April 2024

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**BRIDGING THE GAP: ENHANCING THE SCIENCE-TO-MANAGEMENT PATHWAY FOR CLIMATE-RESILIENT FISHERIES**

**PREPARED FOR**

Environmental Defense Fund – U.S. Oceans Team

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# Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

# Honor Code

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# Client Overview

The Environmental Defense Fund (EDF) is a global non-profit focused on addressing the world’s most critical environmental problems. EDF plays a pivotal role in addressing fishery issues, leveraging its expertise to promote sustainable practices and safeguard marine ecosystems. EDF combines scientific research, policy advocacy, and collaboration with stakeholders to advocate for sustainable fisheries management. Through collaboration with fishermen, policymakers, and scientists, EDF’s Fishery Solutions Center and U.S. Ocean’s Team has emerged as a trusted authority on fishery issues.

EDF is particularly interested in the issue of the science-to-management pathway because ensuring the best available climate science is informing fishery management decisions is one way fisheries can remain resilient to climate impacts. By engaging diverse stakeholders and utilizing evidence-based strategies, EDF continues to shape policies that balance the needs of the fishing industry with the imperative to preserve and restore marine ecosystems. In doing so, EDF is a leading and trusted voice in the pursuit of sustainable fisheries management.

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# Acronyms & Key Terms

**Councils**: Refers to the eight Regional Fishery Management Councils designated under the MSA that are responsible for creating and implementing fisheries policies in the United States.

**EDF**: Environmental Defense Fund

**Fish stock(s):** Fish species that live in the same geographic area (e.g. Atlantic Cod).

**FMP**: Fishery Management Plan

**MSA**: The Magnuson-Stevens Fishery Conservation and Management Act; the preeminent federal legislation designating how U.S. Fisheries are managed.

**MSE**: Management Strategy Evaluation

**NOAA Fisheries:** The National Oceanic and Atmospheric Administrations’ National Marine Fisheries Service; thetrusted government authority on the science and management of fish, other marine life, and their habitats.

**RSA**: Research Set-Aside Program

**Science-to-Management Pathway**: The conduit by which climate science informs management decisions.

**U.S. Fisheries:** Any area in U.S. federal waters where fish are caught for commercial purposes.

# Executive Summary

Climate change is impacting U.S. fisheries in a myriad of ways including through warming oceans, habitat shifts, and changing species distributions (GAO, 2022). These changes pose major risks to domestic fisheries that rely on consistent fish populations and distributions to remain viable industries. As a result, the science-to-management pathway—the conduit by which climate science informs management decisions—is of vital importance to ensure fisheries management remains resilient to climate impacts. This paper provides recommendations on behalf of the Environmental Defense Fund (EDF) to NOAA Fisheries on ways to improve the science-to-management pathway.

The paper offers strategies to facilitate climate-responsive decision-making by improving collaboration between scientists and managers. Drawing from psychological and managerial literature as well as fisheries management best practices, it offers seven alternatives grouped into three categories: improving communication, reprioritizing NOAA funding toward existing programs, and implementing management changes. All seven alternatives are listed below.

1. Improved Communication
   1. *NOAA Fisheries should encourage knowledge co-production by increasing collaboration between scientists and managers early in the management process.*
   2. *NOAA Fisheries should undertake more communication and education efforts showing that well informed management decisions that incorporate the best available climate information help keep fisheries sustainable to climate impacts.*
2. Reprioritize allocated money to fund existing NOAA programs.
   1. *NOAA Fisheries should prioritize and fund advancements in stock assessments for fisheries who lack adequate assessments.*
   2. *NOAA Fisheries should fund climate-scenario planning for all Councils.*
3. Management Changes
   1. *NOAA Fisheries should direct all Councils to systematically integrate climate-related governance frameworks and decision-making procedures into their conceptual models, emphasizing governance processes as a key mechanism for effective climate-resilient fisheries management.*
   2. *NOAA Fisheries should incentivize the use of Management Strategy Evaluation in all jurisdictions.*
   3. *NOAA Fisheries should standardize the way that data is stored across the Councils to improve accessibility for both scientists and managers.*

The alternatives are assessed based on three criteria: knowledge integration and collaboration, political feasibility, and reduction in administrative burden, using a 1-3 scoring scale (3 being best). An outcomes matrix and a discussion of alternatives by criterion can be found on pages 20 and 21, respectively.

Because it is difficult to find data on the effectiveness of management decisions on improving the science-to-management pathway, included in the appendices are three case studies that endeavor to show how successful interventions in fisheries management have improved the science-to-management pathway. Appendix A discusses how climate-induced changes to the distribution and amount of sea bass in the Mid-Atlantic led to concrete management changes, Appendix B discusses the successful research set-aside program in the greater Atlantic region, and Appendix C highlights how management strategy evaluation can be a useful tool in understanding how management changes impact fishery health. These case studies should not be read as oracles for effective science-to-management integration, but rather illustrative of some ways to improve this pathway in real-world settings, as imperfect as they may be.

This paper ultimately recommends NOAA Fisheries adopt the *Improving Communication* alternatives: encouraging knowledge co-production between scientists and managers and communicating how climate-informed decisions aid fishery sustainability as these scored the highest cumulatively on each criterion. An implementation plan is provided on page 25 and brief summary remarks follow thereafter.

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# Introduction

Climate change is drastically altering U.S. fisheries. Warming ocean temperatures, increasingly acidic marine environments, and subsequent fish stock movements to cooler and deeper water are just a few of the mechanisms through which climate change is impacting fish populations and the fishing industries that depend on them. These dynamic changes pose significant risks for domestic fisheries, which rely on consistent and predictable fish stocks to remain economically viable. Scientists and managers create fisheries policies collaboratively, but due to differences in roles, the rigid management structure of U.S. fisheries, and external pressures, there can exist barriers in this vital science-to-management pathway. Ensuring this pathway remains open to both science and management input is crucial for enabling fisheries management to effectively adapt to climate change and maintain the resilience of this essential industry.

# Problem Statement ­

Climate change continues to alter the distribution and abundance of many commercially and recreationally important fish species necessitating novel research and management approaches to promote climate resiliency. Scientists and managers collaborate on fisheries development, but prioritization of management needs and research endeavors do not always align, and the translation of scientific findings into concrete management decisions can be unclear which can hinder the advancement of policy initiatives.

# Background

## Importance of U.S. Fisheries

U.S. fisheries cover 4.4 million square miles of ocean, making it the largest fishery in the world (Fisheries, n.d.-b). U.S. fisheries are any area in U.S. federal waters where fish are caught for commercial purposes (Fisheries, 2021c). U.S. federal waters extend between three and two hundred nautical miles offshore of the U.S. coast (Fisheries, 2021c). All U.S. fisheries are managed by the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service (hereafter NOAA Fisheries) who is responsible for “the stewardship of the nation's living marine resources and their habitats, interactions, and ecosystems” (Fisheries, 2021a). This includes working to increase the domestic seafood supply, maintaining healthy fishery ecosystems for long-term sustainability and creating jobs to support coastal communities (Fisheries, 2021a). U.S fisheries also meaningfully contribute to the economy both through job creation and economic value. The most current report from NOAA Fisheries estimates that U.S. fisheries contributed 1.1 million jobs to the economy, had $154.7 billion in sales, and provided $62.5 billion in value added in 2020 (Fisheries, 2023b). These numbers only account for commercial endeavors, and recreational fishing also contributes billions to the economy every year (Fisheries, 2023b).

