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POLICY ASSESSMENT OF FISHERIES MANAGEMENT IN THE FACE OF CLIMATE CHANGE: IMPLICATIONS FOR THE NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Grace Omer
University of Rhode Island, graceomer@uri.edu

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GRACE OMER

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GRACE OMER

APPROVED:

Thesis Committee:

Major Professor: Jesse Reiblich

Whitley Saumweber

Jason McNamee

Brenton DeBoef

DEAN OF THE GRADUATE SCHOOL

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ABSTRACT

A comparative policy analysis was conducted to examine the current efforts, priorities, and goals for climate adaptive fisheries management at the Federal, Regional, and State level from 2014-2024 by categorizing the resulting documents into four climate adaptive management elements. We are currently encountering a novel challenge in effectively responding to environmental changes resulting from the effects of climate change. This study establishes the expectations of the Federal and State governments and how the New England Fishery Management Council (NEFMC) is responding to those expectations. The federal government (through documents, legislation, and Executive Orders) has established a low bar of expectations, only calling for increased research on climate change impacts on marine resources and broad actions or guidelines with no direct strategy for implementation. The exception to this is the NOAA Fisheries Ecosystem-Based Fisheries Management Policy (effective 2016) and the NOAA Fisheries Ecosystem-Based Fisheries Management Road Map (effective 2017) which established the only clear expectation of an all-inclusive climate adaptive management framework, along with direction on how to implement it. State governments lacked climate action plans specifically tailored for fisheries, beyond the mandated Wildlife Action Plans, lack comprehensive strategies to address climate-related stressors affecting their marine resources. The NEFMC has begun effort towards climate adaptive management through their

draft eFEP for Georges Bank that provides a more flexible and adaptive management strategy by creating a plan that considers a broader range of goals, objectives, and improvements of ecosystem services. However, this document represents the beginning and can serve as a model for addressing similar challenges faced by other species affected by climate change, such as shifts in stock distribution. This study aims to identify State and Federal management strategies that promote climate adaptive fisheries management and assess strategies for the NEFMC to implement for future management strategies.

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PREFACE

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CHAPTER 1: INTRODUCTION

Sea level rise, ocean acidification, rising ocean temperatures, and altered ocean circulation patterns are all environmental effects of climate change that researchers are documenting on a global scale. These trends are expected to continue and worsen into the next century, affecting all aspects of humanity's use of the ocean and its resources (Sumaila et al., 2011; Ding et al., 2017). Effects of climate change are exemplified through changes of ecosystem productivity, shifts in fish-stock distribution and a global underperformance of marine fish capture putting stress on global food security (Brander, 2010, Rice & Garcia, 2011). Specifically, the U.S. Northeast Continental Shelf has been experiencing ocean warming faster than the global average over the last decade (Pershing et al., 2015; Caesar et al., 2018). Because of these environmental alterations caused by climate change, fish species have shown shifts in stock distribution all along the East Coast. There are multiple factors that require climate adaptive fisheries management, from shifting stocks to outdated fisheries management, the need for adaptive efforts is stronger than ever. The Federal Government and State Governments are advocating for climate mitigation strategies through various plans, yet we still face the problem of lacking effective policies for fisheries management in an anthropogenic impacted marine environment due to climate change. Management policies within the New England Fishery Management Council (NEFMC) need to shift to include measures of adaptation and aspects of

flexibility to effectively conserve our resources and maintain sustainable fisheries.

This research identifies the existing management priorities and goals proposed by the Federal Government and State Governments to address climate change issues within fisheries management and assesses the extent to which NEFMC aligns with the proposed efforts established by these governmental bodies in response to these challenges. To accomplish this goal, I conducted a comparative policy analysis to examine the current efforts, priorities, and goals for climate adaptive fisheries management at the Federal, Regional, and State level by categorizing the resulting documents and strategies into four climate adaptive management elements. The outcome of this study is to propose solutions on how the NEFMC can move forward to achieve these goals, executing climate adaptive fisheries management.

The three hypotheses guiding this research study are as follows:

- How is the Federal Government and State Governments working to advance climate-adaptive fisheries management?
- Is the New England Fishery Management Council meeting the expectations that Federal and State Governments are establishing?
- How can the New England Fishery Management Council fulfill the expectations established by these governing bodies?

CHAPTER 2: LITERATURE REVIEW

1. Climate & Fisheries: Biophysical

The world's population has grown more rapidly in the past two centuries than ever before, growing from 1.65 billion to six billion in just the twentieth century (Sadigov, 2022). According to current estimates, the world's population is more than 7.8 billion people (Gibson et al, 2006; Sadigov, 2022; US census bureau). As the human population grows at a rapid pace, so does the anthropogenic effect on the environment. To accommodate such a fast-growing population, the mass production of goods and the destruction of our natural resources through commodification is at an all-time high (Rice & Garcia, 2011). The evolution of industrialization, technological innovations, economies, territorial expansions, and agriculture has increased the total amount of pollutants pumped into the atmosphere (Wadanambi & Wandana, 2020). Carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (P.F.C.s), and sulfur hexafluoride (SF6) are known as greenhouse gasses (GHG) (Wadanambi & Wandana, 2020). These GHG are deliberately emitted by countries to drive economic growth and enhance human well-being (Jorgenson, 2014), but emissions of this magnitude have unprecedented effects on the environment. The carbon dioxide in the atmosphere is the highest it has ever been at for at least the last 15 millennia (Bijma et al., 2013, Tripati et al., 2009, LaRiviere et al., 2012). This large amount of carbon dioxide in the atmosphere has led to chemical and physical impacts on the environment. One direct impact of this is

ocean acidification. The ocean acts as one massive carbon sink, currently absorbing up to 25% of anthropogenic carbon emissions from the atmosphere annually (Heinze et al., 2015). Due to this natural carbon sink, the ocean has become 30% more acidic and is projected to continue, creating an ocean that is more acidic than has ever been seen before (Fabry et al., 2008). Along with ocean acidification, another direct impact of GHG emissions is ocean warming. The addition of GHG to the atmosphere has created a positive feedback loop: heat from the Earth's surface is trapped in the atmosphere that would otherwise escape, overall creating the Greenhouse Effect (Doney et al., 2012). Over the last century this has resulted in global ocean temperatures rising about 1.5 degrees Fahrenheit and in response to warming ocean temperatures, sea levels have risen anywhere between 6-8 inches (Doney et al., 2012). Along with these climbing ocean water temperatures and rising sea levels, other aspects of nature are affected as well, such as altered patterns of ocean circulation, precipitation, and the amount of freshwater input entering the oceans (Doney et al., 2012).

Human disruption of the natural processes of marine ecosystems creates a new problem for marine fauna. Marine ecosystems rely on the dynamic exchange of energy among consumers and producers across the food web, which is further cycled through decomposition and detrital pathways (Doney et al., 2012). This natural flow of energy is being disrupted by ocean temperature and altered ocean chemistry, leading organisms to experience shifts in their physiological attributes, spatial changes, and seasonal

abundance of marine organism populations. Organisms that experience changes in temperature, salinity, and oxygen attempt to remain within the best conditions possible, resulting in spatial distributional shifts of certain species (Bell et al., 2015; Nye et al., 2009). The physical environment that marine organisms live in have a direct impact on their overall fitness and reproduction rate at the individual organism level (Bell et al., 2015). Marine species either migrate to an area with more suitable conditions or suffer the consequences of an inhabitable environment.

Additionally, primary production is a crucial part of maintaining biodiversity and the health of fish stocks. In response to altered patterns of ocean circulation, increased uptake of carbon dioxide, ocean acidification and warming, primary production is impacted, affecting food web structures. Food web structure and function is another side effect of climate change. In marine ecosystems phytoplankton are the foundation of marine food webs. Phytoplankton show the most rapid response to climate change because of their smaller size and quick reproduction rate (Brown et al., 2010). In the case of ocean warming, primary production could increase, therefore increasing the productivity of fish stocks and health, which may or may not be helpful to local secondary consumers (Kim & Kim, 2021). While primary production could increase, it may not result in a more productive ecosystem, and can have negative impacts like hindering the production of phytoplankton in ocean environments due to the alteration of water chemistry (Kim & Kim, 2021). With the multiple effects of climate change, it can be complicated to predict the

impacts of what this will do to marine food webs, but it has the possibility to significantly disrupt the balance of marine ecosystems through documented cases of changes in marine populations and communities affecting large predatory fish in most oceans (Myers & Worm, 2005; Rice & Garcia, 2011). Communities across the globe will experience this loss of marine biodiversity and movement of their resources due to shifting stock distribution. One incredibly important thing to consider amongst all these changes is food security. With the human population projected to grow to more than nine billion people by 2050, the expectation of available food increases tenfold. To meet this need, the production of fish must increase by approximately 50% from the current levels (Rice & Garcia, 2011).

The U.S. Northeast Continental Shelf has been experiencing ocean warming faster than the global average over the last decade (Pershing et al., 2015; Caesar et al., 2018). According to the Climate Vulnerability Assessment conducted on fish and invertebrates on the Northeast U.S. continental shelf, of the eighty-two species studied, 50% ranked “very high” or “high” regarding their climate vulnerability (Hare et al., 2016). Negative impacts were estimated for many of the iconic species in the ecosystem that hold ecological, commercial, and recreational value in New England (Hare et al., 2016). Because of climate change, species have shown shifts in stock distribution all along the East Coast. The species covered in this paper are prime examples of stocks that have already shifted or are at risk to shift due to climate change: Black Sea Bass (*Centropristis striata*), Summer Flounder (*Paralichthys*

dentatus), and Winter Flounder (*Pseudopleuronectes americanus*) (Overholtz et al., 2011; Bell et al., 2015; Mazur et al., 2020).

Climate change alters baseline marine ecosystem conditions in ways that are beyond immediate human control through sea level rise, ocean acidification, rising ocean temperatures, and altered ocean circulation patterns (Craig, 2010). Changes in marine ecosystems introduces a variety of complications, affecting familiar ecologies, regulatory management, and economics. The effects of climate change on marine environments are not only transboundary but also multisectoral, affecting various sectors on a broad scale like recreational fisheries, commercial fisheries, and seafood markets. As fish stocks shift their distribution, fishing vessels, recreational fishers, and subsistence fishers are forced to travel longer distances to meet their quotas or adjust their target species. This increased travel could result in additional pollutants and emissions released into the atmosphere. These shifts caused by climate change can also raise concerns about resource accessibility and food security in coastal communities, and beyond. Adaptation to harvesting marine resources raises significant concerns related to the economic and financial dimensions of the fishing industry, as well as its impact on communities and cultures. We have found ourselves in a situation where regardless of the world's mitigation efforts, the effects of climate change on ecosystems are beyond human control. While we are not able to prevent all of climate changes impacts, we can improve the efficiency and effectiveness of our responses to them through adaptive management strategies.

2. Climate & Fisheries: Fisheries Management

Current fisheries management measures are regulated pursuant to the legal requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The MSA is a federal law that governs and directs fishery management measures in the U.S. first passed in 1976. This federal law created eight Fisheries Management Councils (New England Council (NEFMC), Mid-Atlantic Council (MAFMC), South Atlantic Council (SAFMC), Caribbean Council, Gulf Council, Pacific Council, Western Pacific Council, and Northern Pacific Council) to adhere to the conservation and management stipulations outlined by the Magnuson-Stevens Act's 10 National Standards. The national standards dictate that conservation and management measures shall: prevent overfishing, while achieving on a continuing basis, optimum yield; use best scientific evidence available; manage a stock throughout its range and interrelated stocks as a unit or in close coordination with; not discriminate between residents of different states in relation to fisheries allocations; no measure shall have economic allocation as its sole purpose; allow for/take into account variations among fisheries, fishery resources, and catches; minimize bycatch and if bycatch can't be avoided minimize the mortality of bycatch; and promote safety of human life at sea (*16 U.S.C 1851 § 301*). To meet these national standards, the National Marine Fisheries Service (NMFS) is responsible for implementation and enforcing regulations outlined in MSA. NMFS is a federal agency within the National Oceanic and Atmospheric Administration (NOAA) which is tasked with the stewardship of the nation’s

living marine resources, including fisheries management and conservation (*NOAA Fisheries*). Under NMFS requirements, the status of fish stocks is reported annually, providing a summary of the number of stocks overfished, subject to overfishing, and under rebuilding (NOAA Fisheries, 2023). When stocks are overfished, councils are legally mandated to initiate a period of rebuilding, within a 10-year period.

MSA uses management approaches and tools to help regulate fisheries in adaptive measures such as Individual Transferable Quotas (ITQ), Individual Fisheries Quotas (IFQs), Harvest Control Rules (HCRs), Days-at-Sea limits (DAS), co-management through state, regional, and federal management bodies, and time-area closures. These management strategies, along with the proposed use of Ecosystem-Based Fisheries Management (EBFM), shows an increased effort towards adaptive fisheries management. However, stock assessments are not specifically climate informed, and policy/legislation does not yet explicitly mention “climate change” or “climate change adaptation” (Bryndum-Buchholz et al., 2021). While these aspects of MSA are not yet mandated to be climate inclusive, formal efforts are being made to do so. The MSA Reauthorization Act of 2007 refined and strengthened the relationship between fisheries science, management, and conservation in the Act. However, in the years following, there have been no actions put forward to reauthorize or make amendments to MSA besides an Advanced Notice of Proposed Rulemaking, specifically focused on the National Standards. As of October, an ANPR from NOAA took comments to make amendments to

National Standards 4,8, & 9 in response to ongoing fisheries management challenges like changes in environmental conditions, shifting distributions of fish stocks, and equity /environmental justice considerations (*The Federal Register* 2023). This ANPR was in response to two Executive Orders: E.O. 14008 *Tackling the Climate Crisis at Home and Abroad* and E.O. 13985 *Advancing Racial Equity and Support for Underserved Communities.*

An additional management body not dictated by the MSA is the Atlantic States Marine Fisheries Commission (ASFMC) formed in 1942 by fifteen member states for the purpose of “protecting and managing marine fisheries within the states’ jurisdiction” Atlantic States Marine Fisheries Commission, n.d.). Fishery resources that are a shared coastal resource are managed cooperatively by the Atlantic coastal states through the ASMFC. The ASMFC develops and adopts interstate fishery management plans, which are then implemented at the state level. The ASMFC has management plans for twenty-seven nearshore migratory fish species. Each state in the ASMFC has three representatives, who have one combined vote on actions or motions made by the Commission's species management boards. These representatives include:

- The director of the state’s marine fisheries management agency
- A state legislator
- An individual appointed by the state's Governor to represent stakeholder interests.

