Register) that will apply for each crab fishing year. NOAA cannot adjust the fee percentage at the end of a season. Any debit or credit to the fee collection account must be carried forward and applied toward the fee percentage calculations for future years. This has been the case since implementation of the CRP. The initial fee percentage collected was 3%, and this fee percentage has been subsequently lowered and raised according to credits and debits based on the value and management needs of the fishery (NOAA Fisheries 2008, 2009b, 2010a; NPFMC 2008).

The fee percentage is established in the first quarter of a crab fishery year; therefore, fee collections for any given year may be more or less than the actual costs and fishery value for that year. The fee percentage has declined over time because of a variety of factors including the increasing value of the fishery due to increased total allowable catch limits for various crab species such as Bristol Bay red king crab and Bering Sea Snow crab, increased ex-vessel price per pound of crab relative to previous years, and decreased management costs (e.g., staffing vacancies, multi-year contracts included in prior year costs, more efficient use of staff time as NOAA Fisheries staff developed familiarity with the CRP) relative to previous years primarily due to decreased staff and contract costs (NOAA Fisheries 2010a; NPFMC 2008).

Fees are split between the harvesting and processing sectors, with processors responsible for collecting the fee and making payment to NOAA Fisheries. Catcher/processors do not split the fee, but instead they pay the full amount directly to NOAA Fisheries. Penalties, interest, and administrative charges are added if an RCR becomes delinquent in payments. NOAA Fisheries cannot issue any annual crab permits to a person who owes unpaid fees. The CRP has only been operational for five years, and there has not since been any formal evaluation of monitoring procedures. The most evident change has been in the annual adjustments to recovery fees. Harvest levels have been very close to allocations in most fisheries, and the Bering Sea Tanner Crab fishery, which was closed three years prior to rationalization, is now active.

[5] Under the MSFMCA, costs for management and enforcement of IFQ programs are recoverable from participants, up to a maximum of 3% of the ex-vessel value of the crab. MSFMCA Sections 304(d)(2)(A) and Section 313(j) prescribe the cost recovery framework, including the requirement for fee sharing with the state. Actual costs recovered are only those "incremental costs" associated with management and enforcement of the program. "Incremental costs" are costs directly associated with the program (NOAA Fisheries 2008).

[6] Each year, NMFS calculates and publishes in the Federal Register the fee percentage according to the factors and methodology described in Federal regulations at § 680.44(c)(2). The formula for determining the fee percentage is the "direct program costs" divided by "value of the fishery," where "direct program costs" are the direct program costs for the CRP for the previous fiscal year, and "value of the fishery" is the ex-vessel value of the catch subject to the crab cost recovery fee liability for the current year.

7.4 Icelandic Groundfish Fishery

Fishery Background and Management

Iceland's groundfish fishery targets cod, haddock, saithe, redfish, flatfish, lumpsucker, monkfish, Greenland halibut, and other demersal species using mostly bottom trawl and longline as well as some gillnet, handline, and Danish seine fishing gears. The fishery has a long history, with the first Icelandic-owned trawler operating since 1905. Beginning in 1976 with the designation of the federal exclusive economic zone (EEZ) to restrict foreign access, fishery managers implemented catch quotas for the major demersal fisheries in Icelandic waters. The quota management was unsuccessful due to being overly restrictive and unenforceable (Icelandic Fisheries 2010a; Runolfsson and Arnason 2001).

Subsequently, in 1977, fisheries managers implemented a system of effort limitations that restricted the number of fishing days per year but allowed for new entry into the fishery. This system also proved unsuccessful, and the cod stock declined. An increase in fishing capacity occurred during this time and forced managers to further limit days-at-sea allocated to each vessel. This measure reduced the economic efficiency of the groundfish fishery. Therefore, in order to improve efficiency and protect stocks, the Ministry of Fisheries adopted a management system of individual vessel quotas (IVQs) based on a vessel's catch performance from 1981–1983. The first year of allocating IVQs was 1984.

The IVQ system was initially intended to last for one year, but it was extended until 1990 with some modifications (Meridian Institute and MRAG Americas 2010). Beginning in 1985, vessel owners were given the option to fish under catch quotas or effort quotas. Vessel owners quickly discovered ways to circumvent or manipulate the regulatory system. For example, many switched between catch and effort quotas, maximizing their landings under the effort quota to ensure that they received a higher catch quota (Meridian Institute and MRAG Americas 2010). This made it difficult to limit total catches (Hunt et al. 2002; Meridian Institute and MRAG Americas 2010; Icelandic Fisheries 2010a,b).