## How U.S. Fisheries are Managed

U.S. fisheries are managed under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) which was passed in 1976 and is the landmark legislation dictating how U.S fisheries should be run to prevent overfishing and ensure sustainability for future generations (Fisheries, n.d.-a). Other federal legislation such as the Endangered Species Act and Marine Mammal Protection Act influence fisheries management too, but for the purposes of this report, the MSA is the guiding legal mandate (Mason et al., 2023). The MSA created eight Regional Fishery Management Councils (hereafter, Councils) that are responsible for the day-to-day management of the fisheries in their geographic region and to ensure compliance with MSA’s conservation and regulatory guidelines (Fisheries, n.d.-a). Figure 1 shows the location of the Councils.

A map of the united states

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*Figure 1* (U.S. Regional Fishery Management Councils, n.d.)

The MSA includes ten national standards which serve as principles that Councils must adhere to, such as reducing overfishing and ensuring fish stocks can reproduce at a rate commensurate with commercial fishing needs (Fisheries, 2023c). There are currently 492 managed fish stocks under the purview of NOAA Fisheries (Fisheries, 2023e).

## Climate Impacts to Fisheries

While the MSA has been largely successful in reducing overfishing and creating thriving fisheries in the United States, climate change is reversing many of these successes. Most prominently, warming ocean waters are shifting fish stocks away from their historic habitats and ocean acidification is harming the ecosystems fisheries depend on (Walton & Krupp, 2019). Figure 2 depicts the shifting stocks of three species in the Northeast Atlantic from 1974 to 2019. The graphic clearly shows how these stocks have shifted northward and eastward into colder and deeper water over the past three decades—a trend that can be seen across U.S. fisheries.

A map with different colored graphs and numbers

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*Figure 2* (US EPA, 2016)

Climate impacts to fisheries are top of mind for NOAA Fisheries including scientists and managers, commercial and recreational fishermen, and groups like environmental non-governmental organizations who work on fisheries issues.

The adoption of Ecosystem-Based Fishery Management—a whole of ecosystem approach to management rather than a focus on a single species (Fisheries, 2021b)—and both federal and Council-level initiatives like NOAA’s $349 million commitment to financing the Climate-Ready Fisheries program (Fisheries, 2023g) and The North Pacific Council’s Climate Change Taskforce (Mason et al., 2023) all show the industry’s commitment to addressing these climate impacts. Additionally, an analysis of the past decade of the Council Coordination Committee meeting transcripts—a group made up of leaders from all eight Councils who meet biannually—shows the frequency of the term “climate” is trending upward. This can be used as a proxy measure for the increasing importance of understanding—and addressing—climate impacts to fisheries.

*Figure 3* (*CCC Meetings*, 2024)

## The Science-to-Management Pathway

Taking this all together, the need to get robust climate science into informing fishery management is of crucial importance for the long-term sustainability of both fishery ecosystems and the seafood industry. To understand the bottleneck that can occur in this process, it is important to understand the nature of fisheries management. Comprising stakeholders, scientists, and policymakers, the management structure of U.S. fisheries is complex. Through stakeholder engagement, the Councils formulate management plans based on the best available scientific data (Magnuson-Stevens Fishery Conservation and Management Act, 1976). Decision-making involves assessing fish stock health, setting catch limits, and implementing measures like size restrictions and closed seasons (Fisheries, 2021c). Since these management decisions rely heavily on the integration of the best available scientific data to ensure sustainability, NOAA Fisheries employs advanced research methods and technologies to assess fish populations, habitat conditions, and ecosystem dynamics (Fisheries, 2021c). This scientific approach informs decision-making processes, guiding the implementation of regulations and policies aimed at preventing overfishing and maintaining healthy marine ecosystems. Collaborative efforts between scientists, policymakers, and industry stakeholders contribute to adaptive management strategies, fostering resilience in fisheries. Figure 4 depicts the typical science-to-management pathway, highlighting how scientific data, stock assessments, and management tools all interact to create fishery policies.

A diagram of fish and fish

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*Figure 4* (Fisheries, 2023d)

### Barriers That Exist in the Science-to-Management Pathway

The crucial interplay between scientific recommendations and management decisions is vital for ensuring sustainable fisheries in the United States. However, there is often a disconnect between the scientific recommendations provided by experts and the actual decisions made by fishery managers, particularly in the face of the complex and ever-evolving challenges posed by climate change. Scientific recommendations are generated through rigorous research, data analysis, and modeling, aiming to safeguard fish stocks and the marine environment (Fisheries, 2021c). These recommendations are grounded in ecological principles and designed to achieve long-term sustainability; however, good science takes a long time and is very rarely definitive.

On the other hand, fishery managers also face challenges that make implementing some scientific recommendations difficult. Politics, for one, exerts significant influence on fisheries management decisions, shaping policies, regulations, and decision-making processes. Fisheries management decisions can be influenced by political pressures, including lobbying from various interest groups (Eagle, 2021). These pressures sometimes lead to decisions that deviate from scientific recommendations. Managers must also account for different stakeholder interests whether that be from commercial or recreational fishers or fishing communities. Nevertheless, management decisions can fall short of fully incorporating scientific recommendations which hinders a fisheries’ ability to remain resilient in the face of climate change (Gaines et al., 2018). To be clear, this is not a scientists versus managers problem; instead, the broader ecosystem, different incentives, and fundamentally different jobs of these two groups can create friction in the science-to-management pathway.

Figure 5 attempts to visualize the science-to-management pathway problem by incorporating relevant stakeholders and significant relationships that can lead to some of these barriers discussed. This figure by no means incorporates every stakeholder; it merely attempts to show the complex ecosystem the science-to-management pathway is nestled within.

A diagram of a company

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*Figure 5*

A review of the literature suggests that barriers that exist in this space revolve around communication issues, a lack of trust between stakeholders, the rigidness of the Council structure, and differences in knowledge and language used by scientists and managers (Cooke et al., 2021; Dedual et al., 2013; GAO, 2022; Soomai, 2017b, 2017a). Given these issues concern communication pathways, team dynamics, and interpersonal considerations, the following evidence review relies heavily on behavioral and psychological science literature as well as fisheries management literature to examine potential solutions.

# Evidence on Solutions

## Participatory Communication

This difference in the level of specificity and the rigor of language employed by scientists, managers, and fishers can create communication barriers, making it challenging for them to effectively convey ideas and understand each other's perspectives. Scientific information is often highly technical and can be difficult for non-subject matter experts to understand. This makes it challenging for managers and fishers to interpret and apply the findings (Dedual et al., 2013; Soomai, 2017). Therefore, translating science into plain language is important for effective implementation (Dedual et al., 2013).

One way to combat these problems is through participatory communication. Participatory communication is a communication strategy that centers dialogue and information sharing across groups in an effort to empower all stakeholders (Tufte & Mefalopulos, 2010). In fisheries management, this can look like communicating early and often, keeping two-way flows of information open, having structured forums for sharing perspectives of different stakeholders, and encouraging transparent communication between all relevant parties to encourage information sharing (Dedual et al., 2013). Two-way dialogue through workshops, committees, and knowledge sharing facilitates mutual learning and trust (Cooke et al., 2021). Therefore, purposeful participatory communication can help overcome some of the misalignment that often exists between scientists and managers (Dedual et al., 2013).

Participatory Communication Theory was developed by Paolo Freire in the 1970s and is often used in the context of international development (Fernández-Aballí Altamirano, 2020). However, the hallmarks of participatory communication can be easily applied to other contexts like fisheries where varied stakeholders work together to achieve a common goal. The literature cited here builds upon Freire’s work through application to fisheries management issues.