The Interjurisdictional Fisheries Act also supports the states' management of their shared fishery resources. The Act provides grants to states for management activities. A large part of funds from the Act help pay for the collection of catch and effort statistics and other data for stock assessments which inform management decisions.

There are various policy proposals that advocate for climate adaptive measures for current fisheries management bodies including, but not limited to NOAAs Northeast Regional Action Plan (reflects the implementation of the NOAA Fisheries Climate Science Strategy), E.O. 14008 *Tackling the Climate Crisis at Home and Abroad*, the *Sustaining America's Fisheries for the Future Act of 2021* (H.R. 4690), Turning U.S. Ocean Climate Policy Into Action, The Ocean Justice Strategy and the Ocean Climate Action Plan. The various proposals, recommendations, and legislative actions have a focus on climate change adaptive fisheries management measures. The initiative that is seen on a federal level to be dedicated to climate adaptive fisheries management is evident, but concerns are raised on a regional level as to whether the fisheries management councils have the same priorities and dedication.

3. Adaptation vs Mitigation within Fisheries Management

"Climate adaptive fisheries management" is defined as "precautionary, efficient, and responsive […] that address climate uncertainty, explicitly consider feedbacks within coupled marine social-ecological systems and

integrate tools and policies at multiple spatiotemporal scales" (Holsman et al., 2019). This type of management includes spatial allocations, quota-based fisheries management, and differentiated closure areas (Holsman et al., 2019). Multiple factors necessitate the adoption of a climate adaptive fisheries management framework, from shifting stocks to outdated fisheries management. Climate-informed research studies regarding climate adaptive fisheries management measures have found that none of the major countries mentioned explicitly address climate change impacts on fisheries and marine ecosystems or mandate climate change informed stock-assessments and/or decision-making (Bryndum-Buchholz, et al. 2021). Terms like "mitigation" and "adaptation" within climate policy are often used together without the recognition of complexity for achieving the goals of these terms. Mitigation focuses on the active mechanisms to reduce the causes of climate change such as pollutants and emissions (Tol, 2005). Adaptation refers to anticipatory and reactive actions, and must rely on the abilities of species ecosystems, and socio-ecological systems to respond to contentious alterations in baseline conditions (Tol, 2005). The concept and practice of adaptation often shows complexities from its need to address various layers of governmental interest, as most efforts and measures must be specifically tailored to the local scale or region it regulates. Regarding fisheries management, commentators advocate for a shift from mitigation and restoration to the improvement of resilience and adaptive capacity through adaptation (Craig, 2010.). The focus on mitigating the human effects on fisheries and climate change, while still important and

not to be overlooked, needs to be shifted to focus on adaptation, including adaptive management principles to allow flexibility.

Current management practices require terms of preservation and restoration of marine resources and the environment. Restoration is an attempt to return a resource to a prior “normal” or “natural” state of being, but this is difficult to achieve when the “normal” state of the ecosystem is constantly altered by climate change. Natural resource laws incorporate ideas of preservation and restoration, but these ideas are based on the assumption and expectation that ecosystems are stable and that managers can sustain one historical ecological state of being, when that is not the case in the face of climate change (Craig, 2010.). Preserving and restoring natural resources to an optimal point in time implies that it will be able to stay that way despite environmental and climatic changes. New climate adaptive fisheries management goals should acknowledge and account for potential ecosystem change (Craig, 2010.). When resource managers acknowledge the political and natural uncertainties that come with climate change the more apparent it is that marine resource management should be restructured. The aim of climate adaptive fisheries management is to remain flexible enough to adapt to the ongoing transformation of our ecosystems, thereby enhancing the adaptive capacity of humans, marine species, society, and ecosystems. Regulatory standards should shift from focusing on a “maximum sustainable yield” and similar verbiage in other regulatory standards to “clearly sustainable even under climate change” standards (Craig, 2010.).

Research has identified four key principles for climate change adaptation laws: (1) Scientific Data and Assessment Availability through increased monitoring; (2) Eliminate or reduce non-climate change stressors and otherwise promote resilience; (3) Increased coordination across media, sectors, interests, and governments; and (4) Promote principled flexibility in regulatory goals and resource management; (Craig, 2010., Bryndum-Buchholz et al., 2021). Fisheries management should account for changing ecosystems. Further, because the baseline of these ecosystems can be permanently altered to the point that are beyond immediate human control regardless of mitigation efforts, the only response is to adapt and promote resilience through management frameworks. The overarching goal of climate adaptive fisheries management is to ensure sustainability and conservation under the duress of climate change alterations.

CHAPTER 3: METHODOLOGY

1. RESEARCH FRAMEWORK

To complete this study, a comparative policy analysis was completed to understand the Federal and State governmental efforts, goals, and priorities for the NEFMC in a qualitative manner by categorizing documents, reports, strategies, plans, and initiatives into the four key climate adaptive elements to form content and rhetorical analysis. This research aimed to determine if the Federal and State government's efforts from 2014-2024 are being matched within the NEFMC's initiatives, plans, and priorities. The states selected; Rhode Island, Massachusetts, Maine, New Hampshire, and Connecticut; are found under the jurisdiction of the NEFMC and all contribute to the management of fish stocks in the Northeast region. Focusing on this region highlights how a specific geography will be affected by climate change and shifting fish stock distribution and how they are governed by a specific entity and law.

a. Federal Government

To create a baseline understanding of the Federal policies prioritized, an analysis of literature was first done to identify key elements of climate adaptive management. These elements are as follows: (1) Increased scientific data and assessment availability; (2) Eliminate or reduce non-climate change stresses and otherwise promote resilience; (3) Increased coordination across media, sectors, interests, and governments; and (4) Promote principled flexibility in regulatory goals and resource management (Craig, 2010.,

Bryndum-Buchholz et al., 2021). To identify the Federal policies, the public website Congress.gov was used as the primary source in which legislation was searched. Congress.gov was chosen because it is the official website for U.S. Federal legislative information. It provides access to a wide range of information related to activities of the United States Congress, including bills and resolutions, legislative summaries, and committee reports. Using this database, I searched for “legislation” (including all legislation regardless of the status, ranging from “introduced” to “became law”) with the additional filter selecting the dates between 2014-2024 that included a query of words “climate” and “fisheries.” The year 2014 was used as a starting point to ensure that the analysis was comprehensive of all efforts that were prioritized by the Federal government to promote climate adaptive management strategies over the preceding decade. I used the legislation “tracker” provided by Congress.gov to identify the progress of legislation as it moves through the legislative process. The list of legislations produced was then sorted into five groups which reflect the climate adaptive management elements (Craig, 2010):

1) Increased scientific data and assessment availability for the impacts of climate change with additional focus on conservation and restoration.
2) Climate impacts for the community including disaster relief, resiliency, and economic risks.

3) Increased coordination across media, sectors, interest, and governments.
4) Eliminate or reduce non-climate change stresses and otherwise promote resilience.
5) Legislation that aligns with two or more elements with a focus on fisheries

All legislation that did not meet the criteria of the elements above were excluded from the analysis. To reduce redundancy of the same legislation introduced into the House and Senate, bills were combined. Legislation that offered recognition of a specific day was not included in the analysis as it did not call for action besides recognition. To determine whether legislation met these criteria, the entirety of the informational text provided (proposed Bill from either the House or the Senate) was analyzed to determine specifics of the text aligned with the criteria.

Executive Orders were analyzed using The Federal Register National Archives for Executive Orders. This database displays Executive Orders signed since 1937, which are sorted by year and President. Using this database, I analyzed and sorted Executive Orders from 2014-2024 in accordance with the five groups outlined above. All Executive Orders that did not meet the criteria of the elements above were excluded from the analysis.

Upon consideration, it is evident that no single database offered a comprehensive list of Federal documents, including management strategies, action plans, and initiatives. To compile a comprehensive list, an analysis of

these documents was conducted using three primary sources: Regulations.gov, NOAA.gov, and The Federal Register Daily Journal of the U.S. Government. These databases were chosen because Regulations.gov specifically focuses on regulatory information and NOAA.gov is the official database for the National Oceanic and Atmospheric Administration that provides a wide range of information including regulatory information related to NOAA's jurisdiction. The Federal Register serves as the official publication for announcing federal regulations and government activities. Using these three primary databases, I analyzed all management strategies, action plans, and initiatives from 2014-2024 in accordance with the five elements outlined above. All Federal documents that did not meet the criteria of the elements above were excluded from the analysis. Through this analysis, additional themes and patterns were identified.

b. State Governments

For the State government analysis, there were no comprehensive databases I could use for this research, so a search engine, like Google, was used to arrive at each state government website that is responsible for fisheries management. State government plans and initiatives were then analyzed using the respective state's environmental management websites. The states selected; Rhode Island, Massachusetts, Maine, New Hampshire, and Connecticut, are found under the authority of the NEFMC and all contribute to the management of fish stocks in the Northeast region. Each state has a wildlife and fisheries department or division that is used to manage

their respective marine and land resources. For each state, the departments are as follows: State of Rhode Island Department of Environmental Management (RIDEM), Massachusetts Division of Fisheries and Wildlife (MassWildlife), State of Maine Department of Marine Resources, New Hampshire Fish and Game Department, and Connecticut Department of Energy and Environmental Protection (DEEP). The respective websites were searched for all action plans and management strategies currently implemented that promote climate adaptive management behaviors for each state regarding their fisheries resources.

c. New England Fishery Management Council

The New England Fishery Management Council website, NEFMC.org, was utilized to analyze management plans and relevant documents to evaluate current strategies, plans, or initiatives relevant to the advancement of climate adaptive fishery management.

2. RESEARCH QUESTIONS

This project was designed to identify the current management strategies, priorities, and frameworks established by the Federal Government, State Governments within the New England Fishery Management Council jurisdiction, and the Atlantic States Marine Fisheries Committee. The three research questions guiding this research project are as follows:

- How is the Federal Government and State Governments working to advance climate-adaptive fisheries management?

- Is the New England Fishery Management Council meeting the expectations that the Federal and State Governments are establishing?
- How can the New England Fishery Management Council fulfill the expectations established by these governing bodies?

3. GEOGRAPHIC AND SPECIES SCOPE OF RESEARCH

I opted to concentrate specifically on the New England region, not only to narrow the scope of the assessment but also due to findings in the Climate Vulnerability Assessment for the New England region. This assessment underscores the imperative for climate-adaptive fisheries management to address the vulnerability of “fish and invertebrate species in the Northeast U.S. Shelf that are highly or very highly vulnerable to climate change” (Hare et al., 2016). This vulnerability manifests through shifting stock distribution, a decline in ecosystem productivity, and potential loss of biodiversity. This scope encompasses a varying range of species that have the potential to shift through different regions of management as climate change continues to affect their habitats. Compared to other areas in the U.S. the East Coast manages fisheries on a federal level through three different management bodies: NEFMC, MAFMC, and SAFMC. With various fish species already showing signs of stock distribution shifts, this creates complex management challenges regarding allocations and possession limits (Bell et al., 2015). Thus, making

the U.S. Northeast region the ideal range to focus on climate adaptive fisheries management.

The species in focus on the East coast, Black Sea Bass (*Centropristis striata*), Summer Flounder (*Paralichthys dentatus*), and Winter Flounder (*Pseudopleuronectes americanus*) are at risk of or have already been affected by climate change through shifting stock distribution and are all considered to be high or very highly vulnerable to various other climate change impacts (Overholtz et al., 2011; Bell et al., 2015; Mazur et al., 2020). While all these species are not under jurisdiction of the NEFMC these species are economically and recreationally important for the New England region, and their potential demise would have unprecedented effects on fishing participation and the economic viability of New England's commercial industry.

CHAPTER 4: FINDINGS

1. FEDERAL GOVERNMENT

a. *Legislation*

A total of eighty-three pieces of legislation were introduced from 2014-2024 when queried “climate” and “fisheries” that resulted in specific mention of one or more of the five key elements of climate adaptive management. The following section is divided into five groups, each corresponding to climate adaptive management elements.

Increased Scientific Data and Assessment Availability for the Impacts of Climate Change with Additional Focus on Conservation and Restoration.

A total of twenty-five pieces of legislation were identified to align with this element of climate adaptive management, emphasizing restoration, conservation, and increased scientific data on the impacts of climate change. Among these, twenty-one bills remained at the introduction stage, while two bills have passed the House, two bills passed the Senate, and one became law.

The legislation primarily focused on research initiatives addressing various climate-related issues such ocean acidification, sea-level rise, working waterfronts, and the conservation and restoration of marine ecosystems. Notable bills promoting research initiatives to address the effects of ocean and coastal acidification on ecosystems vulnerability include the Ocean Acidification Innovation Act of 2019 (*H.R. 1921*) which passed House, Coastal

Communities Ocean Acidification Act of 2023 (*S.1808*), Ocean Acidification Research Partnerships Act (*H.R.2734*), COAST Research Act of 2019 (*H.R. 1237*), OCEAN Research Act (*S. 2699*), and Coordinated Ocean Monitoring and Research Act (*S. 1886*). Legislative proposals addressing sea-level rise research include Hudson River Climate Change Protection Act (*H.R.7220*) and Coastal Resilience Research and Education Act (*H.R.5102*). Working waterfronts encompasses water resources such as coastlines or bodies where maritime activities take place which could be affected through impacts of climate change. Bills that promote research concerning the health, development, and protection of the U.S. waterfronts include Beach Act of 2017 (*S.1622*), Beach Act of 2015 (*H.R. 4136*), Water for Tomorrow Act of 2020 (*S.4188*), Keep America's Waterfronts Working Act (*H.R.6641*), Reclamation Climate Change and Water Program Reauthorization Act of 2023 (*H.R.3027*).

The only bill to become law was the Protect and Restore America's Estuaries Act (*H.R. 4044*) in January of 2021. This law prioritizes the reauthorization and revision for the for National Estuary Program, providing grants for estuary protection, restoration, and coastal resiliency projects. Two bills, the Coordinated Ocean Monitoring and Research Act of 2015 (*S.1886*) and the Restoring Resilient Reefs Act of 2020 (*S. 2429*), successfully passed the Senate. Both legislations share commonality on establishing plans and standards to combat climate change, with minor differences in focuses. While the Restoring Resilient Reefs Act of 2020 aims to strengthen federal actions to preserve coral reef ecosystems, the Coordinated Ocean Monitoring and

Research Act of 2015 addresses ocean chemistry concerns, particularly ocean acidification, to enhance scientific data accessibility and abundance.