The current management regime for the Icelandic groundfish fishery was established in 1990, with the creation of the Fisheries Management Act. The Act extended the catch quota system indefinitely, made quotas transferable, eliminated the effort quota option, required that all commercial fishing vessels be licensed, and instituted a moratorium on issuing new licenses (Meridian Institute and MRAG Americas 2010). The Act also extended this new individual transferrable quota system (ITQ) to boats between six and ten gross registered tonnes (GRT) (Meridian Institute and MRAG Americas 2010). Boats less than six GRT were added in 2004 (Arnason 2005; Icelandic Fisheries 2010b). The ITQ system applies to stocks within the Icelandic EEZ or for which Iceland has national fishing rights.

Current fisheries management remains based on ITQs with the intention of limiting total catch to prevent overfishing at any given time. The Minister of Fisheries and Agriculture sets the total allowable catch (TAC) for each species based on scientific advice from the Icelandic Marine Research Institute. Individual registered vessels are allocated a share of TAC of certain species according to each vessel's quota. A species' TAC is set at a

percentage of the average fishable biomass of the current year and the estimated fishable biomass of the coming year (Icelandic Fisheries 2010c). In addition to ITQs, other fisheries management regulations designed to ensure the sustainability of the fisheries and protect vulnerable habitats include area restrictions, gear restrictions, and occasional area closures when concentrations of immature fish within the area reach a certain level. Such closures are implemented by the Icelandic Marine Research Institute and can last up to two weeks (Icelandic Fisheries 2010b).

Each catch quota is fully transferable and divisible so that vessel owners can transfer an entire quota or a portion of a quota to another vessel. Each quota transfer must be registered with the Fisheries Directorate and is subject to quota transfer fees. To ease the transferability of catch quotas, each quota is calculated in "cod equivalents." A cod equivalent is a weight measurement based on the value of a species in proportion to the value of gutted cod, where gutted cod has a value of one (Christensen et al. 2009; Icelandic Fisheries 2010d; Meridian Institute and MRAG Americas 2010). Because they are based on the market value of the fish, cod equivalents fluctuate considerably from one fishing year to the next (Meridian Institute and MRAG Americas 2010). The Ministry of Fisheries publishes the cod equivalents for each fishing year. The cod equivalent system is designed to increase flexibility for vessel owners and decrease discards which are banned in Icelandic fisheries. Vessel owners can catch all other species and deduct their catches from their cod quotas using the cod equivalents (Christensen et al. 2009). This structure only works for fishermen deducting non-cod catches from their cod quotas, not for deducting cod catches from non-cod quotas.

The ITQ system allows vessel owners to roll up to 20% of their catch quota for each demersal species from one year to the next (Icelandic Fisheries 2010e; Meridian Institute and MRAG Americas 2010). If a vessel catches less than 50% of its quota over two consecutive years, however, the quota will be revoked and distributed among the vessels that are still active in the fishery (FAO 2004). In addition, vessel owners are permitted to exceed their annual catch quota for each demersal species by 5% (Meridian Institute and MRAG Americas 2010). In such cases, the excess catch will be deducted from their catch quota for the following year (Directorate of Fisheries 2010; Icelandic Fisheries 2010e).

Since the start of the ITQ system, the number of quota-holding vessel owners in the fishery has decreased from 1,174 in 1993 to 762 in 2007 (Ministry of Fisheries and Agriculture 2008; Meridian Institute and MRAG Americas 2010). There are measures in place to prevent excessive consolidation where a small number of fishing companies dominate the fishery. No one owner, or closely-linked group of owners, is allowed to own more than 12% of the catch quotas for cod; 20% of the quota shares of Greenland halibut, saithe, and haddock; or 35% of the redfish quotas (Meridian Institute and MRAG Americas 2010). In addition, a single company may not own more than 12% of the value of the combined shares of all of the species with TACs (Icelandic Fisheries 2010c).

The Icelandic Marine Research Institute conducts extensive research on the status and productivity of the commercial stocks and long-term research on the marine environment and the ecosystem around Iceland. This research is essential for successful management of

fisheries and is the basis for the advice on sustainable catch levels of fish stocks (Icelandic Fisheries 2010g).