Participatory communication is crucial for effective and sustainable fisheries management. By actively engaging fishermen, coastal communities, indigenous groups, and other stakeholders in decision-making processes, managers can gain important local knowledge and build support for climate-resilient policies. This approach prioritizes collaborative problem solving rather than top-down management. It also gives fishermen and communities a sense of ownership over fisheries resources and management plans.

## Knowledge Co-Production

“Co-production is perhaps the single most effective action that researchers can take to help bridge the knowledge-action divide.”

-Cooke et. al (2021)

Another common issue in management is a lack of trust and preconceived notions among managers, fishers, and scientists. Fishers can be suspicious of scientific recommendations which they fear may restrict fishing access and there is often skepticism that science is biased or impractical (Dedual et al., 2013; Soomai, 2017). Building relationships and mutual understanding is key to overcoming distrust between these groups. One way to do this is through knowledge co-production.

Like participatory communication, knowledge co-production is the process of bringing together diverse stakeholders including scientists, fishermen, policymakers, and members of the public to jointly produce knowledge that can inform decision-making (Cooke et al., 2021; Norström et al., 2020). Norström et al. (2020) defines knowledge co-production as an “interactive and collaborative process[…] involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future” (p. 183). Cooke et al. (2021) sees co-production as a means to overcome the “knowledge-action gap” that arises when there is a “disconnect between scientific knowledge and its application” (90).

This approach not only recognizes that different groups like fishers, managers, and scientists hold unique knowledge and perspectives, but finds that in sustainability work especially, knowledge co-production is better equipped to meet these challenges than traditional scientific approaches (Norström et al., 2020). Norström et al. (2020) proposes effective co-production should be context-based, pluralistic (meaning recognizing there are multiple ways to achieve a desired goal), goal-oriented, and interactive.

Scholars agree that iterative processes and collaborative approaches to information sharing can help create effective knowledge co-production that helps remedy the disconnect between scientific findings and their application in many scientific domains (Lemos & Morehouse, 2005; Polk, 2015; Wyborn et al., 2019). Cooke et al. (2021)—citing research from Fazey et al. (2014) and Cvitanovic et al. (2015)—goes a step further and states that “co-production is perhaps the single most effective action that researchers can take to help bridge the knowledge-action divide” (p. 91).

Despite the benefits of this collaborative approach, co-production does have drawbacks. Most notably for fisheries, co-production can constrain scientific inquiry and limit scientists’ power in an effort to make the entire process more democratic (Young et al., 2016). Scientific recommendations are foundational to fisheries management decisions, so it is imperative that an effective co-production process not constrain scientists too much.

Additionally, while the interplay of scientists and managers in fisheries management mirrors how co-production works in other scientific fields, few researchers have applied this practice to fisheries specifically (Cooke et al., 2021). Knowledge co-production is already baked into many fisheries management practices by bringing together stakeholders to make recommendations on catch limits, gear restrictions, protected areas, and other management measures, but more research is needed to understand the best ways to overcome the many barriers that still exist.

## Bureaucratic Constraints

Bureaucratic constraints also impede the science-to-management pathway. Like any government agency, NOAA Fisheries’ decisions and the federal process can take time and often lead to delays in implementing fisheries policies. This is not unique to the United States. Suzette Soomai (2017b) found that centralized bureaucracy can inhibit information sharing across departments and regions withing Canadian fishery management agencies, for example. Knowing this, it can be helpful to look at management changes which have the potential to limit these constraints.

In decision making, humans often focus on adding more information and options. Interestingly, research by Adams et al., (2021) suggests subtraction can improve decision making. Their work finds that removing information and choices allows people to better evaluate what remains (Adams et al., 2022). This is applicable in many industries, but in fisheries, it could mean reducing some of the barriers that exist within the management structure. Such subtractions could be simplifying the regulatory process through more streamlined and transparent regulatory frameworks; consolidating and eliminating redundant or conflicting fishery regulations to reduce confusion and administrative burden; or implementing more flexible and adaptive management approaches that allow for quicker adjustments to changing climate conditions. Subtraction, in this sense, could also mean not *adding* a new regulation or process. Rather than initiating entirely new projects, NOAA Fisheries could consider prioritizing and building upon their existing climate-related initiatives, leveraging the resources and groundwork already in place (Fisheries, 2024). Eliminating extraneous factors can help fine tune decision making and people in a subtracting mindset make decisions more selectively by discarding irrelevant details (Adams et al., 2021). By simplifying choices, subtraction enables clearer thinking.

The Council process and fisheries regulations, however, have rigid bureaucratic structures for a reason. Council decisions hold immense weight in the fishing community. Management decisions predicated on faulty or hastily conducted science reverberate through fishing communities and can cause significant economic and ecological strain. Therefore, some bureaucratic constraints are needed, but this must be balanced with the Council’s need to be adaptable in the face of fast-moving climate impacts. Mason et al. (2023) finds that the rigid council structure hinders the ability for climate-related information to make its way into management decisions which suggests Adams’s et al. (2021) research on reducing options has the potential to decrease some of these barriers in fisheries management.

# Description of Criteria

Knowledge Integration & Collaboration

Knowledge integration and collaboration is essentially a measure of effectiveness. It is an assessment of the extent to which each proposed policy alternative facilitates the exchange of knowledge and collaboration between scientists and managers, thereby reducing barriers or friction in the science-to-management pathway. This criterion will be scored on a 1-3 scale. An alternative that scores a 3 on this criterion suggests it is an effective way to reduce silos that exist in this pathway. This could mean the alternative increases communication channels or encourages knowledge-sharing avenues that bridge the gap between the language and perspectives of scientists and managers. Crucially, it encourages a system where scientific findings inform management practices. An alternative that scores lower than a 3 may do some of or none of these things and therefore does not meaningfully encourage knowledge integration and collaboration into the management process.

Political Feasibility

Political feasibility refers to the degree to which it would be practical and achievable for NOAA Fisheries to implement each alternative. Such factors that are considered are distance from the status quo and corresponding costs (time, resources, etc.) as well as the political context of each alternative. Additionally, the general political backdrop and attitudes from relevant stakeholders surrounding each option are considered. Political feasibility will be scored on a 1-3 scale. A score of 1 indicates that NOAA Fisheries would likely see the alternative as infeasible from any number of perspectives. A score of 3 suggests NOAA Fisheries would likely implement the alternative based on educated guesses about the above feasibility measures.

## Reduction in Administrative Burden

Reduction in administrative burden refers to the costs associated with an administrative process, such as time, energy, compliance costs, or literal financial expenses (Brown, 2022; Moynihan et al., 2015). This criterion is an important factor to consider in fishery management because of the extensive bureaucracy within NOAA Fisheries and the inherent complexity of the Council process. Any alternative that adds substantial administrative burden would likely face significant pushback during the adoption and implementation phases. Therefore, measuring the potential reduction in administrative burden is a crucial metric for understanding each alternative's feasibility within the existing regulatory framework. This criterion will be scored on a 1 to 3 scale. An alternative that scores 3 on this criterion would represent a significant reduction in administrative burden if implemented, streamlining processes, and minimizing associated costs. Conversely, an alternative that scores 1 on this criterion is likely to increase administrative burden, potentially hindering its adoption and effective implementation due to the additional bureaucratic procedures, paperwork, and compliance requirements it would entail.