Additionally, twelve of the identified bills propose grant funding to establish research proposals, restoration projects, and program expansions to continue their research on climate related issues and conservation of marine resources.

Climate impacts for the community including disaster relief, resiliency, and economic risks.

A total of sixteen pieces of legislation were found to fit under this element of climate adaptive management drawing focus onto climate impacts for communities including vulnerability assessments, planning, and environmental and economic risk management initiatives. Among these, one piece of legislation has passed the House and all remaining bills have not proceeded past the introduction stage. The Coastal Communities Ocean Acidification Act of 2023 (*H.R. 676*), introduced in January of 2023 is the only bill that has moved forward past the introduction stage. This bill includes collaboration on a state, local, and tribal level to conduct vulnerability assessments, research, and climate action plans related to ocean and coastal acidification and their impacts on coastal communities. Other bills include the Coastal State Climate Change Planning Act of 2015 (*H.R. 1276*) which includes amending the Coastal Zone Management Act 1972 to establish “coastal climate change adaptation planning and response programs” to

develop adaptation plans to minimize contributions to climate change and reduce the consequences of climate change and provide technical and financial assistance to implement those plans through enforceable policies. The financial and economic risk posed by climate change are crucial considerations to integrate into climate action plans. These concerns have been addressed in legislation such as the Insular Area Climate Change Act (*H.R. 2780*), the Climate Change Financial Risk Act of 2021 (*H.R. 3571*), the Climate Change Financial Risk Act of 2019 (*H.R. 5194*), the Coastal Communities Adaptation Act (*H.R. 1317*), the RESPOND Act of 2020 (*H.R. 8760*) and the previously mentioned Coastal State Climate Change Planning Act (*H.R. 1276*). Four pieces of legislation focuses on providing grants to incentivize communities to adopt climate-resilient actions management strategies, rather than directly addressing financial or economic risks. Those bills include measures such as the Resilient Ports Act (*H.R. 3033*), a bill that requires the Administrator of the National Oceanic and Atmospheric Administration to award grants to certain entities for purposes of carrying out climate-resilient living shoreline projects that protect coastal communities, the Ocean Acidification Research Partnerships Act (*H.R. 8456*), Climate Resilience Workforce Act (*H.R. 5760*), and the Coastal Communities Adaptation Act (*S. 2783*). Other legislation under this element focuses primarily on research and expanding knowledge about the impacts of climate change on communities. This includes the Coastal Communities Ocean Acidification Act of 2023 (*H.R. 676*), the FEMA Climate Change Preparedness

Act (*H.R. 4823*), and Coastal Communities Ocean Acidification Act of 2019 (*S. 778*).

Increased coordination across media, sectors, interest, and governments.

A total of four pieces of legislation were found to exclusively align with this element of climate adaptive management. In my selection, I aimed to focus on bills addressing climate change across a wide variety of media, sectors, interests, and governments, including partnerships, coordination and collaboration efforts aimed at mitigation on a national level as well as international. While other legislation across the different elements mentioned may touch upon coordination and collaboration between local and state governments, it was not the primary objective of those bills. These four bills are centered on global climate change issues and the broad spectrum of partnerships involved in mitigation efforts: United States Climate Leadership in International Mitigation, Adaptation, and Technology Enhancement Act of 2021 (*S. 1201*), the BLUE Pacific Act (*S. 4811*), the Climate Security Act of 2019 (*S. 745*), and Prioritizing Clean Energy and Climate Cooperation with India Act of 2020 (*S. 4759*). All legislation listed under this element have not passed the introduction stage of the legislative process.

Eliminate or reduce non-climate change stresses and otherwise promote resilience.

A total of twenty-nine bills were found to fit under this element of climate adaptive management. The priorities of this element include aspects of reducing non-climate related stressors on the environment, reduction of greenhouse gasses and emissions, and promoting resiliency. Resiliency takes many forms, notably through transitioning away from fossil fuels, embracing innovations in green energy, and investing in blue carbon ecosystems that play a crucial role in mitigating climate change by capturing carbon dioxide and storing it as seen through various bills mentioned in Table 1.

Climate Adaptive Management Elements	Legislation				
	Introduced	Passed House	Passed Senate	To President	Became Law
Increased Scientific Data and Assessment Availability for the Impacts of Climate Change with Additional Focus on Conservation and Restoration.	Coastal Communities Ocean Acidification Act of 2023 (S.1808); Ocean Acidification Research Partnerships Act (H.R.2734); COAST Research Act of 2019 (H.R. 1237); OCEAN Research Act (S. 2699); Coordinated Ocean Monitoring and Research Act (S. 1886);Hudson River Climate Change Protection Act (H.R.7220); Coastal Resilience Research and Education Act (H.R.5102); Beach Act of 2017 (S.1622), Beach Act of 2015 (H.R. 4136); Water for Tomorrow Act of 2020 (S.4188); Keep America's Waterfronts Working Act (H.R.6641); Reclamation Climate Change; Water Program Reauthorization Act of 2023 (H.R.3027)	Ocean Acidification Innovation Act of 2019 (H.R. 1921)	Coordinated Ocean Monitoring and Research Act of 2015 (S.1886); Restoring Resilient Reefs Act of 2020 (S. 2429)	x	Protect and Restore America's Estuaries Act (H.R. 4044)
Climate impacts for the community including disaster relief, resiliency, and economic risks.	Coastal Communities Ocean Acidification Act of 2023 (H.R. 676); FEMA Climate Change Preparedness Act (H.R. 4823); Coastal Communities Ocean Acidification Act of 2019 (S. 778); Resilient Ports Act (H.R. 3033); A bill to require the Administrator of the National Oceanic and Atmospheric Administration to award grants to certain entities for purposes of carrying out climate-resilient living shoreline projects that protect coastal communities, and for other purposes (S. 2633); the Ocean Acidification Research Partnerships Act (H.R. 8456); Climate Resilience Workforce Act (H.R. 5760); the Coastal Communities Adaptation Act (S. 2783); Insular Area Climate Change Act (H.R. 2780); the Climate Change Financial Risk Act of 2021 (H.R. 3571); the Climate Change Financial Risk Act of 2019 (H.R. 5194); the Coastal Communities Adaptation Act (H.R. 1317); the RESPOND Act of 2020 (H.R. 8760); and the Coastal State Climate Change Planning Act (H.R. 1276).	Communities Ocean Acidification Act of 2023 (H.R. 676),	x	x	x
Increased coordination across media, sectors, interest, and governments.	United States Climate Leadership in International Mitigation, Adaptation, and Technology Enhancement Act of 2021 (S. 1201); the BLUE Pacific Act (S. 4811); the Climate Security Act of 2019 (S. 745); and Prioritizing Clean Energy and Climate Cooperation with India Act of 2020 (S. 4759)	x	x	x	x
Eliminate or reduce non-climate change stresses and otherwise promote resilience.	Break Free From Plastic Pollution Act of 2020 (H.R. 5845); Land-Based Marine Debris Reduction Act (H.R. 1960); Save Our Seas Act 2.0 (H.R. 3969/S. 1982); Oil Spill Prevention Act (S.74/H.R.2261/S.1430); CLEAN Future Act (H.R.1512); Super Pollutants Act of 2015/2014 (S. 2076 / S. 2911); the 100 by '50 Act (H.R. 3314 /S. 987); American Public Lands and Waters Climate Solution Act of 2019 (H.R. 5433); the CREATE Act of 2020 (S. 4341/H.R. 8671); Methan Emissions Reduction Act of 2021 (H.R. 4048); Sustainable Energy Development Reform Act (H.R.4426); Energy Infrastructure Act (S. 2377); Department of Defense Climate Resiliency and Readiness Act (H.R. 2759); EFFECT Act of 2019 (S. 1201), Hydropower Clean Energy Future Act (H.R. 7410); Off Fossil Fuels for a Better Future Act (H.R. 3671); American Energy and Conservation Act of 2016 (S. 3110); Blue Energy Innovation Act of 2022 (H.R. 6680); Clean Economy Jobs and Innovation Act (H.R. 4447); Fossil Energy Research and Development Act of 2018 (H.R. 5745); Blue Carbon Protection Act (H.R. 3906); Blue Carbon for Our Planet Act (H.R. 2750); SEA FUEL Act of 2019 (S.1679/H.R.3227); and Blue Carbon Protection Act (H.R. 3906)	x	x	x	x
Legislation that aligns with two or more elements with a focus on fisheries.	Marine Mammal Climate Change Protection Act (H.R. 1383); SHIFT (Supporting Healthy Interstate Fisheries in Transition) Act (S. 3672); Sustaining America's Fisheries for the Future Act of 2022 (H.R. 4690); Climate-Ready Fisheries Act of 2019 (H.R. 4679); OCEAN Act of 2020 (S. 5056); SAFE Act (H.R. 4490, S.2176,H.R.2840,S.1482,H.R.2748,H.R.2804,H.R.5065, and S.1202); and Ocean-Based Climate Solutions Act of 2020 and 2022 (H.R.8632/H.R.3764)	x	x	x	x

Table 1: Comprehensive list of all legislation introduced from 2014 to 2024 when queried "climate" and "fisheries" in Congress.gov organized into key climate adaptive elements.

Legislation that aligns with two or more elements with a focus on fisheries.

A total of eight pieces of legislation fit under two or more climate adaptive management elements. The elements that encompass climate adaptive management are as follows (Craig, 2010):

1. Scientific Data and Assessment Availability through increased monitoring.
2. Eliminate or reduce non-climate change stresses and otherwise promote resilience.
3. Increased coordination across media, sectors, interests, and governments.
4. Promote principled flexibility in regulatory goals and resource management.

Among the eight introduced bills, only two pieces of legislation encompassed all four of the elements: the Marine Mammal Climate Change Protection Act (H.R. 1383) and the SHIFT (Supporting Healthy Interstate Fisheries in Transition) Act (S. 3672). Notably, although the Marine Mammal Climate Change Protection Act does not explicitly reference mention fisheries, it represents a comprehensive framework for climate adaptive management that could be extended to fisheries.

The SHIFT Act aims to enhance the integration of climate change impact considerations into coastal fishery management by enhancing the efficacy of fishery management planning and proposing amendments to the

Magnuson-Stevens Conservation and Management Act. Other bills, such as the Sustaining America's Fisheries for the Future Act of 2022 (*H.R. 4690*), Climate-Ready Fisheries Act of 2019 (*H.R. 4679*), OCEAN Act of 2020 (*S. 5056*), and the SAFE Act (*H.R. 4490, S.2176, H.R.2840, S.1482, H.R.2748, H.R.2804, H.R.5065, and S.1202*), encompass all elements climate adaptive management except for the second element, which pertains to the reduction of non-climate related stressors and the promoting of resilience. Notably, the SAFE Act, introduced multiple times since 2013, has remained at the "introduction" stage of legislative process.

Finally, the Ocean-Based Climate Solutions Act of 2020 and 2022 (*H.R.8632/H.R.3764*) encompasses all aspects of climate adaptive management except for the third element, regarding increased coordination across media, sectors, interests, and governments. This exclusion of the third element is due to the legislation's focus on offshore wind development, without specific provisions for information sharing related to fisheries.

b. *Executive Orders*

Using the Federal Register, a total of 464 executive orders were enacted between 2014 and 2024 but only four supported the advancement of climate adaptive management measures specifically for fisheries.

The E.O.13754 - Northern Bering Sea Climate Resilience, was signed in December of 2016 with the goal of enhancing environmental stewardship in the arctic. While this specific Executive Order is not broad in the sense that it

encompasses other areas other than the Northern Bering Sea, this framework can be applied to other areas that are threatened by climate change. The E.O 13840 – Ocean Policy to Advance the Economic, Security and Environmental Interests of the United Staes, was enact June of 2018 to improve public access to marine data and information, efficient interagency coordination on ocean-related matters, and increase engagement with all sectors involved in the marine industry. This order promotes the effective management of the productive and sustainable use of ocean, coastal, and Great Lakes waters, which includes fisheries. Additionally, Executive Order 13840 promotes and facilitates coordination, consultation, and collaboration on all ocean-related matters between Federal, State, tribal, local governments, foreign governments, and ocean stakeholders. In May 2021, the enactment of E.O. 14027 established the Climate Change Support Office (CCSO) with the aim of addressing the global climate crisis. The CCSO is tasked with coordinating efforts among various federal departments and agencies to spearhead diplomatic endeavors on climate change and integrate climate considerations into all facets of foreign policy making. This underscores the recognition that climate change is a global issue necessitating international coordination.

In January of 2021, the E.O (14008) Tackling the Climate Crisis at Home and Abroad, addresses the global climate crisis through various measures. Notably, the order establishes a National Climate Task Force chaired by the White House, aimed at implementing a comprehensive government-wide approach to combat climate change. This task force emphasizes reducing

climate pollution, enhancing resilience to climate impacts, and conserving ocean biodiversity. This E.O. recognizes the importance of increasing data availability for adaptation and resilience by requiring agencies to draft action plans detailing climate vulnerabilities and steps for improvement.

c. *Documents*

A total of nine federal documents resulted from the three federal databases that were searched for climate adaptive fisheries management strategies or initiatives from 2014-2024 from Federal agencies including the Executive Office of the President interagency initiatives.

NOAA FISHERIES CLIMATE SCIENCE STRATEGY

The NOAA Fisheries Climate Science Strategy was released in 2015 by the NMFS as a Technical Memorandum in response to changing climate conditions and their effect on living marine resources (LMRs). The climate science strategy is organized into seven priority objectives: (1) Climate-informed reference points; (2) Identify robust management strategies; (3) Adaptive management processes; (4) Project future conditions; (5) Understand mechanisms of change; (6) Track change and provide early warnings; and (7) Build and maintain adequate science infrastructure (Link et al.,2015). Of these seven priority objectives, this document addresses every aspect of climate adaptive management. While it is not specifically mentioned in the primary objectives, it is mentioned that by the reduction of other

stressors that are under regional and local control such as fishing impacts, pollution, and bycatch can result in an increase of resilience and reducing the impact of non-climate related stressors. Also listed within this document are immediate and recommended near-term actions to be taken by management. The immediate actions are: (1) Conduct climate vulnerability analyses in each region for all LMRs to better understand what is at risk and why; (2) Establish and strengthen ecosystem indicators and status reports in all regions to better track, prepare for and respond to climate-driven changes; (3) Develop capacity to conduct management strategy evaluations regarding climate change impacts on management targets, priorities and goals (Link et al.,2015). The near-term actions that are recommended to accomplish include (1) Strengthen climate-related science capacity regionally and nationally to fulfill NOAA Fisheries information regarding climate change; (2) Develop Regional Action Plans (RAPs) to customize and execute this Strategy in each region over the next 3 to 5 years; (3) Allocate sufficient resources to conduct process-oriented research on climate-related factors, aiming to understand the impacts on LMRs better, mitigate these effects and bolster the resilience of LMRs and communities reliant upon them; and (4) Establish standardized, climate-smart terms of reference for application across all NOAA Fisheries' LMR management activities, environmental compliance obligations, and other processes spanning multiple mandates and core policy domains (Link et al.,2015).

