



Building Capacity for Risk-based Management and Management Strategy Evaluation in U.S. Federal Fisheries

Discussion from the East Coast Forum,
May 7–8, 2015, Beaufort, NC

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SUMMARY

The 2015 East Coast Forum convened by the Fisheries Leadership & Sustainability Forum (Fisheries Forum) explored opportunities for federal fishery managers to support effective treatment of uncertainty and risk through risk-based management approaches and management strategy evaluation. The success of federal fishery management plans requires managers to communicate effectively about uncertainty and risk and to make decisions that perform well under conditions of uncertainty and environmental change. By understanding and accounting for limitations on the information that supports decision making, fishery managers can make decisions that are likely to meet management objectives and that reflect an explicit risk tolerance.

The Fisheries Forum convenes a series of forums for council members, council staff, and NOAA Fisheries staff. Each forum focuses on a topic with regional and national relevance. The forums are a unique opportunity for managers to explore emerging issues and questions and to share ideas and information across management regions.

Introduction

The effective treatment of uncertainty and consideration of risk in federal fisheries management is an ongoing learning process. Since implementation of the reauthorized Magnuson-Stevens Act (MSA) in 2007, regional fishery management councils have operationalized annual catch limit (ACL) requirements, developed acceptable biological catch (ABC) control rules and risk policies, and accounted for scientific and management uncertainty in their decision making. The 2015 East Coast Forum convened council members, staff, and invited experts to reflect on the progress that federal fishery managers have made toward the effective treatment of uncertainty and risk and to consider opportunities for further advancement.

The Forum's exploration of uncertainty and risk was particularly timely. In January 2015, National Oceanic and Atmospheric Administration (NOAA) Fisheries released proposed revisions to the National Standard 1, 3, and 7 guidelines. These proposed revisions reflect the experience gained and the challenges identified through ACL implementation. In February 2015, the fifth National Scientific and Statistical Committee (SSC) Workshop focused on providing ABC recommendations in the face of uncertainty, including uncertainty related to data, environmental change, and ecosystem interactions. The National Aquarium recently released *Addressing Uncertainty in Fisheries Science and Management*, a report containing recommendations developed by a working group of experts in fisheries science and management. Uncertainty and risk are also prominent in regional discussions related to ecosystem-based management, climate change, the performance of rebuilding plans, and many other topics.

Federal fishery managers have made tremendous progress toward achieving the mandates of the reauthorized MSA. Maintaining this progress and supporting the long-term success of federal fishery management plans requires managers to make decisions that perform well under conditions of uncertainty and environmental change. By understanding and accounting for limitations on the information that supports decision making, fishery managers can make decisions that are robust given uncertainty, that are likely to meet management objectives, and that reflect an explicit risk tolerance.

Forum Approach and Objectives

The purpose of the 2015 East Coast Forum was to build capacity among council members, council staff, and science advisers to support the effective treatment and communication of uncertainty. Participants explored the concept and implementation of risk-based management approaches, focusing on management strategy evaluation (MSE).

Forum objectives:

- Build awareness of regional and national efforts to advance the treatment of uncertainty in the federal fisheries management process.
- Discuss opportunities for improving communication across the science-policy interface about the sources and treatment of uncertainty.
- Examine risk-based management approaches for evaluating the sources and implications of uncertainty and for explicitly incorporating risk (the probability and severity of consequences) into decision making.
- Explore the concept and application of management strategy evaluation (MSE) for simulating and evaluating the performance of management strategies under conditions of uncertainty, and consider the roles, responsibilities, and logistics of utilizing MSE within the council process.
- Reflect on the benefits and limitations of characterizing uncertainty, and discuss how strategic approaches to addressing uncertainty can promote robust and effective long-term management outcomes.

On the first day of the Forum, participants explored risk-based management; on the second day, they were introduced to management strategy evaluation. The following summary covers each of these two related but distinct topics in turn. The appendix provides a summary of Forum presentations.

Building Capacity for Risk-based Management

Introduction

The first day of the Forum explored the approaches that can be used to consider the sources and implications of uncertainty and to frame decisions in the context of risk. Risk-based management involves explicitly considering a range of potential consequences, acceptable and unacceptable; exploring the implications of uncertainty; and determining and communicating risk tolerance.

There are many different ways to integrate risk consideration into the management process. Risk-based management could be approached as a

- Comprehensive **framework** for considering risk,
- **Process** for articulating and communicating risk,
- **Policy** (i.e., a council's risk policy),
- Set of **principles** or a strategic **goal**,
- Combination of the above.

These approaches to risk-based management are not exclusive. Risk-based management can involve leveraging multiple tools to integrate risk considerations at both the regional and national levels. Forum discussions explored the roles and responsibilities of the councils, NOAA Fisheries, and science advisors as well as the ways that risk considerations are supported and integrated through the following pathways.

ABC Control Rules and Risk Policies

At the council level, risk is often discussed in the context of ABC control rules and risk policies. ABC control rules specify the relationship between the overfishing limit (OFL) and ABC, and they account for scientific uncertainty. ABC control rules also communicate a council's tolerance for the risk of overfishing. ABC control rules can serve as a council's risk policy, or they can be accompanied by a separate risk policy. Forum participants explored the development of the New England Fishery Management Council's risk policy and considered council risk policies as one pathway for supporting a nuanced and explicit consideration of risk within the context of ACLs.