# Description of Alternatives

## Improved Communication

### *NOAA Fisheries should encourage knowledge co-production by increasing collaboration between scientists and managers early in the management process.*

Knowledge co-production is the process of bringing together diverse stakeholders including scientists, fishermen, policymakers, and members of the public to jointly produce knowledge that can inform decision-making (Cooke et al., 2021; Norström et al., 2020). This policy option therefore would have scientists and managers jointly develop research priorities and plans to ensure the science produced will be relevant and useful for management decisions. To be clear, this already happens, as it is a mandate of the MSA. What this alternative is proposing is a more sustained effort by NOAA Fisheries to promote and encourage this type of interaction. This would likely occur early and often in the management process and would involve dedicated time set aside for scientists and managers to work together on fisheries policies. Brewer et al. (2017) suggests that such annual forums “facilitates coalitions that overcome dichotomies between technocratic and local knowledge, extending benefits to fishing communities, academia, and public policy” (274). This is echoed by Dedual et al. (2013) who finds that early, transparent, and meaningful bilateral communication between all parties facilitates shared knowledge and better fisheries management.

### *NOAA Fisheries should undertake more communication and education efforts showing that well informed management decisions that incorporate the best available climate information help keep fisheries sustainable to climate impacts.*

As established in the evidence review, there is distrust that exists between the broader fishing community and those making fisheries policies founded on the belief that incorporating climate-related management changes will inherently limit fishing opportunities (Dedual et al., 2013; Soomai, 2017; Hays, 2022). One way to overcome this is by building relationships and mutual understanding between these groups which can be achieved through policy option *1a*—knowledge co-production.

NOAA Fisheries should also implement an expanded communication and outreach program to demonstrate that fisheries management decisions do not necessarily restrict fishing opportunities over the long term. Specifically, NOAA Fisheries should develop informational materials, presentations, workshops, and other educational tools aimed at commercial and recreational fishing interests that explain how setting science-based catch limits, habitat protections, and other conservation measures help keep fisheries sustainable to climate impacts. NOAA Fisheries already does some of this work, but it could be expanded with an eye towards the climate impacts to fisheries.

The logic goes that such a sustained communications strategy would create more trust among stakeholders. And while there is a dearth of evidence specifically on the impact of such communication efforts on trust-building, evidence suggests that collaborative research between fishers, scientists, and managers does build trust between these groups (Mason et al., 2023; Norström et al., 2020). Ebel et al. (2018) finds that fishers highly regard the personal connections they have with researchers, emphasizing mutual respect cultivated over time. These insights indicate that making the effort to engage with hesitant stakeholders, listen to their concerns, and then educate them in an open and friendly way about the advantages of climate-informed management changes can lead to greater trust and buy-in over time.

## Reprioritize allocated money to fund existing NOAA programs.[[1]](#footnote-1)

### *NOAA Fisheries should prioritize and fund advancements in stock assessments for fisheries who lack adequate assessments.*

Stock assessments are quantitative analyses that allow fisheries managers to determine the health of fish populations, set science-based catch limits that prevent overfishing, and assess how stocks will respond to various harvest levels (Fisheries, 2023b). Robust stock assessments reduce uncertainty and give managers more confidence that catch limits and regulations will achieve management goals (Cooper, n.d.; Fisheries, 2023b). Funding stock assessments should therefore be a priority both for expanding economic opportunities from fisheries and ensuring long-term ecological sustainability. Reliable assessments are the foundation for balancing fishermen’s interests today with maintaining productive fisheries through sound management practices.

While some management councils use robust stock assessments, not all of them do. NOAA Fisheries should conduct a review to identify fisheries that lack adequate stock assessments and prioritize funding them based on factors such as economic importance, ecological significance, vulnerability to climate change, and management needs. This funding could come from grants or by allocating some of NOAA’s research budget to improving stock assessments. This prioritization process ensures that limited resources are allocated to fisheries where improved assessments would have the greatest impact on sustainability and management effectiveness.

### *NOAA Fisheries should fund climate-scenario planning for all Councils.*

Climate scenario planning is already occurring within NOAA Fisheries with one successful example being the East Coast Scenario Planning exercise that occurred between 2021 and 2023 (*East Coast Climate Change Scenario Planning*, 2024). Shifting fish stocks due to climate change is impacting the east coast of the United States in unpredictable ways. Because of this a series of East Coast fishery organizations conducted a scenario planning exercise that focused on the governance and jurisdictional challenges associated with these shifting fish stocks and developed tools and strategies to help respond to changes in fisheries due to climate change (*East Coast Climate Change Scenario Planning*, 2024). Climate-scenario planning is one of the best currently available initiatives NOAA Fisheries is using to understand climate impacts to fisheries, and they should therefore prioritize funding to Councils who lack these assessments. Similarly to Alternative *2a*, NOAA Fisheries should conduct a review of Councils who are not doing ample climate-scenario planning and reallocate money to them so they can engage in this important exercise.

## Management Changes

### *NOAA Fisheries should direct all Councils to systematically integrate climate-related governance frameworks and decision-making procedures into their conceptual models, emphasizing governance processes as a key mechanism for effective climate-resilient fisheries management.*

A key component of improving the science-to-management pathway is by having a thorough understanding of how different Councils integrate scientific findings into their management decisions. Mason et al. (2023), in their discussion of how to best incorporate climate change information to inform fishery management, asserts that one of the best practices is to survey management processes for “on ramps” which they define as “any opportunity to incorporate climate-related information in Council decision-making processes” (4). Conceptual models are helpful in mapping complex management structures (Harvey et al., 2016). While many regions do use some kind of modeling process, they often lack discussion of governance processes, which is a key component to understanding how climate science can best be incorporated into management decisions (Mason et al., 2023).

Surveying the management landscape for these “on ramps” could be a kind of knowledge co-production as it would require stakeholders both within and outside the Council process to collaboratively determine where in the Council process opportunities for change could occur. The collaborative nature of this policy option would also allow stakeholders some ownership of the process, create connections across divides, and help identify any bottlenecks in the management process (Aminpour et al., 2020; Gray et al., 2012; Mason et al., 2023).

### *NOAA Fisheries should incentivize the use of Management Strategy Evaluation in all jurisdictions.[[2]](#footnote-2)*

Management Strategy Evaluation (MSE) is a tool used in fisheries management to assess the performance of different management strategies in achieving predefined objectives (usually as it relates to optimum yield) (*Management Strategy Evaluation for Fisheries*, 2016). MSE involves a systematic approach to simulating the dynamics of fish populations, fishing activities, and the implementation of various management measures (*Management Strategy Evaluation for Fisheries*, 2016). Its primary goal is to inform decision-making processes by evaluating the potential consequences of different management options under various scenarios, considering uncertainties inherent in natural systems and human activities (Kaplan et al., 2021).

NOAA Fisheries incentivizing the use of MSE through grant or research funding would not only require the integration of environmental factors, including climate change effects into fishery management models, by incorporating climate science data and predictions, as well as simulating various climate scenarios and their potential impacts on fishery dynamics, managers can identify vulnerabilities and prioritize adaptation measures. This all leads to more informed decision-making and proactive adaptation planning.

Additionally, NOAA Fisheries should incentivize the use of MSE because climate change introduces significant uncertainties into fisheries management, including changes in species distribution, productivity, and ecosystem structure (Walton & Krupp, 2019). MSE provides a structured framework for assessing the robustness of management strategies under different climate scenarios and uncertainty levels. By quantifying the potential consequences of different management options, managers can make more informed decisions that account for some of this uncertainty.