FEDERAL FISHERIES MANAGEMENT REPORT

The Federal Fisheries Management report from the from the U.S. Government Accountability Office (GAO): *Additional Actions Could Advance Efforts to Incorporate Climate Information into Management Decisions* was published in September of 2016 to identify the federal efforts to address the effects of climate change on federal fisheries management. This report developed two recommendations for executive actions; (1) develop guidance for the NMFS regions and Councils on how climate information should be included into different aspects of fisheries management; and relating to the NOAA Fisheries Climate Science Strategy and (2) agency wide assessments should be held to determine which objectives of the strategy are being achieved and identify which measures of the strategy are considered to be successful performance measures. This report is a performance audit from the GAO acknowledging the challenging effects that climate change has on fisheries, ecosystems, and management strategies. Several challenges that the Councils and the NMFS face have been identified throughout this article including the lack of increased data assessments of climate related information and baseline oceanographic information. Other challenges include limitations of modeling capabilities and having the ability to distinguish between climate change related issues and other factors such as overfishing or pollution. This report calls for an increase of science related information along with incorporating risk management strategies to account for the potential effects of climate change. The analysis of the Climate Science

Strategy in this report recognizes the primary objectives listed previously but ultimately acknowledged that when this report was written the NMFS was still in the preliminary stages of implementation.

NOAA FISHERIES ECOSYSTEM-BASED FISHERIES MANAGEMENT POLICY

Made effective in May of 2016, this policy formalizes NOAA Fisheries support of the implementation of Ecosystem-Based Fisheries Management (EBFM). Recognizing the complex interconnectedness of various components of management such as fisheries (recreational, commercial, and subsistence), biodiversity, habitats, human impacts, and ecosystem variability, this policy asserts that the EBFM is the preferred method for NOAA fisheries to meet the expectation of sustainably managing the nation's living marine resources (National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2024). To have a unified implementation of this policy, NOAA fisheries provided six guidelines to assist in the effectiveness of EBFM through the goal of maintaining productive and resilient ecosystems:

1. Implement ecosystem-level planning;
2. Advance our understanding of ecosystem processes;
3. Prioritize vulnerabilities and risks to ecosystems and their components;
4. Explore and address trade-offs within an ecosystem;
5. Implement ecosystem considerations into management; and

6. Support ecosystem resilience via monitoring and adjusting of management actions.

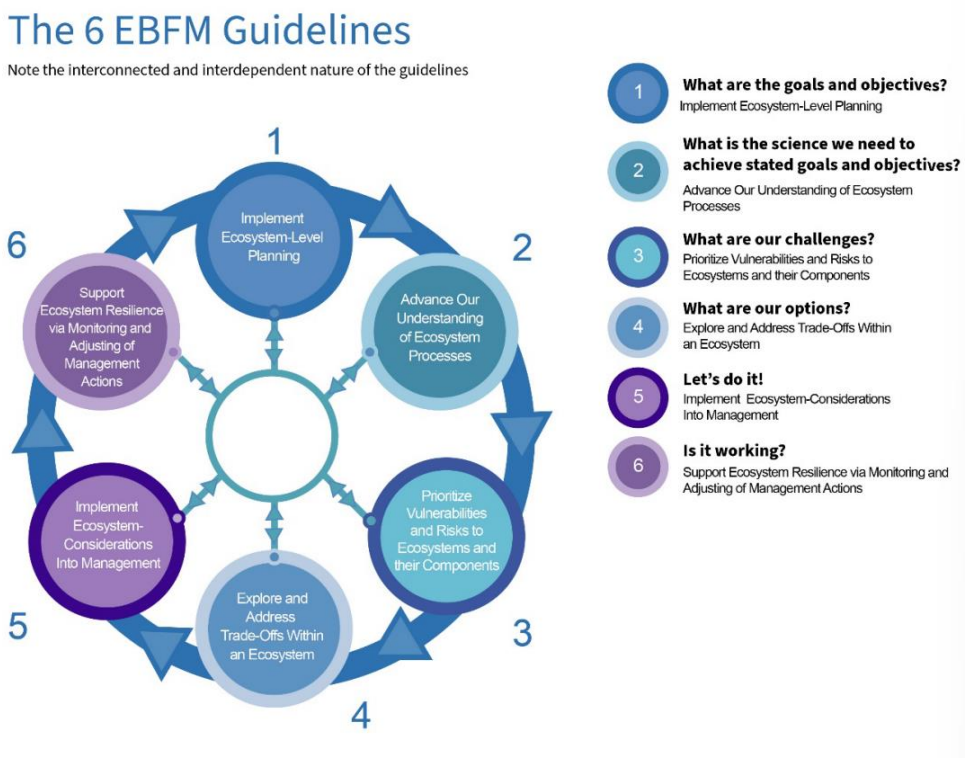

Figure 1. EBFM Guidelines image taken from NOAA Fisheries Ecosystem-Based Fisheries Management Policy (2016)

This policy incorporates three measures of climate adaptive management strategies: increased research availability (guidelines 2, 3, and 6), management flexibility (guidelines 1, 4, 5, and 6), and increased coordination across all sectors (guidelines 1 and 6).

NOAA FISHERIES ECOSYSTEM-BASED FISHERIES MANAGEMENT ROAD MAP

The NOAA Fisheries Procedure 01-120-01, Ecosystem-Based Fisheries Management Road Map was initially put into effect April of 2017 and

renewed in November of 2018. This document operationalizes the commitment of NOAA fisheries to implement ecosystem-based fisheries management (EBFM) into decision-making to effectively respond to climate based environmental changes and make trade-off decisions that impact multiple species instead of the single-species management efforts made previously. The NOAA Fisheries EBFM Road Map expands on how to operationalize the NOAA Fisheries Ecosystem-Based Fisheries Management Policy's six Guiding Principles through two core components for each principle (National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2017).

1. Implement ecosystem-level planning.
    a. Engagement Strategy
    b. Fishery Ecosystem Plans
2. Advance our understanding of ecosystem processes.
    a. Science to Understand Ecosystems
    b. Ecosystem Status Reports
3. Prioritize vulnerabilities and risks to ecosystems and their components.
    a. Ecosystem-Level Risk Assessment
    b. Managed Species, Habitats, and Communities
4. Explore and address trade-offs within an ecosystem.
    a. Modeling Capacity for Trade-Offs
    b. Management Strategy Evaluations
5. Implement ecosystem considerations into management.
    a. Ecosystem-Level Reference Points

b. Ecosystem Considerations for Living Marine Resources

c. Integrated Advice for Other Management Considerations

6. Support ecosystem resilience via monitoring and adjusting of management actions.

    a. Resilience

    b. Community Well Being

Guiding principle 1, *implement ecosystem-level planning*, has core components of *engagement strategy* and *fishery ecosystem plans*. The engagement strategy of the core components encourages the facilitation of participation through partners and stakeholders within the EBFM process. This first guiding principle is achieved by establishing points of contact for each Regional Office, Fisheries Science Center, and Headquarters Offices, forming Ecosystem Plan Development Teams or Ecosystem Committees established by the councils, and developing a uniform implementation strategy for widespread use. Fishery Ecosystem Plans (FEPs) provide one way for Councils to describe ecosystem objectives and priorities for fishery science and development and for informing Fishery Management Plans (FMPs) or amendments. These elements are essential for managing fisheries in an adaptive manner. Guiding principle 2, *advance our understanding of ecosystem processes*, is supported by two core components: *conduct science to understand ecosystems* and *ecosystem status reports*. Conducting science to understand ecosystems acknowledges the importance of science in

understanding ecosystems biologically, their social and economic considerations, and the complex relationship between fisheries, various species, and habitats. The second core component required Ecosystem Status Reports (ESRs) for each Large Marine Ecosystems (LMEs) to identify the status of ecosystem dynamics and any important gaps of data. Guiding principle 3, *prioritize vulnerabilities and risks to ecosystems and their components,* calls to conduct comprehensive ecosystem-level risk assessments and risk assessments for managed species, habitats, and communities. Both core components highlight the importance of risk assessments for areas known to serve important ecological functions and managed species. Guiding principle 4, *explore and address trade-offs within an ecosystem,* has the core components to establish sufficient EBFM modeling capacity to analyze tradeoffs and to develop management strategy evaluation capabilities. The first component creates a “toolbox” to synthesize and integrate a wide range of information and objectives by using ecosystem modeling tools, best practices, data-poor quantitative and semi-quantitative tools, and related decision support tools. This component aims to increase its ecosystem modeling capacity and coordinate ecosystem modeling efforts. The second core component calls for the development of ecosystem MSEs to connect with multispecies and single species MSEs, inclusive of other aspects such as economic, socio-cultural, and habitat considerations and objectives. Guiding principle 5, *incorporate ecosystem considerations into management,* emphasizes three core components: (1) develop and monitor ecosystem-level

reference points; (2) incorporate ecosystem considerations into appropriate LMR assessments, control rules, and management decisions; and (3) provide integrated advice for other management considerations, particularly applied across multiple species within an ecosystem. Through all three of the core components there is a common theme of incorporating ecosystem considerations into management decisions for ecosystems and managed species. The final guiding principle, *support ecosystem resilience via monitoring and adjusting of management actions*, has two core components that recognizes the link between human well-being and the incorporation of ecosystem-based approaches into fishery management. Principle 6 is focused on developing and upholding best practices to enhance resilience and wellbeing within coastal communities.

DEPARTMENT OF COMMERCE 2021 CLIMATE ACTION PLAN FOR ADAPTATION AND RESILIENCE

Established by the DOC in response to the E.O. 14008, *Tackling the Climate Crisis at Home and Abroad*, depicts the work of the Department to address the climate crisis and additionally supports the mission of the DOC to create the conditions for economic growth and opportunity (Department of Commerce, 2021). This action plan was tasked with developing 5 Priority Adaptation Actions:

1. “Foster and enhance the resilience of vulnerable communities against the key climate risks of extreme heat, drought, wildfires, flooding, coastal inundation, and impacts to fisheries;
2. Support the development of climate-ready infrastructure via the development of forward-looking building standards;
3. Improve the ability to process patent application filings for climate change adaptation-related technologies in a timely manner;
4. Improve current analyses and systematically update projections on the impacts of climate change on the national economy as new data is available; and
5. Further embed climate considerations into the Economic Development Administration’s grant making, through investment priorities, grant criteria, application evaluation, and economic development planning” (Department of Commerce, 2021).

This plan recognizes the vulnerabilities identified in the 2014 Climate Vulnerability Assessment, including one pertinent to fisheries: Environmental Stewardship. It underscores that environmental stewardship constitutes a central mission of the DOC, aiming to address various challenges posed by climate change. Among the five priority action items outlined, only the first action item specifically references fisheries in its implementation methods. Notably, the implementation method (1) Engaging with Partners/Providing Technical Assistance highlights habitat restoration to enhance resource benefits and improve the health of marine resources. The remaining priority

actions address other facets of climate change and delineate how the DOC can contribute to mitigating its impacts.

FEDERAL FISHERIES MANAGEMENT: Opportunities Exist to Enhance Climate Resilience

The Federal Fisheries Management: *Opportunities Exist to Enhance Climate Resilience* was published in August of 2022 as a report to the Congressional Committees from the GAO. This report is a performance audit to identify actions taken by NMFS to enhance climate resilience of federal fisheries since GAO's 2016 report, the extent of which fisheries managers have used the climate information provided by NMFS, and the challenges that NMFS and fisheries managers face in enhancing climate resilience of federal fisheries and gaps that exist to address those challenges. While this document is an evaluation, it calls for two recommendations to be put forth to NMFS that encompass the climate adaptive management elements. Firstly, the GAO report calls for the distribution of information on actions taken by Regional Fishery Management Councils, such as management plans, which promote the resilience of fisheries and secondly, to encourage the implementation of the opportunities that exist to address the challenges of climate resilience. Those opportunities include increasing the availability of data through partnerships with the fishing industry to expand monitoring of fish stocks and the expansion of surveys for fish stocks that are under-surveyed or to cover new areas in response to shifting fish stocks. Additionally, creating adaptable

management strategies through the transferring of stock quotas, setting quotas based on current stock distribution data instead of historical measurements of fish, and through using exempted fishing permits to authorize fishing research or to evaluate new gear and revised gear types to reduce bycatch of protected or overfished species. Finally, the GAO report mentions opportunities for increased communication and collaboration for NMFS and the Regional Fishery Management Councils with industry stakeholders, in the form of workshops, meetings, and information sessions.

In addition to the recommendations provided by the findings of the GAO report, challenges that fisheries managers face are also identified. According to the interviews conducted with NMFS, the eight Regional Fishery Management Councils, and others the following challenges were identified: limited data and modeling for the impacts of climate change, lack of flexible management strategies and frameworks, limited collaboration, and resource constraints such as funding or staffing. These challenges mirror the components of climate adaptive management, indicating that fisheries managers recognize them as hurdles they must address. The recommendations put forth by GAO call for executive action by the NMFS to assist fisheries on a federal level to overcome these challenges and become more climate resilient.

OCEAN JUSTICE STRATEGY

The Ocean Justice Strategy is a report published by the Ocean Policy Committee in December of 2023. President George W. Bush created the Ocean Policy Committee when he signed Executive Order 13366 in December 2004. This report has three overarching principles for the Federal Government to take into consideration when providing climate adaptation management. While these principles mention two key climate adaptive management elements (increase in data assessments and availability; and increased coordination), these principles do not mention fisheries specifically, therefore is not applicable to this study.

OCEAN CLIMATE ACTION PLAN

The Ocean Climate Action Plan (OCAP) is a report published in March 2023 by the Ocean Policy Committee. OCAP was developed by the Ocean Climate Action Plan workgroup of the Ocean Resource Management Subcommittee of the Ocean Policy Committee. This action plan outlines opportunities and measures aimed at fostering a climate-ready environment. Of these actions, OCAP addressed all aspects of climate adaptive management through the following priorities: (1) prioritizing ocean research, observations, modeling, forecasting and synthesis; (2) reducing non-climate-related stressors by creating a carbon-neutral future; (3) climate ready fisheries through the use of climate-informed and adaptive management by enabling “Regional Fishery Management Councils and other bodies with Federal nexus, to incorporate climate-ready approaches and decision-

making;" and (4) the facilitation of interagency coordination and strategic planning through partnerships across the Federal and State governments, "Tribal Nations, Indigenous Peoples, States, Territories, communities, the private sector, and civil society." While these opportunities and actions clearly entail the climate adaptive management elements mentioned in this study, there are no specific deadlines or expectations established within this report only guidelines that should be taken into consideration.