The goals of the Icelandic ITQ system were to increase the efficiency of the fishery and to conserve local stocks, especially cod (Runolfsson and Arnason 2001). The fisheries have become more efficient as a result of the ITQ system (Meridian Institute and MRAG Americas 2010). The fishery's increased efficiency is apparent in the decreased number of vessels in the fleet. Between 1990 and 2006, the total number of vessels decreased by 28% (Christensen et al. 2009). There has been public criticism of the ITQ system for marginalizing fishing communities and independent fishermen. Many coastal communities in Iceland have depended on fishing and fish processing for centuries. Larger, more efficient vessels have brought about the ability to process at-sea, putting many land-based processors out of business (Meridian Institute and MRAG Americas 2010).

The results of cod conservation efforts are more difficult to evaluate. The cod stock peaked in 1980 at 1,500,000 tons, but by 1983, the stock had declined below 800,000 tons (Meridian Institute and MRAG Americas 2010). In 1995, after the ITQ system was in place, the cod stock had again fallen to 550,000 tons (Christensen et al. 2009). It should be noted, however, that cod catches did exceed the TAC by more than 10% between 1984 and 1996 (Hunt et al. 2002; Meridian Institute and MRAG Americas 2010).

Monitoring Program Development and Methodologies

Background and Goals

Iceland has strict laws requiring the collection and maintenance of fisheries catch data. According to the Fisheries Management Act, Article 17, Chapter 3:
"Commercially permitted fishing vessels shall keep special logbooks of catch statistics provided by the Directorate of Fisheries. Information to be recorded in each logbook, format and delivery to the Directorate of Fisheries is specified by regulation. Vessels that fail to submit catch log books will have their fishing permits suspended (Icelandic Fisheries 2010e)."

The Directorate of Fisheries established a strict monitoring program to ensure compliance with regulations, specifically adherence to species' TACs. Iceland's monitoring and enforcement regime includes port control, weighing of all catches, and mandatory landing of *all* catches (Icelandic Fisheries 2010b).

Monitoring Strategies

The Directorate of Fisheries, under the Ministry of Fisheries, closely monitors Icelandic fisheries for compliance with the laws and regulations regarding fisheries operation and fish processing. Iceland's enforcement regime utilizes strict port control through the use of Directorate inspectors at ports (and onboard fishing vessels) and requires that all catches must be landed and weighed, thus prohibiting discards, though vessels are permitted to land a small percentage of their catch (usually bycatch) without the use of quota. That

portion of the catch is sold at auction, and the proceeds are used to support marine research (Icelandic Fisheries 2010b).

In order to further deter noncompliance, Iceland utilizes a system of severe penalties of fines or revocation of fishing rights, irrespective of whether the conduct was done by intent or negligence. Serious or repeated intentional offenses are subject to up to six years imprisonment. If a vessel's catch exceeds its quota, the relevant fishing company has a timeline within which they can purchase additional quota for the relevant species. If additional quota is not purchased, the Ministry of Fisheries can revoke the fishing permit and charge a fine for the illegal catch.

Monitoring Strategy: At-sea observers
Fishery: All commercial vessels
Method: At-sea monitoring is conducted by Directorate inspectors. Inspection on-board processing vessels involve monitoring catch, processing yield, and practices. Inspectors may board active fishing vessels at any time to monitor catch composition or to review logbooks, handling methods, and fishing equipment. If inspections reveal the presence of high composition of small fish or juveniles at the fishing grounds, the Icelandic Marine Research Institute temporarily closes the relevant fishing grounds. In cases where Icelandic vessels sell their catch directly to fish markets in Europe, the catches are monitored through sales records transmitted from the importing country to the Directorate of Fisheries (Directorate of Fisheries 2010; Icelandic Fisheries 2010h). Additionally, buyers of the catch (usually the processors) have to register and send the Directorate information on the value and amounts bought and the disposition of the catch. This registration system in effect provides double-checking of the catches.

