Data to Support Adaptive Management

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I PURPOSE

In October 2015, NOAA Fisheries charged the Marine Fisheries Advisory Committee (MAFAC) to provide advice on how NOAA can best meet coastal and fishing community needs with respect to resources, habitat, and socio-economic resiliency during climate changes. Six tasks were identified by MAFAC members and they engaged their Climate and Marine Resources Task Force members in this work.

Subgroup Task 6 was charged with identifying effective tools and mechanisms used under the Magnuson-Stevens Act (MSA), as well as additional models and examples (including international), that can provide for dynamic, adaptive fishery management actions. T**he purpose was to identify tools and strategies that were effective or could be strengthened to allow fisheries management to be more nimble, flexible, anticipatory, and adaptive to mitigate changes in ecosystems and fisheries.**

To initiate the effort, the task members first identified the challenges that hinder managers and fishermen from responding in a timely manner to changes in a fish stock, and then prioritized the problems, and then identified examples or approaches that allow managers to respond to a change more quickly. Three major themes emerged:

1) Using framework or inseason management actions;
2) Improving the data that is needed to make sound decisions (including more real-time data); and
3) Improving communications with fishermen and fishing communities.

The Task 6 subgroup decided to focus on the first two topics, since the third was being addressed by a separate subgroup. The first report from Task 6 focused on examples of good framework and inseason management actions.

The purpose of this paper is to highlight the fisheries and ecosystems data needs that are needed to help fishermen and managers develop flexible and agile strategies, actions, or tools (such as framework or inseason actions) for current and future fisheries management. Identifying the data needed and methods for efficient data collection, management, and dissemination will provide fishery managers with a solid foundation on which to base informed management decisions. Implementation of well-designed data collection processes will enhance the ability of managers to implement agile decisions, including framework-based management options, such as in-season adjustments to quotas, retention limits, fishing start and end dates, closed areas, etc.

The overarching goal is to support dynamic and adaptive management actions in the face of ever-changing environmental conditions.

II BACKGROUND ON THE IMPORTANCE OF DATA

U.S. fisheries are some of the best managed in the world. Under NOAA's National Marine Fisheries Service (NMFS) management and the Magnuson Stevens Fishery Conservation and Management Act (MSA), the U.S. has rebuilt 40 stocks since 2000. U.S. commercial and recreational fisheries are diverse, supporting 1.83 million jobs and approximately $214 billion in economic activity annually (NOAA 2016). The United States is blessed with an abundant and productive ocean environment. Yet, for fisheries managers, changing climate and ocean conditions present a perplexing problem because of the different ways these changes are affecting fisheries, habitat, and protected resources. MAFAC addressed this issue briefly in its 2016 assessment, *Abundant Seas: Making the Most of America's Marine Resources*. More baseline data are needed to help monitor and prepare stakeholders and communities for climate change impacts to fisheries.

Data on fish stocks and fisheries, both the "fishery independent" data collected by scientists and "fishery dependent" data collected from fishing activities, are essential ingredients to the periodic stock assessments that are the foundation of healthy, sustainable fisheries. However, these data and assessments are often too infrequent, incomplete, or inadequate to properly guide timely and appropriate management decisions for commercial and recreational fisheries. Moreover, as environmental conditions in the ocean and along U.S. coasts change, the types of information and analyses needed to understand the changes and impacts on fisheries, as well as the associated management protocols, will need to evolve. Fisheries in some regions of the country have moved to dynamic in-season fishery management frameworks driven by real-time data, an approach that has been demonstrated to address these challenges and more. Other regions lack the resources, capacity, or willingness to make this necessary shift. Coupled with archaic, complex, and sometimes intractable regulations, too frequently this situation has resulted in outdated or unnecessary constraints on fishing activity, leading to underutilization of healthy, sustainably managed fish stocks.

In its 2012 report, *Vision 2020 (v2.0): Charting a Course for the Future of U.S. Marine Fisheries* (2012) MAFAC identified several trends that also emphasize the need for well-organized data collection. These included:

1. **Demands will increase for additional data and science necessary to support ecosystem-based management**. Ecosystem-based approaches to management, which takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives, is based on high-quality and reliable scientific data.

2. **Climate change is leading to changing ocean conditions and negative impacts on riverine, marine, and estuarine environments**. For fisheries managers around the globe, climate change presents an especially challenging problem because of rising sea levels, ocean acidification, ocean warming, and subsequent effects on coastal estuaries. Fish populations are shifting with temporal zone and, in some cases, moving toward the

poles (Nye et al 2009, Parry et al 2007, and Pinsky et al 2013). These shifts are already reflected in changing fish catches and the shifts are expected to significantly increase with projected changes in ocean ecosystems (Cheung et al 2010). NOAA Fisheries recognized the importance of the production, delivery and use of the climate-related information and data needed to fulfill NOAA Fisheries mandates with changing climate and ocean conditions and developed the *Climate Science Strategy* (2015) to address these needs.