NORTHEAST REGIONAL ACTION PLAN

The Northeast Regional Action Plan (NERAP) to implement the NOAA Fisheries Climate Science Strategy through 2024 is a technical memorandum produced by the DOC, NOAA, NMFS, and the Northeast Fisheries Science Center. This action plan was produced in response to the NERAP that was published in 2016 and aims to identify the efforts put forth since 2016 to accomplish the seven objectives outlined in the NOAA Fisheries Climate Science Strategy (NCSS).

2. STATE GOVERNMENTS

For each State that is in the jurisdiction of the NEFMC, the respective State Government websites were searched to identify plans, management strategies or initiatives that promote the four climate adaptive management elements for their respective fishery resources.

a. **RHODE ISLAND**

Rhode Island manages its marine fisheries through the Rhode Island Department of Environmental Management (RIDEM), specifically through the Rhode Island Division of Marine Fisheries (RIDMF). RIDEM has put forth three management and action plans: the RIDEM Division of Marine Fisheries Strategic Plan (2021-2025), RIDEM Strategic Plan FY 2024-2026, and the Rhode Island Wildlife Action Plan (2015).

In 2015, the Rhode Island Wildlife Action Plan (RIWAP) was published to provide a comprehensive plan to coordinate conservation efforts through a statewide plan for the upcoming decade. This plan consisted of seven chapters ranging from identifying threats to key habitats to improving outreach and coordination. Chapter 4 of the document covers two climate adaptive elements: the mitigation of non-climate stressors, including pollution, contaminants, and invasive species, and the identification of climate-related threats to fisheries, along with proposed management actions to address them. Within the fisheries subsection of this chapter, the threat of climate change with actions to address the stressors that exist for all species and habitats that are affected but specifically for fisheries it is mentioned only once to “assess whether a succession of species may be occurring as a result of temperature changes.” The document also includes characteristics that may increase a species vulnerability to climate change, such as: “specialized habitat and/or microhabitat requirements, narrow environmental tolerances or

thresholds that are likely to be exceeded due to climate change at any stage in the life cycle, dependence on specific environmental triggers or cues which are likely to be disrupted by climate change, poor ability to disperse to or colonize a new or more suitable range, and species with long generation times and low fecundity rates that have low genetic variability." While these characteristics have been identified there are few solutions that address these complex challenges that make species vulnerable to climate change. The document suggests the use of "managed relocation" or "assisted migration" as a controversial adaptation action that should only be used after consideration of the various financial costs and ecological risk. Like other climate forward strategies, this document encourages the use of structured decision making and scenario planning approaches to help make controversial decisions.

In 2021 RIDMF produced the Strategic Plan as a framework to guide continued and future initiatives to maintain sustainable marine resources. As stated in the plan, there are four goals that will help the RIDMF achieve the mission to "manage and enhance Rhode Island's marine resources and habitats." Goals one through three show climate adaptive management strategies through increased research and monitoring to better understand marine resources in a changing environment (goal one), creating flexible and innovative solutions for management frameworks and programs (goal two), and coordination and collaboration across sectors through academic partnerships with various outreach initiatives for stakeholders and community members (goal three).

The RIDEM Strategic Plan FY2024-2026, has eight goals that promote strategies to “protect, restore, manage, and promote Rhode Island’s environment and natural resources.” Of these eight goals, goals one, three, and seven encompass aspects like the four key elements of climate adaptive management. Goal one, “Take action to counter climate change and its effects, both locally and regionally,” and goal three, “Protect and restore our environment to create greener, healthier communities” encourages the reduction of greenhouse gas emissions and other stressors on the environment by promoting restoration to environmental ecosystems and supporting regional efforts to reduce environmental stressors. Additionally, goal one also aims to integrate climate change considerations and adaptation measures into all levels of decision-making by addressing current and future threats from climate-related stressors. Goal seven, “Expand and promote local agriculture, and seafood industries,” similarly encourages the use of a “climate resilient infrastructure” to withstand the stressors that climate change has on fisheries management and businesses.

b. **MASSACHUSETTS**

The management of marine fisheries in Massachusetts is primarily overseen by the Massachusetts Division of Marine Fisheries (MADMF), which operates under the Department of Fish and Game. The Massachusetts Department of Fish and Game has put forth two official plans: the Massachusetts State Wildlife Action Plan and the Marine Fisheries Strategic

Plan. In 2015 the State of Massachusetts submitted its State Wildlife Action Plan (SWAP) to the U.S. Fish and Wildlife Service consisting of seven chapters that acknowledge conservation needs for species and habitats, conservation actions, and effective monitoring and adaptive management. Chapters 6 (Conservation Actions) and chapter 7 (Effectiveness Monitoring and Adaptive Management) reflect three of the four key elements of climate adaptive management. Chapter 6 outlines the conservation actions that Massachusetts aims to implement through various strategies: Conservation planning; Initiative-taking habitat protection and securement; Habitat restoration and management; Environmental regulation; Surveys, monitoring, and databases; and public outreach. While much of this chapter focuses on land protection and habitat management strategies, research and monitoring efforts extend to marine, freshwater, and terrestrial resources. Chapter 7 includes Massachusetts' commitment to an "adaptive management approach" using data from different agencies, organizations, and individuals. This document depicts the various target species/habitats and their respective monitoring programs, organizations, and frequency of which this monitoring/surveying takes place. This gathering of data can be used to inform a simplified management strategy called a "Results Chain." The SWAP identifies that while natural systems are complex the solution for adaptive management does not have to be and encourages the use of the "simple results chain" as well as the multi-action results chain.

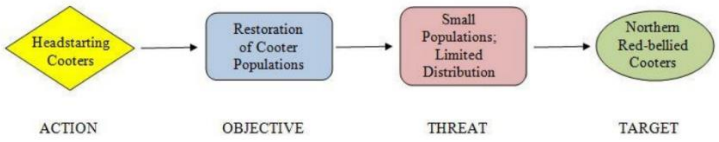

Figure 2. Image taken from the 2015 Massachusetts State Wildlife Action Plan: Chapter 6 depicting an example of a simple results chain.

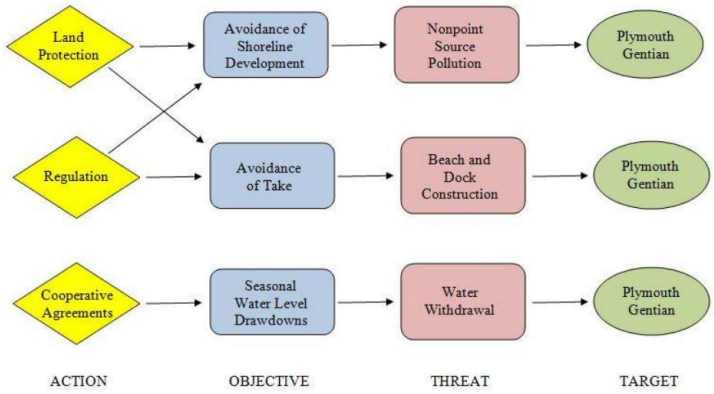

Figure 3. Image taken from the 2015 Massachusetts State Wildlife Action Plan: Chapter 6 depicting an example of a multi-action results chain.

In July of 2019, Massachusetts published a Marine Fisheries Strategic Plan to span the years 2019-2023. This plan is a living document that updates and revises previous policies and strategies as the environmental conditions continue changing. Five goals are mentioned in this plan: (1) Advance understanding and stewardship of our living marine resources, including fish, habitat, and marine protected areas; (2) Support sustainable commercial and recreational fisheries; (3) Protect public health through monitoring and management of shellfish resources and advance the development of a sustainable marine aquaculture industry; (4) Expand and foster regional science, management, and education partnerships; (5) Build and maintain a

high level of staff professionalism administrative leadership. The first goal prioritizes the monitoring, collecting, and assessing of climate related data to improve fisheries management. Additionally, goal four promotes cooperative partnerships to increase management and science through a multi-agency approach. This plan specifically mentions the transition MADMF will make to ecosystem-based management as part of the goal to increase engagement in regional priority. It is notable to mention in 2010 MADMF published their Division of Marine Fisheries Strategic Plan which listed seven marine fisheries goals, like the goals listed in the 2019 goal mentioned above. However, since this document was released in 2010, it was not included in my analysis of documents and strategies from 2014-2024.

Additionally, on the Massachusetts DMF database, a Climate Change Policy Statement was released (date unclear) that lists strategies and priorities to address ecosystem changes and impacts on fisheries as a result from changing environmental conditions. This statement calls for the following strategies and priorities: expanding existing monitoring efforts to include climate related data; identifying external funding opportunities to address climate change and ocean acidification; establishing partnerships with academia, research institutions, fisheries management entities, and the fishing industry to collect and analyze relevant climate data; implementing an ocean acidification monitoring program; establishing an in house committee to solely work on the collection and maintenance of time-series climate data; creating a webpage and additional outreach materials that highlight the current efforts,

future data needs, real-time tracking, and adaptation strategies for future fisheries management objectives; continuing and expanding the support for outside programs to collect climate data; and a standardized approach to long term climate related data. This statement acknowledges the challenges that result from climate change including species alterations in the form of distribution shifts, migration patterns, productivity, and interactions, and various impacts of climate change including economic, biological, and community impacts. Additionally, this statement addresses the need for collaborative work and coordination between various sectors such as: government agencies and research institutions; participating in outside initiatives to address vulnerabilities along; developing adaption strategies; and working with various climate change researchers to obtain funding to aid in the collection of data to identify fisheries management needs are clear goals of MADMF.

c. **MAINE**

Maine fishery resources is managed through the Maine Department of Marine Resources (DMR). In 2015 the Maine Department of Inland Fisheries and Wildlife (MDISW) published their Wildlife Action Plan to evaluate the health of wildlife populations while identifying opportunities for conservation and protection for environments, habitats, and species. This plan is published and revised every ten years to continue the evaluation of the Maine's natural resources. This plan was published by the Department of Inland Fisheries and

Wildlife as an all-encompassing plan that includes marine resources. In addressing the conservation efforts of Maine's finfish, Element 1 explains the decline in marine fish species abundance is due to majority of overfishing acknowledging that declines may be due to environmental changes or habitat alterations from climate change. This first element identifies the need for increased data availability in the form of habitat research, migration patterns, climate change impacts, and shifting predator-prey dynamics. Within element one, the SWAP identifies Species of Greatest Conservation Needs (SGCN) and uses a ranking system of 1-3 to identify the vulnerability of each species (1 – highest priority, 2 – high priority, and 3 – moderate priority) along with the "scale of conservation concern" ranging from state, regional, national, and global. Through this ranking system, only five marine fish species (including three anadromous species) were of high priority for conservation needs. The additional two species that were ranking as high priority include the Atlantic Cod and Haddock. These species are recognized at a state level and this action plan highlights their significance on a regional scale of concern, however it does not specify management strategies beyond the call for increased data collection and monitoring. Element four, "Conservation Actions" depicts various conservation actions separated by action: Habitat Management; Policy; Public Outreach; Research, Species Management; and Survey and Monitoring. For the Marine taxonomic group, showing one habitat management action, zero policy actions, eight public outreach actions, forty-four research actions, twelve species management actions, and thirteen

surveying/monitoring actions. Research and monitoring actions range from identifying impacts of bycatch, habitat usage, mortality rates from discards to stock assessments. Element seven, *coordination with partners,* requires MDIFW to coordinate with federal, state, local agencies, and Indigenous communities that manage areas of land or water within the state, or administer programs that affect the conservation of species. While this aspect of the plan aligns with the climate adaptive element to increase coordination between sectors, this coordination is only specified for inland fisheries and wildlife, not marine fisheries. This plan for marine resources encompasses two elements of climate adaptive management through increased data availability and coordination across various sectors. Coordination and communication have taken form through their public outreach actions working with State partners, Federal partners, Tribal partners, NGOs, and marine industry members.

d. **NEW HAMPSHIRE**

New Hampshire manages its fishery resources through the New Hampshire Fish and Game Department (NHFGD) who is responsible for conserving, managing, and protecting the state's fish and wildlife resources. In 2015 NH published their second WAP consisting of seven chapters. Chapters two, three, and four address New Hampshire habitats and wildlife by identifying which species and habitats are at risk. Chapter five, "Conservation Actions" includes elements of climate adaptive management through the various action categories such as: Species and Habitat actions; Planning

actions; Agency Coordination, Regulation and Policy; and Education and Technical Assistance (New Hampshire Fish and Game Department, 2015). Each conservation action consists of various recommendations and strategies that NH aims to implement to achieve conservation and protection of marine resources through climate inclusive thinking. Chapter six, “Monitoring, Performance, Evaluation, and Adaptive Management,” explains that the success of the conservation actions mentioned in the previous chapter can be accomplished through a multi-step approach to achieve adaptive management for the species and ecosystems at risk. This multi-step approach for adaptive management incorporates “conservation planning, implementation, monitoring, performance evaluation….and the ability to adapt between each phase” (New Hampshire Fish and Game Department, 2015). This document shows an image of a flow chart for the adaptive management process along with an outline of actions NHFGD formally implemented to achieve actions put forth in the Wildlife Action Plan. These actions include:

1. Planning:
    a. Research and analyze threats to wildlife populations and habitats.
    b. Prioritize all proposed conservation actions before implementation to ensure that resources are targeted effectively.
    c. Select performance measures for each action.
2. Implementation

a. Implement strategies and actions to affect change on threat.

b. Monitor population status and trend.

c. Monitor the ecological response to conservation actions to understand links between species, habitats, and threats.

3. Evaluate and Adapt

a. Report results.

b. Refine and adapt all management activities to reflect new science.

c. Manage information and develop media to disseminate to all levels in conservation.

d. Revise the SWAP in 2025 (currently underway).