Requiring or incentivizing MSE in U.S. fisheries management could significantly improve the collaboration and decision-making processes between climate scientists and managers, thus reducing friction between the two groups and enhancing the development of climate-resilient fisheries. NOAA Fisheries does have MSE as a part of their Integrated Toolbox, but it is not required to be used in all jurisdictions (*FIT Tool: Management Strategy Evaluation*, n.d.).

### *NOAA Fisheries should standardize the way that data is stored across the Councils to improve accessibility for both scientists and managers.*

Most fishery data systems are outdated and often siloed, making it difficult for the best available science to inform management decisions (Shields et al., 2024). This is changing, but NOAA Fisheries should do more to aid in this transition to centralized data storage. A centralized data hub can streamline reporting requirements, provide a more comprehensive view of a specific fishery and the ecosystem it operates in, and would ultimately reduce administrative burden since there would not be disparate data centers of which scientists and managers rely to make policy (Shields et al., 2024). Standardized data storage is critical for promoting effective fisheries management and ensuring the long-term sustainability of marine resources.

# Outcomes Matrix[[3]](#footnote-3)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Knowledge Integration & Collaboration** | **Political Feasibility** | **Reduction in Administrative Burden** | **Outcome** |
| **1a** – *encourage knowledge co-production* | 3 | 3 | 2 | **8** |
| **1b** – *communication & education efforts* | 3 | 3 | 2 | **8** |
| **2a** – *fund* *stock assessments* | 3 | 3 | 1 | **7** |
| **2b** – *climate-scenario planning* | 2 | 2 | 1 | **5** |
| **3a** – *governance frameworks* | 2 | 1 | 1 | **4** |
| **3b** – *Management Strategy Evaluation* | 2 | 2 | 1 | **5** |
| **3c** – *data accessibility* | 3 | 3 | 1 | **7** |

# Analysis of Alternatives by Criterion

* Increasing collaboration and communication between scientists and managers will lead to more effective and well-informed management decisions. More interaction and shared knowledge will help bridge gaps and reduce friction in the science-to-management pathway.
* Better stock assessments will lead to more sustainable fisheries management. Therefore, a lack of stock assessments undermines effective management.
* Climate scenario planning is a worthwhile investment of time and resources, and adaptation planning is unavoidable even if not uniformly embraced by every Council.

**KEY ASSUMPTIONS**

The following analysis discusses each alternative by criterion in an effort to show the tradeoffs inherent in choosing one alternative over another. This analysis is grounded in the previous literature cited and is a good-faith attempt at ranking each alternative based on the rather nebulous managerial concepts cited throughout this paper.

## Knowledge Integration & Collaboration[[4]](#footnote-4)

Alternative 1, *Improved Communication* *(1a and 1b)* score highly on this criterion since both sub-alternatives directly address knowledge integration and collaboration. Alternative 1a, which encourages knowledge co-production by increasing collaboration between scientists and managers early in the management process, aims to facilitate direct knowledge sharing and integration from the outset. Alternative 1b, which calls for more communication and education efforts, would also enhance knowledge integration by bridging gaps and reducing potential misunderstandings between scientific and management perspectives. Both alternatives could lead to a significant increase in the number of new opinions shared within the management base, thereby enhancing overall collaboration and reducing friction in the science-to-management pathway. As previously mentioned, co-production is a highly effective way of bridging the barriers that can exist between those with expertise and those tasked with creating management decisions (Cooke et al., 2021; Cvitanovic et al., 2015; Fazey et al., 2014).

Alternative 2, *Reprioritizing Allocated Money to Fund Existing NOAA Programs (2a and 2b)* may have an indirect positive impact on knowledge integration and collaboration. Alternative 2a, which prioritizes and funds advancements in stock assessments for fisheries lacking adequate assessments, could improve the quality and reliability of scientific data available to managers, potentially reducing misunderstandings or conflicts arising from incomplete or outdated information. Stock assessments are the “backbone of fishery management” and are vital for understanding how different ecological factors impact fish stocks (Fisheries, 2023a).

Alternative 2b, which calls for funding climate-scenario planning for all Councils, could facilitate more informed decision-making by integrating climate-related knowledge into the management process. Climate scenario planning is one tool U.S. fisheries can use to adapt to climate changes and it is already being deployed in many Councils (*East Coast Climate Change Scenario Planning*, 2024; Frens & Morrison, 2020). While these alternatives do not explicitly focus on enhancing direct collaboration between scientists and managers, they focus on creating more robust metrics that managers use to make informed decisions. Ensuring all Councils use the best metrics is a way to enhance communication between the two groups.

Alternative 3*, Management Changes (3a, 3b, and 3c)* could potentially improve knowledge integration and collaboration, but the extent of their impact is less clear. Alternative 3a, which integrates climate-related governance frameworks and decision-making procedures scores highly on this criterion because doing so could create opportunities for increased interaction between scientists and managers by having a council-mandated process dedicated to discussing climate information. Alternative 3b, which incentivizes the use of Management Strategy Evaluation (MSE) is a kind of knowledge co-production as it creates potential outcomes on which to base management decisions. Alternative 3c, which standardizes data storage across Councils, could improve accessibility and sharing of information, but does not directly address knowledge integration or collaboration between scientists and managers.

Overall, the *Improved Communication* alternatives *(1a and 1b)* score the highest on the Knowledge Integration & Collaboration criterion, as they explicitly aim to enhance interaction, knowledge sharing, and reduce friction between scientists and managers. The case studies provided in the appendices of this paper also provide examples of successful knowledge integration and collaboration in actual fisheries issues that have occurred in recent years.

## Political Feasibility

* Fragmented, outdated data systems are a barrier to effective integration of scientific information into management decisions.
* There are ample NOAA Fisheries initiatives and programs addressing climate resilience, but they are primarily constrained by resources.
* Councils value autonomy in their management and governance decisions.
* Political feasibility can be reliably assessed based on factors like cost, deviation from the status quo, and potential pushback from stakeholders.

**Key assumptions**

Alternative 1, *Improved Communication (1a and 1b)* is relatively feasible. Alternative 1a aligns well with NOAA Fisheries' mandate to integrate science into fisheries management and, in many cases, is already happening at the Council level (Fisheries, n.d.-a). Therefore, this alternative deviates little from the status quo. If anything, it may improve efficiency over the long term. Politically, this alternative would likely be well received by Councils, scientists, and industry who often express frustration with science outputs being presented without their input (Hays, 2022).

On one hand, Alternative 1b aligns well with NOAA Fisheries’ existing priorities to incorporate climate information into fisheries management (Fisheries, n.d.-a). Many NOAA scientists would likely welcome raising attention on this issue and be willing to help communicate the latest research insights. However, significant skepticism and resistance from both commercial and recreational fishermen poses barriers. Experience shows fishermen often view climate-driven regulation changes as direct threats to their livelihoods (Hays, 2022). Even if messaging frames the goal as ensuring long-term resource sustainability to support ongoing fishing access, overcoming their bias presents challenges. Additionally, while NOAA Fisheries produces abundant outreach, organized resistance to previous climate-related campaigns regarding catch limits and marine protected areas may dull leaders’ appetite for engaging on this potentially contentious issue (*How Foreign Private Equity Hooked New England’s Fishing Industry — ProPublica*, n.d.). Outreach takes resources as well, and NOAA Fisheries may judge that the cost is a limiting barrier. However, both alternatives could potentially enhance efficiency and industry buy-in over the long term, making them more palatable than sweeping top-down mandates like Alternative 3a.