3. **NOAA's *Ecosystem-Based Fishery Management (EBFM) Policy and Road Map* also describes the importance of data** for resiliency approaches for ecosystems management. It highlights the importance and requirement for a holistic, science-based approach that looks at the entire ecosystem.

What kinds of data and information are needed for timely decision-making? Within the context of the basic types of data and information are the *historical data, real-time data, and forecasts.* Examples of data are (not inclusive):

1) Commercial, recreational, and subsistence fisheries
    a. Stock assessments per species
    b. Catch landings and discards
    c. By-catch / incidental catch
    d. Run-timing and escapement
    e. Sector and species data
    f. Economic data reports (EDRs)
    g. In-season and post season catch surveys
    h. Charter boat in-season catch surveys
2) Fisheries science data
    a. Stock assessments
    b. Life history data such as spawning data and juvenile survival and growth
    c. Discard mortality
3) Environmental Data
    a. Trophic interactions
    b. Marine conditions
    c. Estuarine conditions, including coastal habitats
    d. Riverine conditions, including spawning and riparian conditions
    e. General ecosystems: habitat and climate change data that affect all of these
4) Fishing community social and economic data
5) Data on prohibited or protected species

III WHAT ARE THE CHALLENGES?

There are a number of challenges associated with meeting the data requirements associated with implementing framework actions. This will require investments in innovative electronic technologies to enable agile management decisions including those that can be made under frameworks and other in-season actions. Key challenges are:

Many current data collection methods are complex, outdated, and difficult to integrate. One reason for this is that data collection methods were developed for a specific fishery or fishery sector, but are often “layered” onto other fisheries or to accommodate additional reporting regulations has resulted in systems that may be redundant, poorly integrated, and often lead to inconsistencies in the data. NOAA needs to streamline and standardize the data workflow at all points: during collection, submission, review by managers, analysis by scientists, and archival retention.

Currently, electronic technologies are available from a limited number of vendors, and some elements of their systems are proprietary. The development of next-generation electronic monitoring and reporting systems could be exclusively based on open standards and that allow better integration into current data platforms, and potentially be inexpensively adapted to new platforms, such as those being developed by the Fisheries Information System (FIS) Program. In addition, next-generation systems should better integrate fishery monitoring and reporting (by fishermen) with other reporting performed by first receivers, such as enabling real-time offloading reporting.

Data needs are increasing, but budgets are not. Scientists and managers confront the challenge of doing more with less. The costs of data collection and analysis are significant. Over time, the costs for human observers/monitors have increased. Additionally, fishery managers are shifting the financial burden of data collection to the managed fishery. Electronic technology for fishery monitoring has costs for implementation, maintenance, transmission/submission, and back-end infrastructure, but over the long-term, projections indicate a cost-savings as compared to human at-sea monitors. Electronic technologies can reduce the costs to monitor a managed fishery for fishery participants, and can provide increased efficiency and savings within NOAA. In addition to collecting fisheries catch data, electronic technologies can collect other important information, such as temperature, salinity, ocean water characteristics, etc., that can enhance the ecosystem information available to fishery managers.

Fishery participants are not fully engaged in meeting data needs. As was the case during the implementation of early observer programs, fishery participants vary in their support for electronic technology monitoring. “Buy in” from fishery to fishery varies as different electronic monitoring/reporting programs are being introduced. If these technologies are developed to provide direct benefits (specific fishing information, such as species, location, temperature, etc.), fishery participants may better embrace electronic technology. Providing useful data to fishery participants may increase productivity of fishermen and could potentially reduce bycatch and/or interactions with protected or prohibited species.

Fishery participants have legitimate concerns about data confidentiality and proprietary information. NOAA must establish a rigorous chain of custody system with non-disclosure requirements that include substantial penalties for infractions. Storage of data outside of NOAA may better protect confidentiality, but solutions to ensuring confidentiality of data in the custody of the government should also be developed. Other parts of the Federal agencies government have addressed similar data confidentiality/proprietary information challenges in acceptable ways that meet legal requirement. NOAA Fisheries may benefit by researching comparable data collection in other agencies to determine if confidentiality protocols used apply similar constraints on the disposition and origin of that data.

Incorporating Citizen's Science, Community Based Monitoring (CBM), and local and traditional knowledge (LTK) into fishery science and management can be difficult. CBM and LTK are playing an increasingly more prominent role in gathering marine, estuarine and riverine data, as well as related community ecological and economic data, that can help with in-season management as well as long-term understanding of ecosystems and resiliency to climate change. However, both CBM and LTK are also notoriously under-utilized with data not being accepted into mainstream models. The challenge for CBM is to create uniform protocols that NOAA/NMFS and other agencies can accept, test, and verify. The incorporation of LTK is even more problematic but essential in providing historical context as well as real-time application of knowledge. The creation of regional data collection plan teams that include appropriate stakeholder groups can facilitate the development of appropriate tools and protocols that allow the incorporation of these types of data and value its usefulness.