National Standard 1 Guidelines

At the national level, NOAA Fisheries is supporting effective consideration of uncertainty and risk by refining and revisiting important policy guidance. The 2006 reauthorization of the MSA made a strong statement about the national tolerance for risk with regard to overfishing. The National Standard (NS) 1 Guidelines outline the framework for achieving accountability and accounting for uncertainty, monitoring performance, and responding to new information. In early 2015, NOAA Fisheries issued proposed revisions to the NS1, NS3, and NS7 guidelines. These revisions respond to stakeholder and management partner concerns identified during the implementation of annual catch limits and accountability measures, and they enable fishery managers to increase the flexibility of their approach to meeting the mandates of the MSA. Several of the proposed revisions address the implications of uncertainty and risk, including those associated with information inputs such as updated stock assessments.

Scientific Inputs

Strategic investment in scientific inputs is another element of risk-based management. There is high demand for information to support short-term conservation and utilization decisions. This demand must be balanced with the need for longer-term investments in science to support future management

responses, particularly with regard to ecosystem and climate change. NOAA Fisheries' stock assessment prioritization process is one example of considering and prioritizing information needs relative to capacity and risk factors.

Defining Risk-based Management

In simple terms, risk-based management involves considering the possible consequences of a decision. Risk is a function of the **probability** and the **severity** of consequences. Risk-based management begins with risk assessment: what are the potential consequences of a decision, given what is known and not known? Risk management is the handoff from science to policy. Managers must decide how to respond, given their management goals and risk tolerance.

Forum participants defined risk-based management as three-step process: (1) investigating the full range of consequences and outcomes from a decision, (2) identifying a preferred outcome and pathway for achieving it, and (3) establishing a clear and transparent rationale for decisions. According to this process, risk-based management is not fundamentally different from the existing decision-making process. The difference lies in a deeper and more thorough exploration of consequences and in a more explicit process for considering those consequences and making tradeoffs.

Risk is typically framed in terms of avoiding overfishing, given the national framework for managing under ACLs. Social, economic, and ecological dimensions of risk are typically secondary. Risk-based management within the council context involves broadening the consideration of risk to consider all of these dimensions. Forum participants identified several additional factors that can inform how managers weigh the importance of potential consequences:

- **Scale:** All decisions involve biological, ecological, social, economic, and economic consequences, but the magnitude and direction (positive or negative) of these consequences vary across socio-ecological scales.
- **Distribution:** Consequences may be distributed unevenly, for example, among different areas in a management region or among different sectors of a fishery.
- **Time horizon:** Biological, ecological, social, and economic consequences may occur over different time horizons. Managers' ability to correct course and timeline for doing so varies as well.

Operationalizing Risk-based Management

Forum participants considered what risk-based management should look like in practice. Is it best articulated as a formal policy, a set of formulas, a thought process, or a set of shared principles? Risk-based management approaches can be operationalized in multiple ways and at different scales. Some participants stated that risk can be most effectively considered at the FMP level. Risk can be addressed through ABC control rules and explored in the context of specific discussions and decision points (e.g., by developing accountability measures).

Participants considered whether formalizing a risk-based management approach through a comprehensive, overarching council risk policy is an endpoint to which all councils should aspire. Many councils share management of transboundary stocks, which increases the complexity of risk-based management discussions. Participants questioned whether it's feasible to develop an overarching policy that considers risks to different user groups (e.g., commercial industry and subsistence users), when those user groups perceive consequences very differently. Another challenge involves considering interactions across fishery management plans (FMPs) and how a risk policy should integrate cross-FMP priorities and initiatives, such as ecosystem-based management priorities.

National Environmental Policy Act (NEPA) analyses can help frame risk discussions by assisting managers to consider different dimensions of risk and the likelihood and severity of consequences. A

particularly rigorous analysis may share similarities with management strategy evaluation. However, some participants stated that NEPA is an approach to considering consequences, rather than a framework for the explicit tradeoff decisions that result from risk-based management. Some observed that including a more explicit consideration of unknowns and uncertainties within the context of NEPA analysis may be disadvantageous when developing the rationale for a decision.

Participants concluded that there is no single way to operationalize risk-based management. Risk-based management approaches will continue to evolve and to provide an opportunity for councils to learn from their own experience and the experience of other councils.

Conceptual Challenges

Risk-based management involves leveraging uncertainty as information. Forum participants identified several ways in which this approach to uncertainty can challenge the thinking of managers and stakeholders.

Reframing Uncertainty: From Weakness to Strength

Risk-based management begins with reframing the concept of uncertainty—that is, viewing it not as a weakness but rather as information that can support effective management decisions. Uncertainty describes the bounds of confidence in scientific information and how it can be used to inform management decisions. By considering the sources and potential implications of uncertainty, managers can evaluate the full range of potential consequences associated with a decision. Managers can use this information to make decisions that are likely to achieve management objectives.

Responding to Uncertainty: From Tactical to Strategic

Risk-based management can be a process for thinking about uncertainty across a range of time horizons. The federal framework for achieving sustainability, ensuring accountability, and responding to new information is short term and tactical through the annualized ACL process. Increasingly, managers are recognizing the need to take a strategic view to think about how decisions will perform and respond to changes over the long term.