Alternative 2a, which focuses on funding stock assessments, scores highly (3 out of 3) on political feasibility. Stock assessments are fundamental for sustainable fisheries management, and NOAA Fisheries is mandated to incorporate the best scientific information available (Fisheries, n.d.-a). However, many fisheries lack rigorous quantitative assessments, undermining this effective tool. This alternative offers a practical, defensible way for NOAA Fisheries to fulfill its core objective of supporting science-based decision-making. While not inexpensive, comprehensive stock assessments are achievable through collaboration with Councils’ Science and Statistical Committees and external partners (*Scientific and Statistical Committee*, 2024). Stock assessments are crucial for understanding fisheries as a dynamic system (Bonfil, 2005)—of which climate shocks are changing significantly— so it follows that this alternative is highly politically feasible even though it is costly to implement.

Alternative 2b, which focuses on climate scenario planning, ranks slightly lower (2 out of 3) on political feasibility. Climate scenario planning is a way to incorporate uncertainty about climate impacts into management decisions by imagining potential scenarios under different conditions (Frens & Morrison, 2020). In a word, it is being *proactive*. This would be politically feasible since much of this work is already being done at the Council level (*East Coast Climate Change Scenario Planning*, 2024). However, while this alternative assumes funding would come from a reprioritization of NOAA Fisheries funding, the decision to fund would inevitably compete with other priorities in NOAA's budget which could lead to pushback. Furthermore, mandated planning for all Councils could add administrative burden to Councils who have not invested in significant climate-scenario planning. Nonetheless, the rising visibility of climate impacts makes planning inevitable, making this alternative relatively feasible.

The management changes proposed in 3a, 3b, and 3c present varying levels of political feasibility. The first, 3a, which mandates integrating climate governance frameworks, risks backlash from Councils protective of their autonomy and could strain agency resources. In contrast, 3b's incentivization of MSE aligns with promising climate resilience techniques and could be implemented through fund reallocation, making it more feasible than 3A's top-down approach. MSE’s main barrier is the expertise and resources needed to develop custom models (Goethel et al., 2019). With Councils at varying stages of readiness to incorporate MSE, reallocating existing NOAA funds seems plausible and would likely see only minimal political resistance.

Alternative 3c, which calls for standardized data storage, poses minimal deviations from NOAA's mission and therefore ranks as a 3 on this scale. Having streamlined data management is vital for collaboration and climate-resilient governance in fisheries management. One reason this alternative ranks highly is because it poses no major deviations from NOAA Fisheries’ mission and technological capabilities when it comes to data (Fisheries, 2022a). Resistance could come from Councils if changes are poorly communicated or there is high administrative burden for implementing a centralized data system. But proper funding and training for new data platforms could overcome this. With Congressional oversight bodies increasingly focused on data modernization efforts across agencies, NOAA leadership has motivation to pursue this alternative (Walch, n.d.).

Overall, the alternatives under 1 and 2 appear to be the most politically feasible, as they build on existing practices and offer practical, defensible approaches to climate resilience. The management changes in 3, particularly 3A, face greater potential resistance due to their broader scope and potential negative impacts on Council autonomy and agency resources.

## Reduction in Administrative Burden

Alternative 1*, Improved Communication (1a and 1b)* is likely to have a relatively lower administrative burden compared to the other options. Increasing collaboration between scientists and managers early in the process (1a) and undertaking more communication and education efforts (1b) would primarily require additional coordination, meetings, and outreach efforts. Scientists and managers are mandated by the MSA to work together on fishery management policies, so while these activities would demand time and resources from NOAA Fisheries, they would not necessitate significant changes to existing administrative processes (Fisheries, n.d.-a).

Alternative 2, *Reprioritizing Allocated Money (2a and 2b,)* couldpotentially reduce administrative burden in the long run, but may initially prove intensive. Prioritizing and funding advancements in stock assessments (2a) and funding climate-scenario planning for all Councils (2b) would require reallocating budgets and resources within NOAA Fisheries. This process could involve navigating existing administrative procedures and potentially revising funding mechanisms, which could temporarily increase administrative burden. However, once implemented, these alternatives could streamline future management processes by providing improved data and planning tools.

Alternative 3, *Management Changes (3a, 3b, and 3c),* are likely to have the highest administrative burden among the proposed options. Integrating climate-related governance frameworks and decision-making procedures (3a), incentivizing the use of MSE (3b), and standardizing data storage across Councils (3c) would all require substantial changes to existing administrative processes, regulatory frameworks, and management procedures. These alternatives would necessitate revisions to policies, guidelines, and potentially even legislation, which could be time-consuming and resource intensive.

While all alternatives aim to enhance climate resilience in fisheries management, the *Improved Communication* options appear to have the lowest administrative burden, followed by the *Reprioritize Allocated Money* alternatives. The *Management Changes* alternatives, while potentially impactful, would likely face the greatest administrative challenges due to the significant procedural and regulatory changes required for their implementation.

# Recommendation

Based on the above analysis, I recommend Alternative 1: *Improved Communication.* Both sub alternatives score the highest cumulatively on all criteria and the literature supports these communication measures as the most feasible and best practices for improving the science-to-management pathway. When looking at this policy problem holistically, the assumption that underpins the entire problem is that there is a disconnect between science and managers, and more facetime together would help alleviate some of the friction that exists in this pathway. Scholars have different names for this approach, but the two this analysis uses are knowledge co-production and participatory communication. Participatory communication is a communication strategy that centers dialogue and information sharing across groups in an effort to empower all stakeholders (Tufte & Mefalopulos, 2010). In fisheries management, this can look like communicating early and often, keeping two-way flows of information open, having structured forums for sharing perspectives of different stakeholders, and encouraging transparent bilateral communication between all relevant parties to encourage information sharing (Dedual et al., 2013). Like participatory communication, knowledge co-production is the process of bringing together diverse stakeholders including scientists, fishermen, policymakers, and members of the public to jointly produce knowledge that can inform decision-making (Cooke et al., 2021; Norström et al., 2020). By actively engaging stakeholders in decision-making processes, fishery managers can gain important local knowledge and build support for climate-resilient policies through both processes. These approaches prioritize collaborative problem solving rather than top-down management. It also gives fishermen and communities a sense of ownership over fisheries resources and management plans which ensures buy-in to keep fisheries sustainable from multiple perspectives.

# Implementation

This section outlines how NOAA Fisheries can implement the *Improved Communication* alternatives. It is important to note that much of this implementation plan builds off existing structures within NOAA Fisheries, so this plan is meant to help establish a path forward for how NOAA Fisheries could implement improved communication efforts building on the processes they already employ to help address the science-to-management pathway.

**Next Steps:** First, NOAA Fisheries should build on existing structures to establish clear communication channels and knowledge-sharing forums. One key step is to continue to dedicate time in regular meetings and workshops to facilitate the exchange of information, allowing scientists to share research findings, managers to communicate priorities and challenges, and stakeholders to provide insights. The literature on knowledge co-production says that clear frameworks facilitate collaborative processes, so NOAA Fisheries should also encourage Councils to map their processes for implementing climate science into management decisions (Cooke et al., 2021). Councils should follow the blueprint of the North Pacific Council's Climate Change Task Force—an interdisciplinary group who has mapped out their management processes in an effort to see how climate information can be better applied to management decisions (Mason et al., 2023). NOAA Fisheries should encourage other Councils to follow suit. For Councils without formal climate pathways, a useful first step is auditing how information flows between scientists and managers to identify areas for improvement (Soomai, 2017a; Mason et al., 2023). The literature suggests aiming for direct, two-way communication between scientists and managers rather than relying on intermediaries (Dedual et al., 2013). Investing time and resources is crucial to sustain open communication long-term (Dedual et al., 2013).