Monitoring Strategy: Logbooks
Fishery: All commercial vessels
Method: Electronic logbooks are used to report vessel name, registration, call code, and fishing gear size and type in addition to the latitude and longitude at start of fishing, catch by weight and species, and the date and harbor for landings. All recorded data are entered into a computer system that links from each port of landing to a central database maintained by the Directorate and paid for through resource fees. This ensures a steady overview of the status of the allowable catch of every vessel and how much has been taken from the fisheries quota. Processing vessels must electronically submit their logbooks directly to the Directorate of Fisheries. All information on catches, quota share, quota status, and transfer of quota between vessels is immediately available to the public on the Directorate's web site, as mandated by law, thus ensuring transparency. Catch information in the database provides information on individual vessels and summarized data for all Icelandic vessels. Information on individual vessels includes landings, detailed catch reports, transferred quotas, quota status, and how any input of new information can affect a vessel's quota status. The Directorate of Fisheries updates catch data online daily. The database automatically subtracts the catch from a vessel's quotas. These real-time catch figures allow for the Directorate to act quickly if vessels have exceeded their quota. Copies of the data are provided to Statistics Iceland for the production of economic statistics. Iceland has maintained electronic databases of catch data since 1992, and real-time data

online since 1995. The database presently receives daily entries from 60 ports around Iceland (Icelandic Fisheries 2010b, h).

Monitoring Strategy: Catch weighting system
Fishery: All commercial vessels
Method: Port authorities are responsible for the accurate weighing and recording of all catch landed. Weighing must be done by licensed operators who are employed by the local port authorities on scales certified by an independent Governmental Agency; processing plants are also occasionally approved to weigh landed catch (Löggildingarstofa 2010; J. Solmundsson, pers. comm., Sept. 2010). At-sea processing vessels monitor their catch in a similar manner of weighing the landed product. Estimated yield indices are determined several times a day by sampling catch, and processed products on board are used to convert to catch weights. However, this can be problematic as discards are not evaluated when utilization samples are taken (Icelandic Fisheries Laboratories 1997).

Monitoring Strategy: Purchasing and selling
Fishery: All commercial fisheries
Method: Anyone purchasing and/or selling catches is obligated to present reports to the Directorate of Fisheries, containing information on the purchase, sale, and other disposition of fish catches. If a discrepancy between the information stated in the reports and the information received during weighing at the harbor appears in the Directorate of Fisheries' database, measures are taken where appropriate. This measure ensures independent checking of the accuracy of information about catches that are brought ashore (Icelandic Fisheries 2010f).

Funding

Quota holders are required to pay an annual resource fee for the right to participate in the Icelandic fishery, which is considered a public resource. Resource fees are collected by the Directorate of Fisheries three times per fishing year (September 1, January 1, and May 1). The resource recovery fees structure was entered into legislation in 2002, though the first fees were collected in 2004. Resource fees for the following fishing year typically equate to 9.5% of the total value of the landed catch, minus costs (e.g., oil, wages and other operating costs) and are divided by the landed cod equivalents (J. Solmundsson, pers. comm., Sept. 2010; Icelandic Fisheries 2010c).

Program Evaluation

It is unknown if the Icelandic monitoring program is reviewed on a regular basis. The monitoring program does, however, appear to be achieving its established purpose of ensuring compliance with regulations and adherence to TACs. Icelandic cod stocks have been recovering ahead of schedule, which can likely be attributed in part to the strict catch monitoring and prohibition of discards.

8 References

8.1 Guiding Principles

Alaska Department of Fish and Game. 2007. Alaska Salmon Fishery Re-Certified as Sustainable by MSC Decision means Alaska Wild Salmon will continue to carry "ecolabel." Press Release: No. 07-26. http://www.adfg.state.ak.us/news/2007/11-5-07_nr.php

Babcock, E.A., E.K. Pikitch, and C.G. Hudson. 2003. How Much Observer Coverage Is Enough to Adequately Estimate Bycatch? Report by Oceana.

Christina Annand, Director Special Projects (FAM), Department of Fisheries and Oceans Canada. Personal communication, May and August 2010.

Chris Rilling, National Oceanic and Atmospheric Administration. Personal communication, July 2010.

Department of Commerce (DOC). 2004. Fisheries of the Exclusive Economic Zone Off Alaska; Allocating Bering Sea and Aleutian Islands King and Tanner Crab Fishery Resources. Federal Register Notice. Volume 69, Number 209. Page 63199-63248. October 29, 2004. http://www.epa.gov/EPA-IMPACT/2004/October/Day-29/i24103a.htm

Department of Fisheries and Oceans Canada (DFO). 2010a. Atlantic Region Dockside Monitoring Program Policies and Procedures. Accessed July 20, 2010. http://www.dfo-mpo.gc.ca/communic/fish_man/ardmp/ardmp-pvqra_e.htm

Department of Fisheries and Oceans Canada (DFO). 2010b. Pacific Region Integrated Fisheries Management Plan Groundfish. February 21, 2010 to February 20, 2011.