Uncertainty will always be an ingredient in the management process. Understanding of natural systems and human behavior is imperfect, and management decisions are never guaranteed to perform as intended. There is always some acceptable probability, for example, that a recommendation for a catch level may result in overfishing or that a rebuilding plan may not succeed within the intended timeframe. System-level change, including ecosystem and climate change, may alter the context for management decisions. Finally, managers will always need to respond to and account for the uncertainty contained in new information inputs.

Communicating about Uncertainty: From Caution to Confidence

The success of risk-based management is highly influenced by communication and perception. Uncertainty is perceived as a weakness, and the public may incorrectly perceive management as a process of reducing or eliminating uncertainty. It's important to communicate that risk-based management is not just about accepting uncertainty, but also about leveraging uncertainty to make decisions that are likely to deliver desired outcomes. Effective communication is critical for establishing confidence and trust in management.

Operational Challenges

Communicating Uncertainty

The process of accounting for uncertainty is challenging to communicate. Forum participants echoed stakeholder concerns regarding how and when different sources of uncertainty are taken into consideration within the ACL framework. In particular, managers and stakeholders share concerns about

double counting—accounting for a source of uncertainty twice. These concerns can discourage open conversation about the treatment of uncertainty because managers and stakeholders equate uncertainty with additional precaution and lower catch levels. Forum speakers emphasized that there is a difference between identifying a source of uncertainty and responding to a source of uncertainty. Communicating the roles, responsibilities, and processes involved in accounting for uncertainty is important, as is considering how sources of uncertainty interact in a holistic way.

Communication tools can support productive discussions among managers, scientists, and stakeholders. Graphical approaches, such as decision tables and risk matrices, can organize information and focus discussion on key priorities and questions. Working together, scientists and managers can develop effective tools and frame information about uncertainty in a meaningful way.

Effective communication requires balancing simplicity and complexity. Scientists and managers want to be comprehensive in their consideration of the sources and potential consequences of uncertainty. However, the amount of information to be organized, communicated, and considered in the decision making process can be overwhelming. Forum participants and speakers agreed that prioritizing and focusing on the key components of uncertainty are important. This information should be compiled in a concise, straightforward, and accessible way that participants described as “one-stop shopping.” Presenting information in multiple formats, for example, pairing tables with narrative explanations, can be helpful.

A final challenge is facilitating communication between scientists and managers. Effective communication across the science-policy interface is essential for encouraging robust discussion, increasing transparency, and supporting credible decision making. Communication involves an iterative process between scientists and managers, but it can be unclear who should take the lead. Scientists can take the initiative to organize information about uncertainty in a meaningful way, and managers can take the initiative to request certain information, but there remains a gap between communication of what information is needed and what information can be provided. Some Forum participants said that it’s important for decision makers to take the lead to maintain a clear handoff of information from scientists to policy makers.

Accounting for Human Behavior

Fisheries management is about managing people, yet people make decisions and respond, adapt, and innovate to situations in unpredictable ways. The uncertainty associated with human behavior is one of the most challenging dynamics to integrate into a risk-based management approach. One aspect of this challenge is procedural. Risk-based management requires identifying explicit goals and objectives. In a management process based on negotiation, participants have incentives not to reveal their preferences. Another challenge is that risk is subjective. Individuals perceive consequences differently, according to their values, priorities, and other personal attributes. The human dimensions of risk, particularly individual perceptions and tolerances, can make it challenging for managers to explicitly consider risk in a way that is perceived by stakeholders as objective and defensible.

Building Capacity for Management Strategy Evaluation

Introduction

Management strategy evaluation (MSE) is a process for testing and developing management strategies that are robust to uncertainty and perform well relative to management objectives. Risk assessment is a short-term, tactical approach to examine the consequences of a specific decision or action. MSE builds on this concept but involves a long-term, strategic approach for designing strategies to meet management objectives, given potential consequences and sources of uncertainty.

Interest and awareness of MSE in U.S. federal fisheries is rapidly growing. Several management regions have used MSE to explore management questions, and additional MSE investigations are ongoing. To support increasing interest in MSE investigations, NOAA Fisheries is investing in additional capacity to support MSE work at the regional fisheries science centers. The East Coast Forum provided a baseline understanding of MSE and of the range of scenarios and areas of uncertainty that can be explored through an MSE process. Discussions examined the resources and institutional capacity needed to conduct and utilize MSE, the role of decision makers, and potential applications to U.S. fisheries.

The MSE Process

MSE is a versatile process for evaluating how well different management decisions are expected to perform. In simple terms, MSE is a way to explore “what if?” questions and to “test drive” possible management strategies. MSE enables managers to integrate their consideration of the factors that *can* be manipulated as part of the management process (i.e., management decisions), those that cannot (e.g., biology and life history parameters, system-level changes, and management history), and unknowns and sources of uncertainty. This process enables managers to identify tradeoffs and assess the performance of management decisions relative to management objectives. MSE does not generate an answer or an optimal solution, but it does support a rigorous examination of candidate strategies.