To reiterate: this implementation plan is not meant to re-invent the wheel as there is already plenty of collaboration between scientists and mangers at the Council level; these communication recommendations are simply meant to bolster the collaboration that already exists by specifically having NOAA Fisheries encourage existing practices be adopted nationally.

**Stakeholder Engagement:** Robust stakeholder engagement and collaboration are crucial for the successful implementation of these alternatives. NOAA Fisheries already has strong relationships with fishermen, coastal communities, environmental groups, and other stakeholders, so they should continue these relationships as they go about incorporating these collaborative approaches.

**Resources and Funding:** Adequate funding and resource allocation are critical considerations for the successful implementation of these alternatives. NOAA Fisheries should assess the financial and personnel required to organize stakeholder engagement activities and provide support to Councils who undertake these activities. One way to do this could be by partnering with non-governmental organizations and industry associations in an effort to help mitigate resource constraints and leverage existing expertise on these issues.

**Risks to Implementation:** One of the potential risks associated with the implementation of these alternatives is the resistance to change and the reluctance to adopt new communication practices. Some stakeholders—especially managers who are already bureaucratically constrained by the Council process— may be hesitant to embrace new platforms or processes, citing concerns about additional workload or perceived infringement on their established ways of operating. To mitigate this risk, NOAA Fisheries should emphasize the long-term benefits of improved communication, such as more informed decision-making, increased transparency, and better alignment of management strategies with stakeholder needs. In the absence of this assumed goodwill, NOAA Fisheries should rely on their long-held relationships with industry partners and environmental groups to help spread this message. Implementing accountability measures, such as requiring reporting on the implementation of these suggestions (e.g., mapping pathways, auditing information flows), is also recommended.

Overall, the implementation of the *Improved Communication* alternatives requires a concerted effort from NOAA Fisheries, but much of this work is already being done; it just needs to be expanded. By fostering an environment of open dialogue, knowledge-sharing, and collaboration, these alternatives have the potential to enhance the effectiveness of fisheries management decisions while ensuring the best available climate science informs those decisions.

# Conclusion

Climate change is already having profound effects on marine ecosystems and the fisheries that call them home. As ocean temperatures rise, species distributions shift, and ecological processes are disrupted, effective management of fisheries requires a deep understanding of these climate-driven changes. This underscores the urgent need to integrate the best available climate science into the decision-making processes that guide fisheries policies. Often, not because scientists and managers are at odds with one another, but because the Council system in which they operate is complex, rigid, and each group responds to different stakeholder interests, there can be friction in the pathway that exists between getting this good climate science to inform management decisions.

The core premise of this paper, therefore, is that there exists a gap between scientific knowledge and management practices, and increasing direct interactions and collaborative efforts between these two groups would bridge this divide. Participatory communication fosters dialogue and knowledge exchange among different stakeholder groups, empowering all parties involved. The case studies provided in the appendix also showcase how the above referenced concepts improve the science-to-management pathway in actual fisheries issues. Knowledge co-production goes a step further by actively involving diverse stakeholders, such as scientists, fishermen, policymakers, and the public in jointly generating knowledge to inform decision-making processes. Through collaborative problem-solving and decision-making that incorporates the best available climate science will ultimately enhance the sustainability of fisheries management for years to come.

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# Appendix A

**Shifts in Biomass Leading to Regulatory Change in the Mid-Atlantic**

Background

Due to climate changes, the distribution and density of black sea bass and summer flounder along the Atlantic coast is changing which is causing management problems at the north and south ends of these species’ ranges (Bell et al., 2020). Scup, summer flounder, and black sea bass are jointly managed under one fishery management plan (FMP) by the Mid-Atlantic Council (*Summer Flounder, Scup, Black Sea Bass*, 2024). Quotas are allotted by state based on historical data of where those fish have been caught, and the FMP stipulates that all fish must be caught in the state in which the vessel is permitted (Bell et al., 2020). Because these stocks are shifting away from their historic habitats, vessels at the south end of the range (near Virginia) have farther to go and less time to fish than vessels at the north end of the range (near New Jersey) where these stocks are more abundant (Bell et al., 2020). Because more black sea bass and summer flounder are shifting ranges, commercial fishermen in the north end of the range are having to discard more legal-sized fish to be in compliance with their quota (Bell et al., 2020; Dubik et al., 2019). This creates a problem since many in the south are not reaching their quotas due to the increased time required to get to where these fish are. Additionally, states like New York are experiencing higher amounts of black sea bass than their historic quota allows due to these shifts and fishermen feel their quotas should change accordingly (*Council Revises Black Sea Bass Commercial State Allocation Recommendations*, 2021).

To combat this issue of shifting stocks, the Mid-Atlantic Council, in collaboration with the Atlantic States Marine Fisheries Commission, wrote Amendment 23 to the FMP, which, among other things, stipulates changing how commercial sea bass allocations are calculated (*Amendment 23*, 2023). At a regional meeting in August 2021, stakeholders agreed to a 1% increase in New York’s allocation of sea bass (*Council Revises Black Sea Bass Commercial State Allocation Recommendations*, 2021). It should be noted that NOAA Fisheries only partially approved Amendment 23 and did not endorse the new state allocations going in the FMP, but because sea bass are jointly managed with the Atlantic States Marine Fisheries Commission, the new state allocations remain in place through the Commission (*Black Sea Bass Commercial State Allocation Amendment (Amendment 23)*, 2023).

How Amendment 23 Enhances the Science-to-Management Pathway

Amendment 23 to the black sea bass and summer flounder FMP is a clear example of the science-to-management pathway working well. At its most basic level, scientists did research to find out the ways in which climate change was impacting fish stocks’ distribution and density and those findings informed new management regulations. This process enhances the science-to-management in a number of ways:

* *Collaboration:* The Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission worked together to develop Amendment 23, ensuring a collaborative approach that considers the perspectives of multiple stakeholders. The amendment was open to public comment which is one way multiple stakeholders’ voices can be heard (*Amendment 23 - Federal Register*, 2023).
* *Responsive to Scientific Findings:* The amendment is a direct response to scientific research that identified changes in the distribution and density of black sea bass and summer flounder stocks along the Atlantic coast. This research provided valuable data on these shifts and allowed managers to adjust the allotments.
* *Adaptive Management:* Amendment 23 demonstrates an adaptive management approach, where management measures are adjusted in response to changing environmental conditions and scientific information. This adaptability is crucial in addressing the dynamic impacts of climate change on fisheries and creating policies that addresses these issues.

Caveats & Limitations

* *Regulatory Complexities:* The case study highlights the regulatory challenges faced in getting full approval from NOAA Fisheries for the proposed state allocation changes under Amendment 23. More broadly, such regulatory complexities hinder the timely incorporation of climate science into management decisions.
* *Management Distrust:* Like any management change trying to address shifting stocks, care must be taken to ensure the historic habitats—and the economies that relied on them—are not forgotten. Distrust of management decisions can stem from such actions, especially if these communities feel they are being left behind (Bell et al., 2020). Fishers’ skepticism of climate science is a major hurdle in addressing the science-to-management pathway (Dedual et al., 2013; Soomai, 2017).
* *Reactive Rather Than Proactive:* This case study highlights how management decisions are reactive to shifting stocks rather than being particularly proactive about them (Bell et al., 2020). Therefore, the question of how such a complex regulatory body like NOAA Fisheries can be proactive about climate changes remains a difficult question. This suggests that management measures need to be continuously adjusted as the impacts of climate change on fisheries evolve.