Department of Fisheries and Oceans Canada (DFO). 2009. Evaluation of the commercial groundfish integration pilot program, November 2009. 27 pp. http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/Groundfish/documents/Groundfish_evaluation.pdf

Department of Fisheries and Oceans Canada (DFO). 2006. Review of Dockside Monitoring Program - Reporting on the Implementation of the Management Action Plan. http://www.dfo-mpo.gc.ca/ae-ve/maps-spag/06-07/65149-eng.htm

eLandings. 2010. Elandings website. Accessed July 2010. http://elandings.alaska.gov/

Federal Register. 2009. Fisheries of the Exclusive Economic Zone Off Alaska; North Pacific Halibut and Sablefish Individual Fishing Quota Cost Recovery Programs. Federal Register: 74(237): 65741-7. http://www.fakr.noaa.gov/notice/74fr65741.pdf

Forrest Bowers, BS/AI Area Biologist, Alaska Department of Fish and Game. Personal communication, May 2010.

Garber-Yonts, B. 2009. BSAI crab rationalization. NMFS national catch shares workshop, NOAA Fisheries. http://www.st.nmfs.noaa.gov/st5/workshop/2009/documents/Approved_Presentations/2a_bsaicrab_bgy.pdf

Genesys. 2008. Success Story: Government. Department of Fisheries and Oceans Canada. http://www.genesyslab.com/system/files/2871_SS_NA_Canadian%20DOF_screen.pdf

Heather Gilroy, International Pacific Halibut Commission. Personal communication, May 2010.

Kerns, T., P. Burns, C. Wilson, D. Allen, and B. Glenn. 2010. 2009 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for American Lobster (*Homarus americanus*), 2008 Fishing Year. Atlantic States Marine Fisheries Commission. 15 pp. http://www.asmfc.org/speciesDocuments/lobster/annualreports/fmpreviews/lobsterfmpreview09.pdf

Mark Helvey, National Oceanic and Atmospheric Administration. Personal communication, July 2010.

MRAG Americas, Inc. 2008. Best Practices in US Fishery Management. A report of the Lenfest Best Practices Working Group. http://www.mragamericas.com/wp-content/uploads/2010/04/MRAG-Best-Practices-Report.pdf

National Oceanic and Atmospheric Administration (NOAA). 2010. Fisheries Sampling Branch, Northeast Fisheries Science Center Website, Accessed July 2010. http://www.nefsc.noaa.gov/femad/fsb/

National Oceanic and Atmospheric Administration (NOAA). 2010b. National Observer Program FY 2009 Annual Report. Department of Commerce, NOAA, Natl., Mar. Fish. Serv., Silver Spring, MD, 36 p. http://www.st.nmfs.noaa.gov/st4/nop/Outreach/Fy_2009_NOP_Annual_Report_FINAL.pdf

National Oceanic and Atmospheric Administration (NOAA). 2008. Bering Sea and Aleutian Islands Crab Rationalization Report Fishing Year 2006/07 July 1, 2006–June 30, 2007. NOAA Fisheries Service (NMFS), Alaska Region Restricted Access Management (RAM), February 2008. http://www.fakr.noaa.gov/sustainablefisheries/crab/rat/ram/0607crabrpt.pdf

National Oceanic and Atmospheric Administration (NOAA). 2007. National Observer Program FY 2006 Annual Report. December, 2007. http://www.st.nmfs.noaa.gov/st4/nop/Outreach/FY2006_NOP_Annual_Report_FINAL.pdf

NOAA Fisheries. 2009. Catch Shares Spotlight Number 4: Bering Sea & Aleutian Islands (BSAI) Crab (King & Tanner) Rationalization Program. http://www.nmfs.noaa.gov/sfa/domes_fish/catchshare/docs/crabrat_program.pdf

North Pacific Fishery Management Council (NPFMC) and National Marine Fisheries Service (NMFS) Alaska Region. 2006. Regulatory Impact Review and Final Environmental Assessment for Proposed Amendment 68 to the Gulf of Alaska Fishery Management Plans. Central Gulf of Alaska Rockfish Demonstration Program. August 2006. http://www.alaskafisheries.noaa.gov/analyses/amd68/finalgoaea_rir.pdf

O'Boyle, R., C. Annand and L. Brander. 1994. Individual Quotas in the Scotian Shelf Groundfishery off Nova Scotia, Canada. pp. 152 – 168. In K. Gimbel's [ed] Limited Access to Marine Fisheries: Keeping the Focus on Conservation. Center for Marine Conservation and World Wildlife Fund US, Washington, DC.