The purpose, design, and rigor of an MSE process can vary. The core attributes and components of an MSE process generally involve the following:

- **Guidance, stakeholder input, or both:** Stakeholders, managers, or a combination of these or other sources provide guidance and constraints regarding acceptable tradeoffs, outcomes, and management strategies. (The Magnuson-Stevens Act and National Standards are one source of guidance in U.S. fisheries.)
- **Management objectives:** Quantifiable management objectives and performance metrics are used to gauge the performance of candidate management strategies.
- **Uncertainty:** Sources of uncertainty that may affect the performance of a management strategy are characterized.
- **Operating model:** Components of the management system, including the stock, fishery, data collection, and implementation of management measures, are represented in a model(s).
- **Management strategies:** Candidate management strategies are identified.
- **Simulation:** The performance of candidate management strategies is tested and evaluated in the context of the operating model.

Applications

MSE can be used to support short-term decision points, such as evaluating the performance of different harvest control rules. In other cases, MSE can be a comprehensive, stakeholder-driven process to design an entire management system for long-term performance. Additional applications of MSE can include

- Assessing the performance and possible impacts of management measures (e.g., different minimum size limits);
- Assessing, refining, and prioritizing information needs (e.g., determining how adjusting the frequency of a survey may affect uncertainty);
- Eliminating management strategies that don’t perform well; and
- Examining multiple hypotheses about stock status, population structure, environmental parameters, and other factors.

Speakers at the East Coast Forum shared six examples of MSE in U.S. and international fisheries. Summaries are provided in the appendix. Additional examples and MSE resources can be found on the Fisheries Forum Information Network.

Discussion

Opportunities and Benefits

MSE supports a rigorous examination of uncertainties, tradeoffs, and strategies relative to management objectives, and it can be used to explore a wide range of fishery management scenarios. Council members, council staff, and NOAA Fisheries staff see value in building the capacity to support additional MSE processes in U.S. federal fisheries. MSE could enable scientists and managers to explore fishery-specific issues as well as broader questions about the tradeoffs involved in ecosystem-based management, the resilience of management strategies to change, and other topics.

Forum discussions also explored the ancillary benefits MSE can provide to the management process. MSE can be designed to enhance constructive dialogue among scientists, managers, and stakeholders and to strengthen core components of the management process:

- **Setting goals and objectives:** MSE requires managers and stakeholders to articulate clear goals, objectives, and performance metrics to evaluate the performance of different decisions and management strategies.
- **Connecting strategies and objectives:** MSE evaluates the performance of potential management strategies relative to management objectives, establishing a direct linkage between strategies and objectives and making tradeoffs explicit.
- **Enhancing transparency:** MSE processes can promote transparency by involving managers and stakeholders in development of an operating model and in selection of management alternatives to be evaluated.
- **Framing constructive discussions:** MSE can accommodate divergent views and competing interests by focusing discussion on the identification of objectives and the performance of management strategies.

The opportunity to capture these additional benefits depends on the purpose and design of an MSE and on whether stakeholder participation is a central feature of the process..

Defining MSE

The term *management strategy evaluation* encompasses a set of processes that share common elements but that can take different forms, depending on the scenario and terms of reference. MSEs vary widely in terms of the management questions and examined scenarios, data inputs, the timeline and process, the involvement of managers and stakeholders, and other parameters.

Forum discussions considered whether a simple, shared definition of MSE is necessary or even feasible. The core features of an MSE process include the characterization of uncertainty, the rigorous examination of tradeoffs and management scenarios, and the central role of clear management goals and objectives. However, there are different perspectives—including among MSE practitioners—about whether a quantitative simulation is the centerpiece of an MSE process or whether a rigorous, complex analysis of possible scenarios can constitute an MSE. There are also different perspectives on whether stakeholder participation in an MSE process is a defining feature or a matter of design.

The versatility of MSE is an asset, but the difficulty of defining MSE in simple terms poses challenges, particularly to managers and stakeholders. It can be difficult to communicate clearly about MSE, frame questions and concerns, and explore the institutional capacity and investment needed to support a successful MSE process. Forum participants stated that effective communication is particularly important for council members and staff who interface directly with the public. Developing the capacity to communicate effectively about MSE is one component of building institutional capacity.

Building Institutional Capacity

MSE requires dedicated time, resources, and expertise. Building additional MSE capacity at NOAA Fisheries and across U.S. management regions is an institutional-level investment, and it involves all aspects of the federal fisheries management framework. With an emphasis on the council process, Forum participants and speakers explored the following questions, concerns, and communication opportunities.

Where Is MSE a Good Fit? How and Why Does MSE Originate?

The versatility of MSE prompted participants to ask two questions: What issues and fisheries are the best “fit” for MSE? Where can MSE be leveraged most effectively? While stating that there is no simple answer to either question, speakers suggested that MSE is generally a good fit for multi-objective issues requiring an explicit identification and balancing of tradeoffs and acknowledgment of uncertainties and unknowns.

In practice, MSE processes in U.S. fisheries have originated and been supported through a range of pathways. Some MSEs are internal to NOAA Fisheries (for example, those conducted at a regional science center), and others have originated through a direct request or recommendation—for example, from a council’s SSC—to investigate a specific issue. Other MSEs have emerged through an opportunistic alignment of capacity, expertise, and interest. In some regions, SSCs help facilitate connections between councils and the academic community. MSEs with external partners are typically developed in collaboration with science and management bodies, such as SSCs, plan development teams, technical committees, and so on.

How Does MSE Fit into the Council Process?