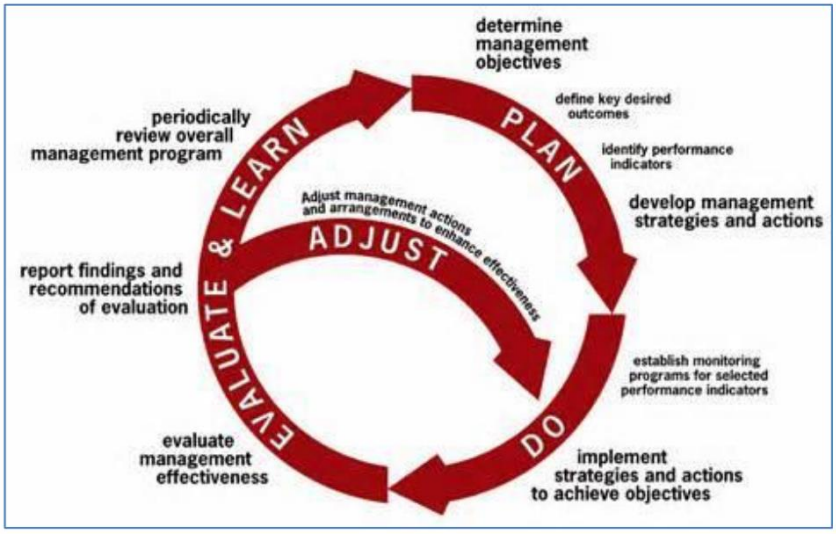

Figure 4. New Hampshire Fish and Game Department adaptive management flow chart taken from the 2015 State Wildlife Action Plan

Other initiatives and programs include the Fish Conservation Program which was shortly established after New Hampshire completed the first Wildlife Action Plan to assist in restoring and protecting healthy aquatic ecosystems to

support New Hampshire's fish. In 2012, the NHFGD released the Ecosystems and Wildlife Climate Change Adaptation Plan as an amendment to the New Hampshire Wildlife Action Plan, published the years prior. While this plan was not included in the research due to the extent of the time frame for this study it is worth noting their effort because the 2015 NH Wildlife Action Plan was created shortly two years later, and the amendments and recommendations put forth from that plan were included in the revised updated version.

e. **CONNECTICUT**

Connecticut manages its marine fisheries resources through the Connecticut Department of Energy and Environmental Protection (DEEP) which is responsible for conserving and managing the state's natural resources. In 2015, Connecticut completed and updated its Wildlife Action Plan which included chapters and appendices that promoted the climate-adaptive management elements prioritized in this research. Chapter three identifies the threats that are affecting greatest conservation need (GCN) species and Appendix three includes their links to conservation actions. The threats mentioned in chapter three range from development, resource use, and pollution to climate change. Non-climate related stressors on marine environments such as pollution, energy production in the form of windmills or mining, and human disturbances are countered with actions and guidelines to reduces these stressors. These guidelines include: the development of best practices to minimize marine impact in the face of green energy; the

encouragement of wildlife stewardship ethics to reduce pollution; and the prioritization of threatened marine habitats for conservation and protection. Within this chapter, six major management challenges were identified and of those six challenges, three align with the climate adaptive elements: (1) Insufficient Resources to maintain and enhance wildlife; (2) Insufficient scientific knowledge regarding wildlife, fish, and their habitats; and (3) Insufficient wildlife conservation and management at a regional level. For each of these management challenges, there are several solutions and guidelines for each of the challenges mentioned including increasing research, coordinating with stakeholders, conservation partners, and governments to promote the conservation of marine ecosystems and habitats, and the development of conservation practices and management strategies to be implemented on a regional/multi-state scale.

Chapter four presents the highest priority actions developed in response to address the issues presented in chapters one, two, and three. It is noted in the beginning of this chapter that only the highest priority conservation actions, research, survey, and monitoring needs were presented in this chapter. This chapter depicted climate change adaption actions for specific habitats ranging from near-term strategies, mid-term strategies, and long-term strategies. Specifically, for “open water marine” habitats the near-term strategies listed for climate adaptive actions include, monitoring marine resource challenges and reducing pollutant runoff via watershed management. The only action for mid-

term strategies was identifying ways to diversify fisheries and additionally there was no long-term strategy.

3. ATLANTIC STATES MARINE FISHERIES COMMISSION (ASMFC)

In 1942, the Atlantic coastal states created an Interstate Compact ratified by all states and approved by the U.S. Congress. The Compact acknowledged the need to manage shared migratory fishery resources and confirmed the states' commitment to cooperative stewardship. The ASMFC manages fisheries along the Atlantic coast from Maine to Florida, covering state waters (up to 3miles offshore) adjacent to federal waters. Its jurisdiction extends from the coastline out to the edge of state waters. Decisions are made through a one state/one vote concept that promotes fairness in decision making while collaborating closely with federal partners to maintain state fishery management and monitoring programs. According to the Commission's mission statement in the 1942 Compact, there is a total of four guiding principles:

1) States are sovereign entities, each having their own laws and responsibilities for managing fishery resources within its jurisdiction.
2) States serve the broad public interest and represent the common good.
3) Multi-state resource management is complex and dependent upon cooperative efforts by all states involved.

4) The commission provides a critical sounding board on issues requiring cross-jurisdictional action, coordinating cooperation, and collaboration among the states and federal government.

In addition, annual reports are published every year to provide stakeholders a summary of activities and progress in fulfilling the Commissions cooperative stewardship responsibilities. The reports also include historical trends in stock status or catch for each of the twenty-five species under the commissions management.

Five-Year Strategic Plan 2014-2018; 2019-2023; and 2024-2028

In 2014, 2019, and 2024 the ASMFC released a Five-Year Strategic Plan to articulate the mission, vision, goals, and objectives needed to accomplish the mission of the Commission. Every five years, the ASMFC reassesses its' eight overarching goals and the corresponding strategies aimed at achieving each goal. The first Strategic Plan, released in 2014, initial consisted of seven overarching goals: (1) "Rebuild, maintain, fairly allocate, and promote Atlantic Coastal Fisheries; (2) Provide the scientific foundation for and conduct stock assessment management actions; (3) Promote compliance with fishery management plans to ensure sustainable use of Atlantic coast fisheries; (4) Protect and enhance fish habitat and ecosystem health through partnerships and education; (5) Strengthen stakeholder and public support for the commission; (6) Advance Commission and member states' priorities through a proactive legislative policy agenda; and (7) Ensure fiscal stability and efficient

administration of the Commission” (Atlantic States Marine Fisheries Commission, 2014). In 2019, the Commission introduced the eighth overarching goal: "Produce dependable and timely marine fishery statistics for Atlantic coast fisheries." This goal has been maintained in subsequent plans and is anticipated to persist in future iterations as well (Atlantic States Marine Fisheries Commission, 2014). Goal one within the 2014 Strategic Plan establishes the baseline of approaches to managing interstate fisheries resources sustainability through science-based methods and emphasizing collaboration between state and federal entities. This goal highlights the importance of adapting management strategies to address emerging issues and ensuring efficient and transparent processes with additional focus on evaluating the progress of rebuilding fisheries and management to achieve comprehensive and effective management. In the 2019 Strategic Plan, Goal one introduced the strategy to "Promote the sustainable harvest of and access to rebuilt fisheries," while retaining the other components of the strategies unchanged. In the 2024 Strategic Plan, Goal one added several new strategies to the existing list through the two previous plans, including important management changes such as implementing "nimble" management frameworks adaptable to climate change and integrating climate change considerations into management strategies (Table 2). The 2014 Strategic Plan established a baseline of key strategies to achieve the second goal of this plan including developing stock assessments using comprehensive data sources and rigorous technical analysis while emphasizing proactive measures to

address research priorities through collaboration with state, regional, and stakeholder data collection programs and projects, among others (Table 2).The 2019 Strategic Plan included additional strategies that focused on improving data assimilation across states and exploring new technologies to prioritize efficiency and the timely delivery of scientific products (Figure 2). Additionally, there is a push to facilitate effective communication with stakeholders to maintain consistency between on-the-water observations and scientific findings. The 2024 Strategic Plan introduced new efforts that involved the development and use of industry-based surveys and collaborative research opportunities along with utilizing ecosystem and climate science products to inform fisheries management decisions, particularly in anticipating shifts that may have implications for quota allocations (Table 2). For the third goal, all three Strategic Plans have maintained consistent key strategies, focusing on fostering stakeholder awareness of management measures through outreach initiatives. These efforts are facilitated using emerging communication platforms to deliver real-time information about regulations and law enforcement outcomes. Additional efforts within this goal include fostering stakeholder buy-in by developing practical compliance requirements while evaluating the enforceability of management measures and law enforcement programs. Additional partnerships with state and federal agencies are expanded to enhance coordination in natural resource law enforcement (Table 2). The 2014 Strategic Plan introduced a baseline of strategies to accomplish this goal through identifying critical habitats through fisheries management

programs and partnership, while educating stakeholders and the public about the significance of healthy fisheries and ecosystems. Local, state, and regional governments are engaged in habitat protection and enhancement programs through partnerships, fostering participation from various stakeholders to leverage support (Table 2). The 2019 Strategic Plan was the only plan to include additional strategies to accomplish this goal. These additional strategies include the increase of habitat information and data into fishery management plans and stock assessments with increased collaboration with partnerships at the local levels, advancing shared habitat goals. To accomplish the fifth goal, the 2014 Strategic Plan introduced strategies that include clarifying Commissions procedures to encourage stakeholder involvement, transparency, and accountability, while bolstering media relations to amplify coverage of Commission initiatives and utilize innovative technologies for broader public engagement (Table 2). Goals six and seven included strategies that are consistent throughout each of the three Strategic plans that focus on enhancing the Commission's visibility and support in congress through relationship-building efforts with members, their staff, and Commission officials, while ensuring sustained or increased funding for Commission programs. Additionally, a key component of fisheries management is funding for the various research efforts to maintain effective and efficient strategies. The Commission focuses on this through maintaining fiscal stability through conservative management of operations and budgets, leveraging technology to streamline processes and communications, and

refining strategies for staff recruitment and development (Table 2). The eighth strategy, *produce dependable and timely marine fishery statistics for Atlantic coast fisheries,* was a new addition by the 2019 Strategic Plan which developed the baseline of strategies to accomplish this goal. These strategies include prioritizing activities that align with partner and end-user needs while maximizing benefits within available resources, collaboratively establish and uphold coastwide data standards, and enhance partner data collection (Table 2).

Atlantic States Marine Fishery Commission Strategic Plans

Strategic Plan	Goals & Strategies							
	1. Rebuild, maintain, fairly allocate, and promote Atlantic Coastal Fisheries	**2. Provide the scientific foundation for and conduct stock assessments to support informed management actions**	**3. Promote compliance with fishery management plans to ensure sustainable use of Atlantic coast fisheries**	**4. Protect and enhance fish habitat and ecoystem health through partnerships and education**	**5. Strengthen stakeholder and public support for the Commission**	**6. Advance Commission and member states' priorities through a proactive legislative policy agenda**	**7. Ensure fiscal stability & efficent administration of the Commission**	**8. Produce dependable and timely marine fishery statistics for Atlantic coast fisheries**
2014-2018	Manage interstate resources that provide for productive, sustainable fisheries using sound science; Strengthen state and federal partnerships to improve comprehensive management of shared fishery resources; Adapt management to address emerging issues; Practice efficient, transparent, and accountable management processes; Evaluate progress towards rebuiding fisheries; Strengthen interactions and input among stakeholders, technical, advisory, and management groups	Conduct stock assessments based on comprehensive data sources and rigorous tehcnical analysis; Proactively address research prioirites through cooperative state and regional data collection programs and collaborative research projects; Facilitate stakeholder involvement in research initiatives and the stock assessment process; Promote data collection and research to support ecosystem-based management; Provide stock assessment training to improve the expertise and involvement of state and staff scientists	Develop practical compliance requirements that foster stakeholder buy-in; Evaluate the enforceability of management measures and the effectiveness of law enforcement programs; Promote coordination and expand existing partnerships with state and federal natural resoruce law enforcement agencies; Enhance stakeholder awareness of management measures through education and outreach; Use emerging communication platforms to deliver realtime information regarding the regulations and the outcomes of law enforcement investigations	Identify critical habitat through fisheries management programs and partnerships; Educate Commissioners, stakeholders, and the general public about the importance of habitat to healthy fisheries and ecosystems; Engage local, state, and regional governments in mutually beneficial habitat protection and enhancement programs through partnerships; Foster participation with management agencies, researchers, and habitat stakeholders to leverage regulatory, political, and financial support; Identify mechanisms to evaluate ecosystem health; Engage in state and federal agency efforts to ensure climate change response strategies are included in habitat conservation efforts	Increase public understanding and support of acitivites through expanded outreach at the local, state, and federal levels; Clearly define Commission processes to facilitate stakeholder participation, as well as transparency and accountability; Strengthen national, regional, and local media relations to increase coverage of Commission actions; Use new technologies and communication platforms to more fully engage the broader public in the Commission's activities and actions	Increase the Commission's profile and support in the U.S. Congress by developing relationships between Members and their staff and Commissioners, the Executive Director, and Commission staff; Maintain or increase long term funding for Commission programs through the federal appropriations process and other available sources; Engage Congress on fishery-related legislation affecting the Atlantic coast; Promote member states' collective interests at the regional and national levels; Promote economic benefits of the Commission's actions	Conservatively manage the Commission's operations and budgets to ensure fiscal stability; Utilize new information technology to improve meeting and workload efficiencies, and ehance communications; Refine strategies to recruit professional staff, and enhance growth and learning opportunities for Commissioners and state personnel; Fully engage new Commissioners in the Commission process and document institutional knowledge; Utilize legal advice on new management strategies and polices, and respond to litigation as necessary	×
2019-2023	**Promote sustainable harvest of and access to rebuilt fisheries**	**Characterize the risk and uncerntainty associated with the scientific advice provided to decision-makers; Streamline data assimilation within individual states, and among states, and ASMFC; Explore the use of new technologies to improve surveys, monitoring, and the timeliness of scientific products; Promote effective communitcation with stakeholders to ensure on-the-water observations and science are consistent**	✓	**Better integrate habitat information and data into fishery management plans and stock assessments; Work with ACFHP to foster partnerships with like-minded organizations at local levels to further common habitat goals**	✓	✓	✓	Focus on activities that maximize benefits, are responsive and accountable to partner and end-user needs, and are based on available resources; Cooperatively develop, implement, and maintain coastwide data standards through cooperation with all program partners; Provide electronic applications that improve partner data collection; Integrate and provide access to partner data via a coastwide respository; Facilitate fisheries data access through an on-line, user-friendly, system while protecting confidentiality; Support technical innovation
2024-2028	**Create management frameworks that are nimble, adaptable, and robust to climate change; Develop criteria for prioritizing management actions for species that are depleted due to factors other than fishing mortality; Include climate change considerations in management strategies**	**Balance requests from fisheries management with finite assessment workload capacity; Support the development and utilization of industry-based surveys & other cooperative research opportuntiies; Utilize ecosystem and climate science products to inform fisheries management decisions, including projected shifts with quota allocation implications**	✓	✓	**Develop proactive communication to directly address issues of public concern**	✓	✓	**Develop, implement and maintain coastwide data standards through cooperation with all program partners; Support data systems modernization and integration**

Table 2: This table represents a comprehensive list of all efforts and goals shown in the 2014, 2019, and 2024 Strategic Plans released by the ASFMC.