IV WHAT DATA SYSTEMS ARE MEETING THE NEEDS OF FRAMEWORK ACTIONS?

There are many successful industry, and NGO data collection and management systems around the country, in addition to the example government programs identified below, and these should be recognized and assessed on a regular basis.

NOAA's Fisheries Information System

The Fisheries Information System (FIS), managed under the NOAA Fisheries' Office of Science and Technology, is one effort striving to improve fisheries-dependent data collection systems. The FIS mission is to provide opportunities for NOAA Fisheries scientists to work collaboratively through partnerships to improve access to comprehensive, high quality, timely fisheries information. The program invests in three broad areas: (1) data gaps and data quality; (2) efficient technology and data integration; and (3) effective coordination and communication in the design, collection, and uses of data.

A case study of a FIS project is the Integrated Atlantic Highly Migratory Species (AHMS) Information System. Various sectors of the AHMS fishery report their information in a variety of ways. Some sectors report information via a post-trip website, some report discard information by an automated telephone system, and some sectors have VMS and video electronic monitoring systems. Sectors also have different observer as well as logbook reporting requirements. In addition, first receivers have differing requirements based on gear type and species, including special requirements pursuant to international convention.

This integrated system, developed in collaboration with the Atlantic HMS Management Division and the Southeast Fisheries Science Center, enables validation of these multiple data streams, eliminating duplication and storing the resulting data in the SEFSC data warehouse. Ultimately, the system will provide users with dependable access to more comprehensive, accurate, and timely data for management decisions, as well as varying levels of data access to users, including the general public. FIS is developing similar solutions that are applicable to other NOAA fisheries programs.

Norwegian Reference Fleet

Norway's Institute of Marine Research (IMR) developed an innovative and cost effective approach to improve the data used in stock assessments. Since 2000, IMR has collected data directly from vessels involved in offshore fisheries through a "Reference Fleet" program. The Reference Fleet consists of a small group of active vessels in the fishery that receive compensation to provide the IMR with detailed information about their fishing activity, vessel details, and catches on a regular basis. The vessels in the Reference Fleet are representative of the Norwegian fishing fleet and deliver detailed information to IMR at regular intervals.

The High Seas Reference Fleet was established in 2000, consisting of 19 vessels. Its main objective was to collect sufficient biological samples by area, season, and gear to estimate catch (landings and discards) at size and age to support stock assessments. For political reasons, Norway decided not to use onboard observers. To address confidentiality concerns and enhance "buy-in," the Fisheries Minister of Norway agreed that data would not be used for inspection and enforcement purposes.

In 2005, a similar Coastal Reference Fleet of 20 vessels was established along Norway's entire coast. The participants were trained in all procedures of standardized data and sample collection. They utilized various electronic technologies during the study, including electronic logbooks, electronic fish measuring boards, computers with satellite links, and vessel monitoring systems.

In the beginning of the program, compensation was provided by granting participants a portion of fish quota set-aside. In 2013, the compensation was changed from quotas to direct monetary compensation. This change affected participation to some extent.

In addition to the data collected by the study, IMR scientists have improved their dialogue with the industry, which in itself has been highly useful for them. Weekly telephone contact, as well as annual fleet-wide meetings, helped to maintain the connection and improved the trust between managers and industry.

An evaluation of the Reference Fleet was carried out by in 2011. The review valued the Reference Fleet and endorsed it be continued with defined objectives, since some had changed since its start; that the effective sampling size and types of vessels be routinely evaluated to address data needs; and that new tenders should address issues of fleet size and composition such that not all of the vessels are changed at one time to promote consistency in the time series aspects of the Reference Fleet data.

New England Fishery Science Center (NEFSC) Study Fleet

The Study Fleet are a subset of fishing vessels from which high quality, self-reported data on fishing effort, area fished, gear characteristics, catch, and biological observations are collected. Participating vessels fish in commercial mode and are selected to be representative of the larger fleet over time. Data collected from these vessels can be used to supplement the stock assessment process. This program began in 1999.

The NEFSC Study Fleet was initiated with the dual objectives of:

1. Assembling a "study fleet" of commercial New England vessels capable of providing high resolution (temporal and spatial) self-reported data on catch, effort and environmental conditions while conducting "normal" fishing operations; and
2. Developing and implementing electronic reporting hardware and software for the collection, recording, and transferring of more accurate and timely fishery-based data.