Stebbins, S. Archipalego Marine Ltd. Personal Communication, July 2010.

Stebbins, S., R.J. Trumble, and B. Turris. 2009. Monitoring the Gulf of Mexico commercial reef fish fishery, a review and discussion. Archipelago Marine Research, Ltd., Victoria, BC. 99 pp.

Stokes, K., N. Gibbs, and D. Holland. 2006. New Zealand's Cost Recovery Regime for Fisheries Research Services: An Industry Perspective. Bulletin of Marine Science. 78(3): 467-485.

United Nations Food and Agricultural Organization. 2010. Fisheries Glossary. http://www.fao.org/fi /glossary/default.asp

United States Government Accountability Office (GAO). 2005. Individual Fishing Quotas. Management Costs Varied and Were Not Recovered as Required. March 2005. GAO-05-241. http://www.gao.gov/new.items/d05241.pdf

8.2 British Columbia Groundfish Case Study

Clark, Munro, & Associates. 2007. Impacts of Harvesting Rights in Canadian Pacific Fisheries. Final Report Prepared for DFO Ottawa, March 2007.

Department of Fisheries and Oceans Canada (DFO) Pacific Region. 2009. Evaluation of the commercial groundfish integration pilot program, November 2009. 27 pp. Available at: http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/Groundfish/documents/Groundfish_evaluation.pdf

Stebbins, S. 2010. Archipelago Marine Research, Ltd., Victoria, BC., Personal communication, July and August 2010.

Stebbins, S. 2010. Archipelago Marine Research, Ltd., Victoria, BC., Personal communication, November 2010.

Stebbins, S., R.J. Trumble, and B. Turris. 2009. Monitoring the Gulf of Mexico commercial reef fish fishery, a review and discussion. Archipelago Marine Research, Ltd., Victoria, BC. 99 pp.

Trumble, R.J., J. Abbot, D. Brannan, G. Gislason, G. Knapp, and J. Swasey. 2010. Economic analysis of the impacts of catch shares on fisheries employment and income. MRAG Americas report for Environmental Defense Fund. MRAG Americas, St. Petersburg, FL. 123 pp.

Turris, B. R. 2000. A comparison of British Columbia's ITQ fisheries for groundfish trawl and sablefish: similar results from programmes with differing objectives, designs and processes. In FAO Technical Paper 404/1: 254-261.

8.3 Gulf of Mexico Red Snapper Case Study

Florida Fish and Wildlife Conservation Commission (FFWCC). 2010. Reef Fish Gear Rules. http://myfwc.com/RULESANDREGS/Saltwater_Regulations_Gear_index.htm

Gulf of Mexico Fishery Management Council (GMFMC). 2010. Gulf of Mexico Commercial Grouper and Tilefish Individual Fishing Quota (IFQ) Program Frequently Asked Questions, January 2010. 8 pp. http://sero.nmfs.noaa.gov/sf/pdfs/Gulf_Reef_Fish_IFQ_FAQs010310.pdf

Gulf of Mexico Fishery Management Council (GMFMC). 2008. Final Reef Fish Fishery Management Plan Amendment 30B, October 10, 2008. GMFMC, Tampa, FL. http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/Final%20Amendment%2030B%2010_10_08.pdf

Gulf of Mexico Fishery Management Council (GMFMC). 2007. Amendment 27 to the Reef Fish Fishery Management Plan and Amendment 14 to the Shrimp Fishery Management Plan (including supplemental environmental impact statement, regulatory impact review, and regulatory flexibility act analysis). GMFMC, Tampa, Florida.

McKinney, D. Coyote Consulting, Personal Communication, September 2010.

National Oceanic and Atmospheric Administration (NOAA). 2009a. Final Amendment 31 to the Fishery Management Plan for Reef Fish Resources in the Gulf of Mexico. Gulf of

Mexico Fishery Management Council. Department of Commerce. Silver Spring, MD. http://www.gulfcouncil.org/fishery_management_plans/reef_fish_regulatory.php

National Oceanic and Atmospheric Administration (NOAA). 2009b. Status of US Fisheries. Department of Commerce. Silver Spring, MD. http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

Pria M.J., H. McElderry, M. Dyas, P. Wesley, 2008. Using Electronic Monitoring to Estimate Reef Fish Catch on Bottom Longline Vessels in the Gulf of Mexico: A Pilot Study.