While Amendment 23 demonstrates a commendable effort to incorporate scientific findings into fisheries management, it also highlights the complexity of balancing ecological, socioeconomic, and regulatory considerations. Ongoing monitoring, stakeholder engagement, and adaptive management strategies will be crucial to address the dynamic challenges posed by shifting biomass distributions effectively.

# Appendix B

**Case Study 2: Research Set-Aside Program**

Background

The Research Set-Aside (RSA) Program, instituted by the New England and Mid-Atlantic Fishery Management Councils, is a unique and innovative approach to bridging the gap between scientific research and fisheries management. RSA programs are competitive grant initiatives designed to fund research projects that can provide valuable data and insights to guide fishery management decisions (Fisheries, 2022b). RSAs allocate a portion of the total allowable catch or quota for a fish stock to fund scientific research projects related to that fishery (Fisheries, 2023f). A percentage of the annual quota is sold or auctioned to commercial fishing entities, generating revenue used to support relevant research about a targeted fish stock (Fisheries, 2023f). This system is particularly noteworthy because it does not rely on federal funding allocations, as the grant money is generated through the auction of catch quotas (Fisheries, 2023f). Currently, the monkfish and sea scallop fisheries are the two active RSAs in the greater Atlantic region. The research funded through these RSAs focuses on addressing critical knowledge gaps and priorities identified by managers, scientists, and stakeholders, such as stock abundance, life history, habitat, and gear impacts (Fisheries, 2023f).

How RSAs Enhances the Science-to-Management Pathway

The RSA Program facilitates effective translation of scientific findings into management decisions in several ways:

* *Collaboration*: RSAs foster collaboration among regulators, researchers, and the fishing industry, ensuring that the research addresses relevant issues and can be effectively integrated into fishery management plans.
* *Relevant Data Collection:* The data that is collected through the RSA provides vital information that feeds directly into stock assessments and management decisions. Stock assessments give managers both the historical and current size of the stocks while also attempting to predict what might happen to a stock given future management changes (Cooper, n.d.). The value of stock assessments is they provide “decision makers with the information necessary to make reasoned choices” (Cooper, n.d.). Stock assessments are one way to stay abreast of climate impacts to fisheries by having researchers be well informed on the ways warming oceans are impacting these ecosystems.
* *Stakeholder Buy-In:* By involving the fishing industry in the research process and compensating vessel owners for their participation (*Research Set-Aside Program*, 2024), RSAs promote stakeholder buy-in and increase the likelihood that scientific findings will be accepted and incorporated into management strategies.
* *Addressing Priorities:* The research funded through RSAs is specifically designed to address the knowledge gaps and priorities identified by managers, scientists, and stakeholders, ensuring that the findings are directly relevant to management needs (Fisheries, 2022b).

Caveats & Limitations

While RSAs have been successful in the greater Atlantic region, broad generalizations should not be made. Below are three limitations to RSAs effectiveness, especially as it relates to an RSA’s ability to bridge the science-to-management pathway:

* *Funding*: Since the program relies on funding from the auction of catch quotas, there may be less funding for research for less valuable fish stocks, even if the value of that research might be high.
* *Limited Scope:* RSA programs are only found in the greater Atlantic region and the only active RSAs currently concern monkfish and sea scallops (Fisheries, 2023f). The limited scope, therefore, makes it difficult to extrapolate broader lessons from such an isolated management tool*.* Additionally, success may be difficult to replicate as there are so few RSA programs currently operating.

The RSA Program represents an innovative and promising model for fostering collaboration, generating relevant scientific data, and facilitating the translation of research findings into concrete management decisions, ultimately promoting more sustainable and climate-resilient fisheries.

# Appendix C

**Case Study 3: Management Strategy Evaluation**

Background

Management Strategy Evaluation (MSE) is a framework that evaluates the potential outcomes and trade-offs of different management approaches across multiple objectives, allowing decision-makers to weigh the pros and cons of each strategy (Smith, 1994). In the realm of fishery management, this means being able to evaluate tradeoffs between different management strategies as they relate to ecological differences across fisheries (Kaplan et al., 2021; Smith, 1994). Rather than dictating a single optimal solution, MSE equips decision-makers with comprehensive information to make well-reasoned choices that align with their specific goals, value judgments, and risk tolerance levels (Smith, 1994). Effective MSE requires clearly defined management goals, performance criteria, a list of management strategies that are being considered, and a way to measure effectiveness (Kaplan et al., 2021; Smith, 1994). While there is no perfect way to measure and predict the effect of a management change, MSE is one of the tools available that allow managers and decision makers to evaluate tradeoffs between different fishery management options (Kaplan et al., 2021).

How MSE Enhances the Science-to-Management Pathway

* *Collaboration*: Collaboration between decision-makers, scientists and relevant industry leaders is at the heart of effective MSE (Smith, 1994). The process of creating clear management objectives and robust evaluative criteria, all while ensuring those goals are in alignment with previous fishery management decisions *is* the science-to-management pathway. And while it may not be given this name, that collaborative process likely involves knowledge co-production and participatory communication—the two psychological concepts underpinning the logic of this report.
* *Clarity*: MSE requires decision-makers to be explicit about management objectives and targets, facilitating a clear understanding of goals and priorities. Clarity is vital for the science-to-management pathway to work effectively, as scientific research can often be presented in a complex and technical manner, making it challenging for individuals without specialized knowledge in those domains to comprehend the information effectively. Consequently, decision-makers and practitioners, such as managers and fishers, face difficulties in interpreting and applying the scientific conclusions (Dedual et al., 2013; Soomai, 2017). Therefore, a management strategy like MSE that requires clarity—specifically agreed-upon objectives and goals early in the process—can help alleviate this barrier in the science-to-management pathway.
* *Scientific Imperative*: The reason reducing barriers in the science-to-management pathway is important is because of the underlying assumption that management decisions using the best available climate science will help ensure fisheries remain resilient to climate impacts. Therefore, the importance of scientific findings cannot be overstated. MSE is a valuable tool because it puts science at the forefront of this evaluation process.

Caveats & Limitations

* *Complexity*: MSE is complex, requiring significant expertise and resources to conduct effectively.
* *Prioritization*: Decision-makers may struggle to prioritize and reconcile competing objectives, making selection of goals a challenge.
* *Data*: Robust data and models are necessary to accurately evaluate performance criteria and account for uncertainties. Getting quality data can be costly and difficult to obtain, especially for Councils who might have strict data rules they have to adhere to.

Despite these limitations, MSE represents a valuable approach for fostering collaboration, clarifying objectives, evaluating management strategies, and facilitating informed decision-making based on a comprehensive understanding of trade-offs and uncertainties.

1. To learn more about a successful NOAA Fisheries program that can improve the science-to-management pathway, see the case study in Appendix B about research set-aside programs. [↑](#footnote-ref-1)
2. For more detail on ways MSE can be implemented in fisheries management, see the case study in Appendix C. [↑](#footnote-ref-2)
3. Based on cumulative scores by criterion: Green = best; yellow = fair; red = poor [↑](#footnote-ref-3)
4. To see an example of successful knowledge integration and collaboration in the science-to-management pathway see the case study in Appendix A. [↑](#footnote-ref-4)