The relationship between MSE and the council decision-making process is not clearly defined and understood. Forum participants questioned whether MSE is an input to the decision-making process, part of the decision-making process, or something separate. The group also wondered how MSE fits into the broader fisheries management framework and how it interacts with established pathways and timelines for communicating and sharing information and products among councils, science centers, and regional offices.

What Investment of Resources Is Required? What Data Are Needed?

MSE requires a commitment of time and resources. Participants questioned whether supporting an MSE involves shifting existing resources, or whether MSE creates tradeoffs and additional demands on staff time, council bandwidth, and stock assessment capacity. Forum speakers clarified that MSE does not necessarily require a net increase of resources; it can be considered one way of organizing a process and workload for an issue that needs to be addressed. MSE can be customized to an issue and available data, but it can also be adapted for more broadly applicable processes, tools or platforms, and findings (for example, performance of control rules).

How Does an MSE Process Scale Up?

MSEs can range from a targeted investigation of a particular question to a broad exploration of issues and tradeoffs across one or more fisheries. Participants questioned whether the complexity, information demands, and challenges of identifying goals and objectives increase with the scope of an MSE. Speakers

emphasized that MSE can investigate “big” questions, but these questions should be prioritized and focused.

How Should Council, Council Members, and Stakeholders Be Involved?

In the United States, councils, council members, and other stakeholders have typically had limited direct involvement in MSE. Some Forum participants stated they had opportunities to learn about MSE and to stay informed about it through coordination and communication among the groups involved (e.g., plan development teams, SSCs) and through council staff. Other participants were not directly involved or aware of MSE in their region, and they suggested that state agency representatives may be more able to engage in MSE processes than appointees. The group generally agreed that it’s important for council and agency bodies that may be involved in an MSE to communicate with one another.

The role for stakeholder participation depends on how an MSE process is designed. In the United States, MSE is most often used to analyze management options and scenarios as an information input into the management process. Direct involvement by managers and stakeholders may be limited. In international and multinational contexts, such as the International Pacific Halibut Commission’s MSE process, stakeholder participation is often a central feature of MSE design.

Elements of Success

Most examples of MSE in U.S. fisheries represent an alignment of expertise, interest, available resources, and, in many cases, connections between management regions and the academic community. Forum speakers reflected on the factors that can facilitate—or constrain—the utility of MSE as a component of the management process.

- **Funding:** The financial resources to support an MSE—particularly time and effort, both at NOAA Fisheries and in the academic community—are a primary limitation.
- **Scientific expertise:** MSE expertise is limited and concentrated in a few regions of the United States. NOAA Fisheries has committed to building dedicated MSE expertise at each science center.
- **Communication:** MSE requires effective communication, outreach, and education across roles, responsibilities, and council/agency bodies. Successful communication requires skilled science communicators and the resources and training to support communication. MSE can also benefit from facilitation support. MSE can be a long-term process, and changes in council membership and loss of institutional memory reinforce that effective communication is an ongoing need.
- **Motivation:** MSE is valuable for taking a strategic and proactive look at a fishery management system, though the process may be more likely to gain traction when there is a clear issue to address and a desire for change.
- **Commitment and investment:** Fostering and maintaining commitment to the MSE process is critical, particularly when stakeholder and manager participation is a core principle of that process’s construction.

Finally, MSE should be designed to acknowledge the inherent challenges of a public process. MSE does not automatically lead to buy-in from stakeholders and follow through by managers. Building trust in the MSE process up front, through establishing the objectives and the rules of the process, is essential; otherwise, participants may later question the validity of the process and its outcomes. Maintaining the credibility of MSE as a tool is also critical, particularly as U.S. fishery managers seek to build awareness

and capacity. If stakeholder involvement is not successful or the information is not accepted or used, MSE may be viewed as an unsuccessful approach.

Managing Expectations

Integrating MSE into U.S. federal fisheries also requires setting and managing reasonable expectations. MSE can help support informed decision making, but it does not provide answers. MSE also does not circumvent the value judgments and balancing of interests that are fundamental to making decisions, particularly allocation decisions. Forum participants expressed concern that MSE could be oversimplified and viewed by stakeholders as a solution for complex management challenges. Finally, building awareness and capacity to conduct MSE processes will involve aligning a conceptual understanding of MSE with the reality of integrating MSE into an existing management process and framework for stakeholder participation.

Managing expectations is also important with regard to complexity. MSE cannot address every variable and source of uncertainty. Fisheries have many moving parts, and incorporating greater complexity into an operating model creates more sources of uncertainty. Although MSE is advancing to include economic drivers and information, other variables—particularly human behavior—will remain challenging or even impossible to account for in the process.

Evolution or Revolution?

The 2015 East Coast Forum was a valuable and timely reflection on the progress councils have made toward the effective treatment of uncertainty and consideration of risk. More importantly, the Forum provided an opportunity to look ahead. Risk-based management approaches and MSE are forward-looking opportunities to utilize uncertainty as information, improve communications, make strategic long-term decisions, and support the performance of federal FMPs.

Forum participants questioned whether risk-based management is, in their words, “evolution or revolution.” Is risk-based management something radically new and different, or does it represent the maturing of the logic and framework for responding to uncertainty? The group concluded that it’s a little of both. Treatment of uncertainty and consideration of risk continues to evolve through innovation and shifts in thinking. Councils will continue to play a critical role as the translators who bridge the gap from risk assessment to risk management.