State Climate Change Initiatives Gaps and Recommendations

Approved by the ASMFC Policy Board in 2018 the State Climate Change Initiative Gaps and Recommendations report depicts three recommendations and assesses the various strategies that the Atlantic Coastal states are initiating or have put into effect to acknowledge climate change and work towards a resilient and climate adaptive environment. The three recommendations are as follows:

1. Energy production and use.
2. Science and monitoring.
3. Increasing resiliency.

The first recommendation is a key element of climate adaptive management through encouraging the use of renewable energy production while encouraging energy developers to minimize impacts on marine resources. The second recommendation aligns with another element of climate adaptive management by increasing science related to long-term monitoring of various ecosystems to understand climate change effects on fish species and their habitats and continue climate vulnerability assessments, like the Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf published in 2016 (Hare et al., 2016). The third recommendation, increasing resiliency, promotes the consideration of climate change planning for coastal development and encourages the state and federal agencies to incorporate climate change analysis into their environmental review documents. Additionally, this recommendation promotes

the use of best management practices to support resiliency in the face of climate change.

Management, Policy and Science Strategies for Adapting Fisheries Management to Changes in Species Abundance and Distribution Resulting from Climate Change

In February of 2018, the Climate Change Workgroup was tasked with developing science, policy, and management strategies to assist the ASMFC with adapting their management strategies to account for changes in species and distribution due to climate related impacts. The purpose of this document is to be an evolving and updating guide as new climate related information becomes available. This document resulted in five main outputs: (1) A stepwise approach; (2) Management options for stocks at persistent low biomass; (3) Management options for stocks with changing spatial distributions; (4) Including a climate change term of reference; and (5) Climate change data availability and gap analysis.

The first output, *a stepwise approach,* outlines seven steps to achieve "effective management strategies" when dealing with climate change effects on fisheries. This output suggests the use of a generalized framework to help managers fully understand how to implement climate change adaptation measures into management strategies by breaking the process down into smaller steps:

1. Define planning purpose and scope.

2. Assess climate impacts and vulnerabilities.
3. Review/rewrite management goals and objectives.
4. Identify possible adaptive management options.
5. Evaluate and select adaptive management options.
6. Implement adaptive management options.
7. Track action effectiveness and ecological responses.

The outlined steps highlight three key elements of climate-adaptive management. Firstly, they emphasize the increased availability of data assessments before, during, and after the implementation of proposed management strategies, highlighting the necessity of continually updating climate-related scientific research for marine ecosystems and their habitats. Secondly, the prioritization of “climate-informed and forward-looking” management strategies implies a flexible framework, evident in steps three through seven, which encompass revision, implementation, and adjustments based on the latest information from monitoring efforts. Thirdly, step six acknowledges the significance of cohesion and coordination, encompassing individual leadership, institutional commitment, and resource allocation, as well as early engagement of partners in the management process.

The second output, *management options for stocks at persistent low biomass,* addresses two main questions put forth by this output: (1) what, if any is an appropriate harvest level; and (2) how many resources should be committed to continue monitoring and managing the species. To answer these questions, four approaches were put forth:

1. Status quo.
2. Evidence of a change in productivity.
3. Evidence the stock has a low to no productivity; recovery to sustainable levels is highly unlikely.
4. Management and monitoring cease and harvest does not continue.

The first approach, *status quo,* addresses the first question put forth by this output regarding appropriate harvest levels acknowledging that current strategy focuses on setting harvest levels that aim to rebuild the fish population by targeting a specific fishing mortality rate (F) alongside a biomass target derived from historical assessment data. The assumption is that by maintaining low fishing mortality rates, the fish stock will eventually recover to desired levels. However, if the biomass of the fish stock continues to decline despite these efforts, there are two potential options for adjusting harvest strategies: (1) Continuing the current strategy with further reductions in F, which involves continuing with the existing approach but implementing additional reductions in fishing mortality rates to further alleviate pressure of the declining population; (2) Implementing a harvest moratorium, which would temporarily but a halt on harvesting activities for a specific period of time based on the life history of the species in question allowing for the species to recover without additional fishing pressure. The second approach, *evidence of a change in productivity,* suggests that the harvest levels would be adjusted based on redefined reference points that the stock will not be able recover to previous biomass targets due to a change in productivity caused by climate

change related environmental causes. This approach calls for a lower sustainable yield compared to historical levels and in response could lead to a smaller fishery with fewer number of participants. Additionally, this approach could implement a rebuilding period, like the first approach, where fishing pressure is further reduced to allow recovery. The third approach, *evidence the stock has a low to no productivity; recovery to sustainable levels is highly unlikely,* established two options: management or monitoring. The management option would put in place a permanent moratorium or continue harvest until it is "economically unfeasible." The distinction between choosing the two options of management would come from prediction of recovery and consideration of genetic diversity. The monitoring option would simply determine what level of monitoring should occur: increased, current, or reduced. This approach also recognizes that for each option presented there is a great demand for science and produces several questions to be answered before choosing the most effective option.

The third output, *management options for stocks with changing spatial distribution,* depicts three options to manage stock allocations: (1) Maintain current state-by-state or regional allocations; (2) Maintain regional or state-by-state allocations and develop a Commission policy to revisit allocation based on identified triggers; (3) Change management away from state-by-state allocations. The first allocation option, *maintain current state-by-state or regional allocations,* discusses the concept of quota sharing within or between fisheries and explains that under current state-by-state management, allowing

quota transfers between states is essential to adapt to changing stock distribution. However, under regional or coastwide management, the need for quota sharing becomes less critical for responding to these changes. This option also considers adding a minimum allocation for states with low quotas or those located on the edge of where stocks are shifting out of their jurisdiction. Additionally, the inclusion of a “episodic events approach” where a portion of the coastwide quota would be set aside for species that periodically move into and out of a particular region. This approach allows for the harvesting of these fish when they temporarily appear in a specific area, ensuring that fishers can take advantage of these opportunities without exceeding the overall quota. The second approach, *maintain regional or state-by-state allocations and develop a Commission policy to revisit allocation based on identified triggers,* suggests that triggers could be based off time, indicator of change, or threshold of public comment. This approach also provides options for who makes the final decision regarding allocation indicating that states could push for specific allocation through political pressure. To adjust allocations, several options are mentioned: using distribution and abundance data from certain fisheries that cover extended geographical areas, a combination of historical allocations and current distribution that adjusts through time (e.g., 75% historical allocation years 1-2, 65% historical allocation years 3-4), and using catch distribution, recruitment, productivity, and total yield across years to determine allocation. The third option, *change management away from state-by-state allocations,* would

change allocations from species based to area based where industry members are permitted for multiple species at once so they can move form stock to stock or change allocation by timeframe using seasons and calendar quotas where they would be further divided out by area (e.g., northern and southern allocation).

The fourth output, *including a climate change term of reference,* recommends that stock assessment committee incorporate a “terms of reference” to assess the presence of climate change impact on the species under consideration.

The fifth output, *climate change data availability and gap analysis,* recommended the establishment of a coastwide database that compiles information on the climate-related data collected by various state, federal and university programs. This database would not store the actual data but would instead provide the metadata on the programs involved such as including a summary of the types of environmental data collected, temporal and spatial aspects of the data, sample design, and contact information. Ultimately serving as a centralized hub to aid species assessment committees, offering the option to identify and request climate data pertinent to the species and geographical region under examination. Climate data types that would be included in this database would be temperature, salinity, pH, precipitation, wind, currents, and global climate measures (e.g., North Atlantic Oscillation and Atlantic Multidecadal Oscillation).

3. **NEW ENGLAND FISHERY MANAGEMENT COUNCIL**

The New England Fishery Management Council (NEFMC) is one of eight regional fishery management councils established by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) in 1976. The NEFMC is responsible for managing fisheries in federal waters off the New England coast, which includes the Gulf of Maine, Georges Bank, and southern New England waters. The NEFMC's jurisdiction spans federal waters from 3 to 200 miles offshore, covering an extensive area known for its varying marine resources and diverse ecosystems. The NEFMC consists of eighteen voting members, consisting of twelve appointed by the governors of New England states, the five principle state officials with marine fishery management responsibility from each state under regional jurisdiction, and the Regional Administrator of NOAA Fisheries in the Greater Atlantic Region (GARFO). These members represent a diverse range of interests, including commercial and recreational fishing sectors, environmental organizations, and academia. One of the various responsibilities of the NEFMC includes the development of Fishery Management Plans (FMPs) for a variety of fish stocks and species under its jurisdiction.

Management Plans

The NEFMC has nine FMPs in affect that apply to twenty-eight marine and one anadromous species. The Northeast Multispecies FMP is managed under a sector-based approach from a system of catch share management. A

sector is defined as a group of three individuals, each holding limited access vessel permits, who have voluntarily entered a contract and agreed to specific fishing restrictions for a defined period. This group is granted a quota to pursue objectives aligned with the goals and objectives outlined in the relevant fishery management plan. Approved annually, sectors receive a quota allocated for groundfish stocks in the form of an annual catch entitlement which is based on the potential sector contribution of its participating vessels and calculated using each vessels fishing history.

Only two of the nine FMPs were mentioned due to their successes and future failures. The Northeast Multispecies FMP features species exhibiting a broad spectrum of climate vulnerabilities, ranging from “low” to “very high” that will require future climate adaptive management strategies (Hare et al., 2016). Notably, the Scallop FMP serves as a successful model by implementing adaptable and flexible climate-forward strategies, thereby enhancing the fishery's resilience.

Northeast Multispecies (Groundfish)

This management plan was initially implemented in 1986 with the aim of reducing fishing mortality for heavily exploited groundfish stocks. This plan is comprised of twenty stocks that live off the coasts of New England and the Mid-Atlantic. The twenty species included in this management plan are: Atlantic Halibut; Redfish; Southern New England/Mid-Atlantic winter flounder; Gulf of Main winter flounder; Georges Bank winter flounder; White Hake; Witch

flounder; American Plaice; Pollock; Cape Cod/Gulf of Maine yellowtail flounder; Southern New England/Mid-Atlantic yellowtail flounder; Georges Bank yellowtail flounder; Georges Bank haddock; Gulf of Maine haddock; and Gulf of Maine cod. Since 2014, there have been five plan amendments and eighteen framework adjustments/specifications. Of the amendments to this plan, one has been withdrawn and the remaining four amendments focus on monitoring, bycatch, and accurate representation of catch landings/discards. The framework adjustments range from modifying or replacing control rules including rotational harvest programs, reduction of allowable catches, stock rebuilding plans, and stock and allocation adjustments. The species listed in this plan are allocated based on a sector-based approach into a system of catch share management. All vessels with a federal limited access Northeast multispecies permit are eligible to join a groundfish sector and receive an annual catch entitlement approved on an annual basis. These sectors do not have trip limits (apart from Atlantic Halibut) because they are restricted by its annual catch entitlement. Participants who do not join a sector are able to continue fishing under a “common pool” system under sub-annual catch limits and accountability measures. The common pool collectively can harvest a specific amount of a particular stock, which is equivalent to the common pool sub-annual catch limit. This limit constitutes a portion of the commercial groundfish quota allocated for that stock. The common pool fishing year is divided into 4-month trimesters, and the sub-annual catch limit for each allocated groundfish stock is apportioned among these trimesters based on

seasonal fishing effort, referred to as the Trimester Total Allowable Catch (TAC). When 90% of a trimester TAC is reached, the corresponding area is closed to common pool vessels until the end of that trimester. TAC areas are delineated into various marine locations specified by the FAO as fishing areas to establish catch possibilities. Any uncaught portion of the trimester TAC from the first two trimesters is carried forward into the subsequent trimester. Conversely, if a trimester TAC is exceeded during the first two trimesters, the overage is deducted from the next trimester's allocation. Vessels operating under the common pool system are required to adhere to trip limits.

According to the Northeast Climate Vulnerability Assessment figure depicting ranges of climate exposure and biological sensitivity, species included in this management plan show a wide range of climate vulnerability. The following list shows the species under this management plan and their climate vulnerability:

Very High Climate Vulnerability

Winter flounder

High Climate Vulnerability

Atlantic Halibut

Witch Flounder

Moderate Climate Vulnerability

Atlantic Cod

White Hake

Pollock

Low Climate Vulnerability

Yellowtail Flounder

American Plaice

A total of eighteen framework adjustments and specifications resulted between the years 2014 to 2024. Of the eighteen framework adjustments, three of those are currently still under development: Frameworks 68, 67, and 66.

Sea Scallop

Implemented in 1982, the Atlantic Sea Scallop FMP aimed to restore adult stocks and reduce the fluctuation of the year-to-year stock abundance. Currently, the Sea Scallop fishery is managed through two primary fleets: the Limited Access (LA) fleet and the Limited Access General Category (LAGC) fleet which are both managed differently. The LA fleet is specifically managed through a DAS limit with a rotational area access program to promote optimal yield in the fishery while restoring the stock status. Under this rotational program, the NEFMC closes areas with large concentrations of fast-growing, small scallops before the scallops are exposed to fishing efforts. This effort allows the scallops to use this key time to grow at a substantial rate, resulting in an increased amount of scallop stock biomass. Once a period is closed, an evaluation takes place according to the specific guidelines and procedures established by this FMP and will re-open when the scallops are larger and

more suitable for harvest. The LAGC fleet are vessels with individual fishing quotas or IFQs. The vessels under this fleet are allocated a yearly quota that may be leased or permanently transferred among the LAGC fleet to be fished throughout the fishing year. LAGC Fleet vessels are allowed a specific number of fleet-wide trips into the scallop access areas, while the scallop fishing by these fleets occurs in open areas. These areas include: the Gulf of Maine, Southern New England. Great South Channel Scallop Dredge Exemption Areas, and the Mid-Atlantic Exemption Area.