This Study Fleet is a Cooperative Research program that provides several benefits to its commercial participants including:

- Direct participation in the scientific data collection process
- Input into the development of electronic reporting technology
- Sharing ideas and observations with fisheries scientists
- Gaining insight into how environmental factors influence catch rates
- Financial compensation for time and effort involved

Depending on its needs, the Study Fleet contracts between 20-35 vessels that participate in most of the major Northeast, located from Maine to New Jersey with concentrations heaviest around Gloucester and Point Judith.

Recently, Study Fleet has focused on the trawl fishery, and in addition to trip reporting requirements, participating vessels have collected fish samples for age and growth scientists, and provided opportunities for field scientists to get out to sea to perform biological sampling. Future goals include accruing a larger range of data for commercially important species such as yellowtail flounder, winter flounder, and dogfish.

V CONCLUSIONS AND RECOMMENDATIONS

A primary goal of improving monitoring, data integration, and data management capabilities should be the speed and timeliness of the integration and incorporation of data from the harvesters and docks to the managers. The data need to provide management regimes the ability to respond and adapt to real-time changes in fish stocks and landings and achieve efficiencies in agency operations.

Using framework actions supported by better data should reduce regulatory delays and allow obsolete, inefficient regulations to be replaced with nimble and dynamic ones. This would allow fishing communities to take better advantage of opportunities to capitalize fisheries, increase landings, and expand markets for underutilized and under-fished species without triggering overfishing. Increases in understanding of ocean ecosystems, improvements in technology for ocean observations, and interest and engagement by stakeholders, scientists, and others in ecosystem-based fisheries management may also present managers with important opportunities and the wherewithal to anticipate, predict, and respond to dynamic, as well as longer-term, changes in ocean ecosystems.

To achieve this, we recommend that the Agency places a priority on implementing the recommendations in MAFAC's recent document, *Abundant Seas: Making the Most of America's Marine Resources* (2016), as well as *Improving Net Gains: Data-Driven Innovation for America's Fishing Future* (2017), which was developed by the Fishing Data Innovation Taskforce. We also recommend that NOAA continue to be mindful of the relevant recommendations in *MAFAC's Vision 2020 (v2.0): Charting a Course for the Future of U.S. Marine Fisheries* (2012). Although progress has been made on some of these recommendations, many remain unfulfilled.

These recommendations continue to be extremely relevant to enable framework and other in-season, agile management options. The agency should continue to foster the development – both inside NOAA as well as with outside entities – of next-generation technologies that improve on existing systems and enable better integration of data collection, analyses, dissemination, and storage processes. Technology and data capabilities are emerging that can enhance framework decision processes, including genomics and data sharing capabilities.

It will be important for regional fishery managers to determine the information they need to enable flexible and dynamic management actions for their regions. Real-time data needs vary by fishery, and the managers are best suited to identify their fishery-specific needs.

In support of our recommendation, these are some principles of good data collection programs:

- Tools that can provide increased efficiency and reduce redundancy are critical. NOAA Fisheries should continue to test, validate, and expand the use of electronic monitoring tools in line with its policy, through efforts such as Cooperative Research programs. Increases in efficiency are also needed with respect to the application of data to specific management needs.

- Consistent and shared protocols for data collection and management that allow for modernized data systems that communicate with each other and enable integration of comprehensive ecosystem and fishery data collection systems.

- Increasing the use of community based monitoring (CBM), citizen science, and crowd sourcing, can improve efficiencies especially during periods of reduced resources, but also increases stakeholder and fishermen awareness, builds trust, and fosters improved relations between them, scientists, and managers.

- Protecting proprietary information is important to fishing operations. Data confidentiality requirements need to be consistently applied, but where appropriate data access needs to be provided.

- Identifying and integrating data depositories *not held by NOAA or NOAA Fisheries*, but that complement NOAA data, should be prioritized to reduce redundancy of efforts. This includes better integration of local and traditional knowledge (LTK) and traditional ecological knowledge (TEK). Citizen science, LTK, and TEK can help to build a stronger picture of what is going on in the ecosystem.

- Transparency in data collection and management is foundational for trust. Extrapolation and statistical process are necessary for scientific conclusion, however it is also necessary to know what methodologies were employed. Additionally it is vital to know how data is weighted. Even in stock assessments that are thought to have robust data when there are critical gaps filled by statistical assumptions about behavior, habitat, or other factors it can lead to weak conclusions that contradict what fishermen observe, and which may prove to be inaccurate. A transparent environment that utilizes critique as a tool for refinement of process will yield a more accurate result. Further, transparency can engender a trust building schematic between research personnel and those whose livelihoods are made on the ocean.

Both at the Agency-wide level, as well as through regional and cross-regional collaborations, implementation of these recommendations will improve management of our dynamic fisheries and ecosystems.

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