Appendix: Presentation Summaries

Addressing Uncertainty in Fisheries Science and Management

Eric Schwaab, Chief Conservation Officer, National Aquarium (former)

Eric Schwaab established the context for the East Coast Forum by describing the main outcomes of the National Aquarium's 2014 report, *Addressing Uncertainty in Fisheries Science and Management*. The report includes findings, recommendations, and best practices identified by a panel of experts in fisheries science and management.

Schwaab emphasized that addressing uncertainty in the fisheries management process is critical for maintaining the progress that has been made following the 2006 reauthorization of the Magnuson-Stevens Act. Some sources of uncertainty can be reduced, whereas others need to be managed. Understanding this distinction, and communicating information about the sources and treatment of uncertainty, is critical for having constructive conversations about uncertainty within and beyond the immediate management process. The report includes four categories of recommendations with regard to identifying uncertainty, reducing uncertainty, managing fisheries in the context of environmental change, and adopting risk-based management approaches. Schwaab concluded by reflecting on the role of councils in supporting effective dialogue and communication about uncertainty.

Development of the New England Council's Risk Policy

Lori Steele, Fishery Analyst, New England Fishery Management Council (former)

Lori Steele described the New England Fishery Management Council's progress toward developing a comprehensive council risk policy. This effort was led by the Risk Policy Working Group (Working Group), which was responsible for developing an approach to provide the council and the Scientific and Statistical Committee (SSC) with clear guidance for specifying risk-based annual catch limits (ACLs) and accountability measures (AMs). The Working Group includes council members, council staff, and NOAA Fisheries and SSC participants.

The Working Group developed a high-level risk policy, which was recently approved by the Council. The Working Group is now developing a framework to operationalize this policy and eventually apply it across Council fishery management plans. The Council's Risk Policy Statement begins: "Recognizing that all fishery management is based on uncertainty information, it is the policy of the New England Fishery Management Council to weigh the risk of overfishing relative to the greatest expected overall net benefits to the Nation." The stated purposes for the policy include (1) providing clear guidance for accounting for risk and uncertainty, (2) communicating the Council's priorities and preferences regarding risk and uncertainty to NOAA Fisheries, and (3) making management more transparent, understandable, and predictable.

Steele described the Working Group's discussions and the reasons for developing a comprehensive risk policy. Although the Council has successfully implemented ACLs, it had no structured framework for setting Acceptable Biological Catch (ABC) levels and ACLs, and it provided no clear guidance on its risk tolerance and tradeoffs to inform the SSC's ABC recommendations. Although the ABC-setting process is the basis for the risk policy, the Working Group determined that true risk management should involve considering and accounting for tradeoffs throughout the management process. The Working Group intends for the risk policy to support a structured, analytical approach, potentially along the lines of an MSE approach, for looking at tradeoffs. Steele concluded her presentation by describing New England's risk-based management approach as a way of thinking based on a shared set of principles.

Proposed Revisions to the Magnuson-Stevens Act National Standard 1, 3, and 7 Guidelines

Wes Patrick, Acting Branch Chief for Fisheries Policy, Office of Sustainable Fisheries, NOAA Fisheries

Patrick provided an overview of proposed revisions to National Standard 1, 3, and 7 guidelines, released by NOAA Fisheries in early 2015. The proposed revisions incorporate feedback from stakeholders and managers on the first several years of ACL implementation. The revisions establish no new requirements; rather, they identify opportunities to accommodate uncertainty and provide flexibility within the ACL mandates of the MSA.

Patrick focused on proposed guidance for increasing flexibility in rebuilding plans, beginning with extending rebuilding timeframes. Variations in and uncertainty about environmental conditions (e.g., whether recruitment is above or below average) can affect whether a stock rebuilds by the expected target date. The proposed revisions clarify that rather than adjusting fishing mortality to meet the target date, maintaining the rate of fishing mortality expected to result in rebuilding given average or better conditions is sufficient. Another proposed element of the revisions addresses uncertainty in overfishing determinations by specifying that a rebuilding plan can be discontinued if new information indicates that the stock was never overfished.

Patrick described several provisions for providing stability in catch levels and for moderating the impacts of scientific uncertainty on ACLs. These provisions address multi-year overfishing determinations, phase-in approaches for increasing or decreasing catch levels, and carrying over quota from one fishing year to the next.

Dealing with Scientific Uncertainty in Stock Assessments

Rick Methot, Senior Scientist for Stock Assessments, NOAA Fisheries

Methot discussed opportunities to address scientific uncertainty through strategic investments in stock assessment science. Stock assessments are a starting point for balancing tradeoffs between conservation and utilization and for avoiding overfishing. Methot explained that overfishing can occur for different reasons and over different time horizons. Avoiding overfishing begins with setting and adhering to catch limits, as required by the revised Magnuson-Stevens Act (MSA). Avoiding overfishing also requires considering the effects of scientific uncertainty and evaluating whether catch limits are set at sustainable levels. Long-term challenges involve predicting, responding, and adapting to ecosystem and climate change.