Shipp, Robert L. and S. A. Bortone. 2009. A Perspective of the Importance of Artificial Habitat on the Management of Red Snapper in the Gulf of Mexico. Reviews in Fisheries Science 17(1): 41– 47.

Southeast Regional Office (SERO). 2010. IFQ Terms you should know. http://sero.nmfs.noaa.gov/sf/pdfs/Common_IFQ_Terms.pdf

Southeast Regional Office (SERO). 2009. 2008 Gulf of Mexico Red Snapper Individual Fishing Quota Annual Report. SERO, National Marine Fisheries Service, St. Petersburg, FL. http://sero.nmfs.noaa.gov/sf/pdfs/2008RedSnapperIFQAnnualReport1.pdf

Stebbins, S., R.J. Trumble, and B. Turris. 2009. Monitoring the Gulf of Mexico commercial reef fish fishery, a review and discussion. Archipelago Marine Research, Ltd., Victoria, BC. 99 pp.

Strelcheck, A. National Marine Fisheries Service, Personal Communication, September 2010.

8.4 Bering Sea Aleutian Island Crab Case Study

Barnard, D. and D. Pengilly. 2006. Estimates of Red King Crab Bycatch during the 2005/2006 Bristol Bay Red King Crab Fishery with Comparisons to the 1999-2004 Seasons. Fishery Data Series No. 06-23. Alaska Department of Fish and Game. May 2006.

Bowers, F. Alaska Department of Fish and Game, Personal Communication, July and August 2010.

Bowers, F. R., M. Schwenzfeier, K. Herring, M. Salmon, K. Milani, J. Shaishnikoff, H. Barnhart, R. Burt, B. Baechler, and A. Buettner. 2010. Annual management report for the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea and the Westward Region's Shellfish Observer CRP, 2008/09. Alaska Department of Fish and Game, Fishery Management Report No. 10-24, Anchorage.

Carroll, A. Yr unknown. Alaska's Crab Fishery: Big Money Days are Gone. http://www.wildlifenews.alaska.gov/index.cfm?adfg=wildlife_news.view_article&articles_id=181

Danner, S. 2009. Monterey Bay Aquarium Seafood Watch Report. Snow and Tanner Crabs (*Chionoecetes opilio, C. bairdi, C. tanneri, C. angulatus*) – Alaska and Canada. Last Updated July 29, 2009. http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_SnowCrabReport.pdf

Department of Commerce (DOC) and State of Alaska (2005). Community Development Quota (CDQ) CRP. Juneau, Alaska, July 2005.

Federal Register. 2005. Magnuson-Stevens Act Provisions; Fishing Capacity Reduction Program; Bering Sea/Aleutian Islands King and Tanner Crabs; Industry Fee System for Fishing Capacity Reduction Loan. Federal Register 70(179): 54652-6. http://www.nmfs.noaa.gov/mb/financial_services/buyback_docs/fee_system_final_rule.pdf

Fina, M. 2005. Rationalization of the Bering Sea and Aleutian Islands crab fisheries. Marine Policy 29: 311-322.

NOAA Fisheries. 2010a. Alaska Regional Office website. Crab Rationalization CRP. Accessed August 2010. http://www.fakr.noaa.gov/sustainablefisheries/crab/crfaq.htm

NOAA Fisheries. 2010b. 2010 Status of U.S. Fisheries. Accessed August 2010. http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

NOAA Fisheries. 2010c. Alaska Regional Office website. BS/AI Crab Rationalization - Economic Data Reports. Accessed August 2010. http://www.fakr.noaa.gov/sustainablefisheries/crab/rat/edr/default.htm

NOAA Fisheries. 2009a. Catch Shares Spotlight Number 4: Bering Sea & Aleutian Islands (BS/AI) Crab (King & Tanner) Rationalization CRP. http://www.nmfs.noaa.gov/sfa/domes_fish/catchshare/docs/crabrat_CRP.pdf

NOAA Fisheries. 2009b. Bering Sea and Aleutian Islands Crab Rationalization Report Fishing Year 2008/09. July 1, 2008–June 30, 2009. NOAA Fisheries Service (NMFS), Alaska Region Restricted Access Management (RAM). November 2009. http://www.fakr.noaa.gov/sustainablefisheries/crab/rat/ram/0809crabrpt.pdf

NOAA Fisheries. 2008. Bering Sea and Aleutian Islands Crab Rationalization Report Fishing Year 2006/07. July 1, 2006–June 30, 2007. NOAA Fisheries Service (NMFS), Alaska Region Restricted Access Management (RAM). February 2008.