Methot reviewed sources of uncertainty in stock assessments and the major reasons for redoing assessments, including adding data to a time series, integrating new information or understanding of stock dynamics into assessment models, and maintaining set assessment schedules. Updating or improving stock assessments can enhance managers' ability to adjust catch levels and consider tradeoffs between conservation and utilization. However, time and resources for conducting stock assessments are limited. Frequent and data-intensive updates are not feasible for every stock, and the level and frequency of stock assessment that is "good enough" and "timely enough" will vary by stock. Methot described the drivers and tradeoffs involved in prioritizing stock assessments, and he emphasized that these decisions should be deliberate and strategic. He concluded by noting the importance of dedicating sufficient bandwidth to also consider ecosystem-level impacts and changes across a range of assessment levels.

Management Strategy Evaluations: An Overview

James Ianelli, Fisheries Biologist, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries

Ianelli provided an introduction to management strategy evaluation (MSE) from the perspective of an assessment scientist. MSE requires managers and stakeholders to declare their strategic goals and to use all available information to develop a management strategy. Ianelli identified four defining elements of an MSE, using the acronym MUST:

- **M**ultiple management objectives (i.e., the National Standards)
- **U**ncertainty is characterized
- **S**takeholder involvement
- **T**radeoffs are evaluated

MSEs may draw on these four elements in different ways, as evidenced by two analyses conducted by scientists at the Alaska Fisheries Science Center. Ianelli stated that the first analysis, which explored harvest policies for the Bering Sea pollock fishery under climate change scenarios, can be considered an MSE primarily because it helped to illustrate the tradeoffs associated with the current harvest control rule. The second analysis, an Environmental Assessment/Regulatory Impact Review of Chinook salmon bycatch, also in the pollock fishery, can be considered to constitute an MSE because it involved a rigorous analysis of potential management strategies and outcomes that was comparable to an MSE process.

Application of Management Strategy Evaluation to Data-Poor Fisheries and the Recreational Summer Flounder Fishery

John Wiedenmann, Assistant Research Professor, Department of Marine and Coastal Sciences, Rutgers University

Atlantic Mackerel

There are many methods for setting catch limits in data-poor scenarios. Wiedenmann described the use of MSE to compare these methods and test whether they are robust to sources of uncertainty and different plausible scenarios. Because data-poor control rules often involve assumptions about population status, the consequences of getting those assumptions wrong must be considered. Applying a control rule based on incorrect assumptions about the status of a population could lead to adverse impacts to the stock or to unnecessary restrictions on the fishery. Wiedenmann described a recent collaboration with the Mid-Atlantic Fishery Management Council (MAFMC) in which MSE was used to explore the short-term consequences and tradeoffs of setting catch levels for the Atlantic Mackerel stock, which he described as “information poor” because the most recent assessment could not be used to set an ABC. Management strategy evaluation can help inform the MAFMC Scientific and Statistical Committee’s recommended ABC for Atlantic Mackerel through assessment of risk of overfishing, given different catch levels and possible population sizes.

Summer Flounder

Wiedenmann discussed a case in which MSE was used to explore objectives and tradeoffs for managing the East Coast recreational summer flounder fishery. Two specific concerns were identified. First, the use of minimum size limits to control harvest results in a high proportion of regulatory discards and increases selection for female fish (summer flounder are sexually dimorphic, and females are larger). The MSE considered whether a slot size could protect a greater number of females. Second, summer flounder is managed using state-by-state quotas, and states often experience overages. The MSE considered how buffers could be used to avoid large and frequent overages.

Wiedenmann highlighted the collaborative nature of this MSE process. Academics, managers, scientists, and stakeholders all contributed to development of the operating model, and helped identify the regulations and scenarios that were reasonable to test. This case demonstrates that MSE can be used to explore specific questions grounded in existing data and that MSE is a versatile tool for considering a wide range of “what if” questions and possible scenarios.

Management Strategy Evaluation on the East Coast

Mike Wilberg, Associate Professor, Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science

South Atlantic Recreational King Mackerel Fishery

Wilberg shared the case of a stakeholder-driven MSE process, organized as a collaboration among scientists and stakeholders, for the South Atlantic recreational king mackerel fishery. This MSE was designed to help involve stakeholders in developing management recommendations and, ideally, to improve acceptance of and compliance with management regulations. Participants were responsible for proposing management objectives, choosing management options to consider, and identifying performance metrics. They were also closely involved in development of an operating model, which helped provide transparency and improve understanding of the knowns and unknowns of king mackerel population dynamics and biology. Wilberg described the value of MSE for identifying shared goals, exploring different objectives (such as providing access and simplifying regulations) and stimulating discussion.

ABC Control Rules

Although often specific to a species and fishery, MSE can also be used to evaluate management approaches in a more generalizable way. Wilberg shared a case in which the Mid-Atlantic Council, NOAA Fisheries, and academic scientists collaborated on use of MSE to test the performance of different approaches for ABC control rules. In this work, which was related to the above-noted data-poor work described by Wiedenmann in reference to Atlantic Mackerel, the MSE involved several “prototype” life histories similar to those of species managed by the Mid-Atlantic council.

Wilberg described development of the operating model for this MSE and the steps involved in the simulation process, which include sampling and data collection, stock assessment, application of an ABC control rule, implementation of a catch limit, and application of the results to the population dynamics of the stock. The simulation was repeated to test the performance of a control rule over time. It incorporated uncertainty about factors such as recruitment, selectivity, and natural mortality, and it compared the performance of different control rules with outcome metrics such as average catch, probability of overfishing, variability in catch, and rebuilding success. The simulation confirmed that the Mid-Atlantic’s control rule is likely to perform reasonably well. Wilberg emphasized that although MSE doesn’t generate an “answer,” it can be a valuable process for ruling out management approaches that are unlikely to achieve management objectives.

International Pacific Halibut Commission Management Strategy Evaluation Process

Ian Stewart, Quantitative Scientist, International Pacific Halibut Commission

Stewart introduced his presentation by highlighting an important difference between domestic and international use of MSE: in U.S. federal fisheries, the objectives of an MSE are informed and constrained by the mandates of the Magnuson-Stevens Act; in international fisheries, they are not.

The International Pacific Halibut Commission (IPHC) manages Pacific halibut through a convention between the governments of the United States and Canada, which implement regulation based on the IPHC’s stock assessments and catch limits. The IPHC initiated an MSE process for Pacific halibut amid

changes to the biology of the fishery and the way the halibut stock is assessed and managed. Stewart emphasized that in the case of Pacific halibut, MSE is a continuous process to help inform halibut management, from data collection to decision making. The IPHC's MSE approach is shaped with input from the Management Strategy Advisory Board (MSAB), which represents stakeholders in the halibut fishery. The MSAB provides input on the management objectives and procedures to be evaluated and facilitates communication with stakeholders and the IPHC.

The MSAB has been identifying testable management objectives and performance metrics for candidate management procedures. Stewart identified three questions that must be answered for a management objective to be testable:

- What do you want? (That is, how should stock conservation be achieved?)
- How badly (in a probabilistic sense) do you want it?
- When (e.g., every year, on average) do you want it?

Another important step of the MSE process involves distinguishing between factors that *can* be manipulated as part of the management process and those that cannot. Factors that can be changed, such as size limits and catch limits, become part of the management procedures to be evaluated. Those factors that cannot be controlled, such as natural mortality or stock movement among regulatory areas, contribute to scenarios that can be explored in the operating model for an MSE. Because the resulting number of factors and possible scenarios are too numerous to explore, IPHC staff developed an interactive tool in the statistical program R that enabled stakeholders to explore the factors that are likely to have the strongest effects.

Stewart concluded by reflecting on the early success of this MSE process, which includes the MSAB's increased ownership of the process and identification of objectives and performance measures.

Management Strategy Evaluation for the Southern Bluefin Tuna fishery

James Ianelli, Fisheries Biologist, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA Fisheries

Ianelli described the process of developing an MSE, or management procedure (MP), for the southern bluefin tuna (SBT) fishery, found in the Pacific Ocean's southern hemisphere. SBT is managed under international convention by the Commission for the Conservation of Southern Bluefin Tuna, formed in 1994. The founding members include Australia, New Zealand, and Japan, and additional members and cooperating non-members have been added in recent years. Although members recognized the need for conservation and management to rebuild the SBT stock, they disagreed on the best stock assessment and management approach.

Development of a MP for SBT provided an opportunity for members to pursue a collaborative process that took from 2002 until 2011 to complete. Ianelli described the major steps of this process, beginning with development of an operating model and control rules. Member nations were actively involved in identifying candidate control rules. The MP adopted by the commission aims to achieve a 70% probability of rebuilding the SBT stock to 20% of original spawning stock biomass by 2035. It addresses the tradeoffs between catch rates and rebuilding by constraining the allowable minimum and maximum changes to total allowable catch. Among the key sources of uncertainty it considers are stock productivity, natural mortality, and the interpretation of catch per unit effort (CPUE) trends.

Ianelli shared emerging issues and challenges, including disparities between quotas and harvest, defining and responding to exceptional circumstances (situations in which managers may deviate from control rule), and considering changes to information inputs (e.g., discontinuing surveys, new sources of

information inputs). He concluded that the process of developing an MP helped support a constructive dialogue among scientists, managers, and stakeholders.

Fisheries Leadership & Sustainability Forum

The Fisheries Leadership & Sustainability Forum (Fisheries Forum) provides policy-neutral support to the federal fisheries management community through collaborations with the regional fishery management councils, National Oceanic and Atmospheric Administration (NOAA) Fisheries, and other management partners. The Fisheries Forum empowers fishery managers, scientists, and stakeholders to work through challenges, build capacity, develop professional networks, and explore emerging issues on the forefront of fisheries science and policy. Established in 2008, the Fisheries Forum has served as a trusted partner by convening stakeholders and facilitating constructive dialogue on a wide range of topics. The Fisheries Forum's portfolio of services and materials from past collaborations are available online at fisheriesforum.org.

Nicholas Institute for Environmental Policy Solutions

The Nicholas Institute for Environmental Policy Solutions at Duke University is a nonpartisan institute founded in 2005 to help decision makers in government, the private sector, and the nonprofit community address critical environmental challenges. The Nicholas Institute responds to the demand for high-quality and timely data and acts as an "honest broker" in policy debates by convening and fostering open, ongoing dialogue between stakeholders on all sides of the issues and providing policy-relevant analysis based on academic research. The Nicholas Institute's leadership and staff leverage the broad expertise of Duke University as well as public and private partners worldwide. Since its inception, the Nicholas Institute has earned a distinguished reputation for its innovative approach to developing multilateral, nonpartisan, and economically viable solutions to pressing environmental challenges.

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