North Pacific Fishery Management Council (NPFMC). 2008. Three-Year Review of the Crab Rationalization Management CRP for Bering Sea and Aleutian Islands Crab Fisheries. September 12, 2008. http://www.wafro.com/imageuploads/file176.pdf; or http://www.fakr.noaa.gov/npfmc/current_issues/crab/BS/AIcrab3year908.pdf

8.5 Icelandic Groundfish Case Study

Arnason, R. 2005. Property rights in Iceland: Iceland's experience with ITQs. Reviews in Fish Biology and Fisheries 15: 243–264.

Christensen, A-S, T.J. Hegland and G. Oddson. 2009. The Icelandic ITQ System. In Hauge, K. J. and D.C. Wilson (eds.). Comparative Evaluations of Innovative Fisheries Management, Global Experiences and European Prospects: 97-118.

Directorate of Fisheries. 2010. Icelandic Fisheries Management. http://en.fiskistofa.is/cntPage.php?pID=4

FAO. 2004. Information on Fisheries Management in the Republic of Iceland. http://www.fao.org/fi/oldsite/FCP/en/ISL/body.htm

Hunt, S., D. Pee, and T. Parsons. 2002. ITQ Case Studies. http://www.biology.duke.edu/bio217/2002/fish/management2.html

Icelandic Fisheries. 2010a. Icelandic Fisheries: Fishing Vessels. Information Centre of the Icelandic Ministry of Fisheries and Agriculture. http://www.fisheries.is/fisheries/fishing-vessels/

Icelandic Fisheries. 2010b. Icelandic Fisheries: Management. Information Centre of the Icelandic Ministry of Fisheries and Agriculture. http://www.fisheries.is/management/

Icelandic Fisheries. 2010c. Icelandic Fisheries: Individual Transferable Quotas. Information Centre of the Icelandic Ministry of Fisheries and Agriculture. http://www.fisheries.is/management/fisheries-management/individualtransferable-quotas/

Icelandic Fisheries. 2010d. Icelandic Fisheries: Cod Equivalents. Information Centre of the Icelandic Ministry of Fisheries and Agriculture. http://www.fisheries.is/management/total-allowable-catch/cod-equivalents/

Icelandic Fisheries. 2010e. Icelandic Fisheries: The Fishery Management Act. Information Centre of the Icelandic Ministry of Fisheries and Agriculture. http://www.fisheries.is/management/fisheries-management/the-fisheriesmanagement-act/

Icelandic Fisheries. 2010f. Icelandic Fisheries: Statement on Responsible Fisheries in Iceland. http://www.fisheries.is/management/government-policy/responsible-fisheries/

Icelandic Fisheries. 2010g. Icelandic Fisheries: Research. http://www.fisheries.is/management/research/

Icelandic Fisheries. 2010h. Icelandic Fisheries: Collection of data. http://www.fisheries.is/management/total-allowable-catch/collection-of-data/

Icelandic Fisheries Laboratories. 1997. Utilisation surveillance aboard processing vessels. Icelandic Fisheries Laboratories Summary Report. September 1997. http://www.matis.is/media/utgafa//Skyrsla_17-97.pdf

Löggildingarstofa. 2010. Company website Accessed September 2010. http://www.randburg.com/is/loggildingarstofa/

Meridian Institute and MRAG Americas, Inc. 2010. Catch Shares in New England: Key Questions and Lessons Learned from Existing Programs. February 2010. http://www.mragamericas.com/wp-content/uploads/2010/04/Catch-Shares-in-New-England-FINAL-02-10.pdf

Ministry of Fisheries and Agriculture. 2008. Icelandic Fisheries in Figures 2008. http://eng.sjavarutvegsraduneyti.is/media/sjavarutvegur_i_tolum/Sjavarutvegur_i_tolum_2008_allur.pdf

Runolfsson, B. and R. Arnason. 2001. Initial Allocation of ITQs in the Icelandic Fisheries. In Shotton, R. (ed.). Case studies on the allocation of transferable quota rights in fisheries. FAO Fisheries Technical Paper. No. 411. Rome, FAO. 2001. pp. 24-31.

Solmundsson, J. Marine Research Institute, Iceland, Personal Communication, September 2010.