This FMP has a total of fourteen framework adjustments/specifications, with one currently under development and six plan amendments. According to the Northeast Climate Vulnerability Assessment figure depicting ranges of climate exposure and biological sensitivity, Atlantic Sea Scallops are considered to have high biological sensitivity and highly exposed to climate changes as well. Of these framework adjustments and specifications, this FMP has implemented measurements that aim to increase harvest while preventing overfishing through a rotational harvest program, limited access quota fleets to reflect the spatial management of the scallop fishery, and stock possession limits. In progress since April 2023, Framework 37 aims to establish a rotational harvest program around a closed habitat area. This adjustment is designed to avoid habitats critical to specific juvenile fish species, minimize impacts on essential fish habitats, and reduce economic and biological impacts on managed fisheries, all while enhancing the success of the scallop fishery.

Ecosystem-Based Fishery Management Committee

Resulting from an EBFM Pilot Project in 2005 and federal reports such as the 2004 U.S. Commission on Ocean Policy Report and the 2014 Training Course: Essential Ecosystem Approach to Fisheries Management (EAFM) (Staples et al., 2014), this committee has been exploring EBFM to lead to a new fishery ecosystem plan or to contribute to new ecosystem policies and initiatives that would apply across multiple fishery management plans (Figure 5). This exploration of EBFM represents a significant advancement for Regional Fishery Management Councils, offering the potential to foster climate-adaptive fishery management initiatives that enhance the resilience and sustainability of fisheries. A memorandum addressed to the EBFM Committee in March of 2015 identified four potential processes for the NEFMC to develop and apply EBFM policy: (1) Ecosystem Approach (EAFM) Policy documents, which would develop through a series of policy documents that the council would take into consideration through broad management objectives that would be applied to all management polices through FMP amendments; (2) Example Fishery Ecosystem Plan (eFEP), which includes a prototype of a Fishery Ecosystem Plan (theoretically or practically) for a specific defined area that could be used as a template or example for future actions; (3) Implemented Fishery Ecosystem Plan (iFEP) is labeled as a very holistic approach that would develop a whole new FMP intended to replace existing management in a specific area, but would need to include alternatives to address jurisdictional and allocation issues among areas with overlapping

species ; and (4) Blended Fishery Ecosystem Plan (bFEP) which would develop an omnibus amendment to produce management alternatives to address ecosystem issues but not to replace FMPs, more so to address specific issues such as forage based Acceptable Biological Catch (ABC) control rules or responses to climate change (NEFMC, 2015).

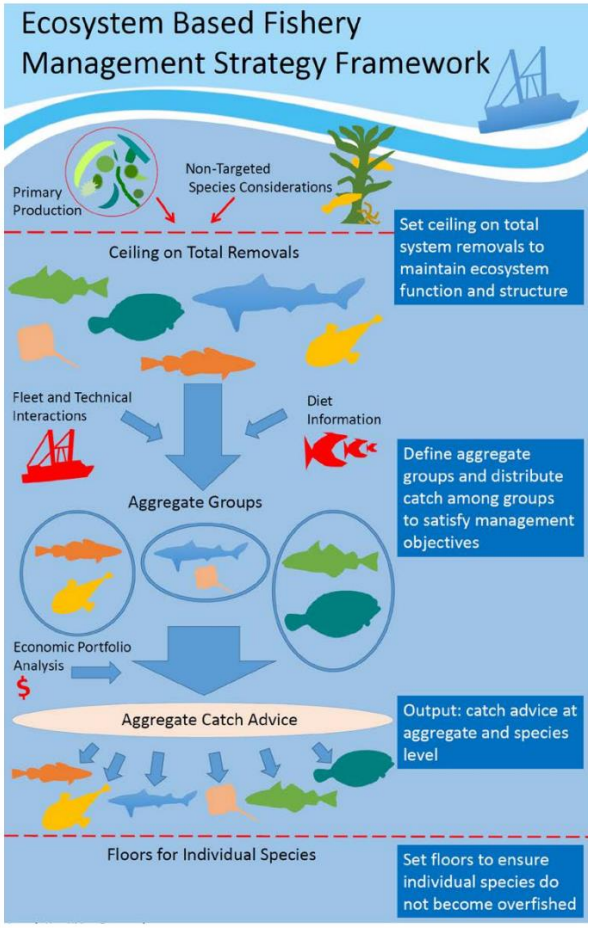

Figure 5. Elements of the proposed hierarchal process for specifying Acceptable Biological Catch (ABC) levels for species within defined Fishery Species Complexes (New England Fishery Management Council & Ecosystem Based Fishery Management Plan Development Team, 2019).

Following the processes described by the memorandum, the council developed an Example Fishery Ecosystem Plan (eFEP) for Georges Bank drafted in 2019. This FEP framework is designed to “consider the management of living marine resources within ecological production units in an integrated, systemic fashion, providing a holistic perspective but at the same time providing flexibility for addressing societal objectives within biodiversity constraints provided by overfishing and overfished criteria central to legislation” (New England Fishery Management Council & Ecosystem Based Fishery Management Plan Development Team, 2019).

In addition to the FEP framework, in January of 2022, an EBFM Workshop Summary Report was published to reflect on the six workshops/listening sessions prepared by the NEFM in various northeast fishing ports to introduce and discuss EBFM. Despite not being a management document, this is the first step to implementation as well as a key component in climate adaptive management (*increased coordination across media, sectors, interests, and governments*) through the inclusion of fishers and interested parties. These workshops validated core issues, posed informative questions, and deliberated on trade-offs concerning the future implementation of EBFM (New England Fishery Management Council & Ecosystem Based Fishery Management Plan Development Team, 2019).

CHAPTER 5: DISCUSSION

1. FEDERAL GOVERNMENT

a. Legislation

The legislation stemming from my research was categorized into five groups, each aligned with distinct climate adaptive elements. Over the past decade, majority of legislation introduced has primarily entailed amendments to existing laws, advocating for measures such as enhanced collaboration, expanded research initiatives, gear restrictions, and greenhouse gas reduction. While various bills have addressed the restoration of marine ecosystems and research into climate-related impacts such as ocean acidification, coastal erosion, and land issues, their focus has not been exclusively on fisheries. The abundance of legislation introduced in this regard underscores the significance of information availability and accessibility in fisheries management. The purpose of this discussion is to explore legislation falling within the final category, which encompasses bills aligned with two or more climate adaptive elements and specifically targets fisheries. Climate adaptive management is recognized as comprehensive, addressing various facets of fisheries and their interconnected influences. However, all pieces of legislation falling into this category have yet to advance beyond the introduction stage in the legislative process.

Introduced in January of 2024, the SHFT Act (S.3672) encompasses every aspect of climate adaptive management. If passed, this legislation would amend the Atlantic Coastal Fisheries Cooperative Management Act to direct

the Secretary to encourage the inclusion of climate change impact data in fishery management plans (Section 2). Secondly, the legislation would also amend MSA to add new fisheries or fishing gear to the list of authorized activities. This addition would necessitate an analysis of the potential adverse effects on essential fish habitat, existing fisheries, fishing communities, and the marine ecosystem (Section 4). Finally, it would establish a procedure for the MSA to determine whether a substantial portion of a fishery extends beyond the geographical area of authority of any one council. If such cases, the concerned councils would be required to designate one council to prepare a fishery management plan (or prepare to jointly prepare one) with additional time for decision-making and plan preparation (Section 3). This bill aims to enhance the consideration of climate change impacts in coastal fishery management planning and authorization processes under federal law. This is the only law that encompasses all aspects of the climate adaptive management elements that specifically applies for fisheries. Additionally, the Ocean-Based Climate Solutions Act of 2020 (H.R. 8632), initially introduced in October 2020, encompasses a range of ocean-based policies, programs, and objectives aimed at mitigating climate change and minimizing greenhouse gas emissions. Notably, it would establish the Blue Carbon Program, which advances conservation efforts for fish and wildlife habitat restoration and promotes coastal resilience. This bill would accomplish this through climate and fisheries research programs, essential fish habitat consultation, increased funding for scientific research and ocean aquaculture research and policy

programs. This legislation also incorporates the reduction of non-climate related stressors such as fuel-efficient vessels and the prohibition of oil and gas leasing in all areas of the outer continental shelf. While the climate adaptive element of increased data availability and data sharing is mentioned within this legislation, it only specifies that it is for offshore wind development. The element of flexible management is seen through the establishment of policy programs including: a shifting stocks task force; climate-ready fisheries innovation program; and a climate and fisheries research and management program. Another piece of legislation that proposes the creation of programs includes the Coastal State Climate Preparedness Act of 2023 (H.R. 2735) which would direct the DOC to establish a coastal climate change adaptation preparedness and response program. Additionally, this legislation would also do two things in response to changing climate related issues, (1) assist coastal states with voluntarily developing coastal climate change adaptation plans, and (2) provide financial and technical assistance as well as training for coastal states to implement the adaptation plans.

The Climate-Ready Fisheries Act of 2019 (H.R. 4679), introduced in October of 2019 section 3, mandates the submission of a report examining the endeavors of the Regional Fishery Management Councils, the Atlantic States Marine Fisheries Commission, and the National Marine Fisheries Service in preparing and adapting fishery management to climate change impacts. However, it does not prescribe specific recommendations or establish standards for fisheries management. Instead, it directs all Councils, the

Commission, and NMFS to review and reassess their management strategies in accordance with the recommendations provided.

While there are additional plans that encompass more than two climate adaptive elements, the plans mentioned above mark the dawn of a new era characterized by federally mandated guidelines and regulations. These initiatives hold the potential to mitigate climate-related stressors and foster adaptive management strategies conducive to the conservation and effective stewardship of our marine resources.

b. Executive orders

Based on my analysis of 464 executive orders between 2014 and 2024, only four of them were found to support the advancement of climate adaptive management. In 2016 E.O. 13754, *Northern Bering Sea Climate Resilience,* was signed. This E.O., while only specified for the Northern Bering Sea, the framework of key goals and provisions specified here including: establish an Intergovernmental Tribal Advisory Council; provide recommendations on reducing pollution from vessels through zero-discharge zones and noise reduction measures; reduce the impact of shipping routes by identifying the best routes for navigation, safety, and the marine environment; the development of oil spill preparedness plans; and the continuing of existing habitat protection are key climate adaptive goals that can be applied to other areas threatened by climate change. E.O. 14027, *Establishment of the Climate Change Support Office,* and the E.O. 14008, *Tackling the Climate Crisis at Home and Abroad,* both assist in the establishment of two offices that support

the department of state and other executive departments in their efforts to combat climate change through initiatives that promote renewable energy, conservation, climate resilience, adaptation, and ultimately reinstating environmental regulations through the National Climate Task Force. E.O. 13840, *Ocean Policy to Advance the Economic, Security and Environmental Interests of the United States,* promotes the productive and sustainable use of ocean, coastal, and Great Lakes waters, including fisheries. Additionally, this executive order facilitates coordination, consultation, and collaboration on all ocean-related matters among federal, state, tribal, and local governments, as well as with foreign governments and ocean stakeholders. This E.O. aims to foster a collaborative environment with the shared goal of promoting sustainability.

The four executive orders promote frameworks that encompass aspects of climate adaptive management, whether through the development of task forces with similar goals or the establishment of area-specific objectives. These efforts demonstrate the federal government's commitment to addressing climate-related challenges. However, there is still a lack of a comprehensive federal mandate on climate adaptation established through executive orders. Such a mandate should effectively integrate the efforts of councils, state governments, and federal agencies, providing clear direction on how to implement the climate adaptive strategies proposed.

c. Documents

In response to the NOAA Fisheries Climate Science Strategy, 7 Fish Stock Climate Vulnerability Assessments were published including the Northeast Fish Stock Climate Vulnerability Assessment published in 2016. The Climate Science Strategy underscores the importance of addressing the implications that climate-related stressors have on fisheries, ecosystems, and management. Throughout this document the importance of and the integration of science into fisheries management and management strategies is highlighted within every objective ranging from identifying research gaps to incorporating regular and routine evaluations on marine ecosystems or management strategies. While this document addresses key components of fishery management, specifically the integration of climate informed science, there is no direction on how to create and implement climate adaptive fisheries management into current management frameworks besides the increased data assessments. Other documents that follow this same pattern include Ocean Justice Strategy and the Ocean Climate Action Plan. These documents have a commonality of calling for more climate focused research in relation to fisheries and other areas affected by climate change, yet do not provide specific ways to integrate this research besides through stock assessments.

The Federal Fisheries Management: Opportunities Exist to Enhance Climate Resilience report, published in August of 2022 suggests creating adaptable management strategies through the transferring of stock quotas, setting quotas based on current stock distribution data instead of historical

measurements of fish, and through using exempted fishing permits to authorize fishing research or to test new gear and revised gear types to reduce bycatch of protected or overfished species. Strategies like this would require a substantial change in the management strategies of the councils. An approach like the one suggested, would be the Transboundary Management Guidance Committee (TMGC), which was developed and used for the management of shared Georges Bank resources between the U.S. and Canada. This approach involves a dynamic solution for gradually adjusting state-specific allocations using a combination of historical allocations and current levels of stock distribution. A similar approach was proposed by the ASMFC to respond to Black Sea Bass shifting stock distribution to the northern portion of its range, the Dynamic Adjustments to Regional Allocations, otherwise known as DARA. To accomplish this approach, a gradual transition would take place, giving more weight to historical participation at first, then slowly phasing in the distributional aspects over time, and then implement changes to specific allocations through a two-step process.

The NOAA Fisheries Ecosystem-Based Fisheries Management Policy (effective May 2016) and the NOAA Fisheries Ecosystem-Based Fisheries Management Road Map (effective April 2017) made a massive step in climate adaptive management by making EBFM the preferred method for NOAA Fisheries to meet the expectation of sustainably managing the nation’s living marine resources. The EBFM Road Map published by NOAA Fisheries in

2017 operationalizes NOAA's commitment to EBFM. Through this guideline, there are six guiding principles with various components for each principle to help achieve the goal of EBFM. This road map depicts the only strategized document plan to implement EBFM into current management frameworks. Using this as a guideline, Councils, Commissions, and States can adhere to federal expectations to embrace the climate adaptive management strategy to sustainably manage fisheries resources. The guiding principles and their core components for each principle is as follows:

1. Implement ecosystem-level planning.
    a. Engagement Strategy
    b. Fishery Ecosystem Plans
2. Advance our understanding of ecosystem processes.
    a. Science to Understand Ecosystems
    b. Ecosystem Status Reports
3. Prioritize vulnerabilities and risks to ecosystems and their components.
    a. Ecosystem-Level Risk Assessment
    b. Managed Species, Habitats, and Communities
4. Explore and address trade-offs within an ecosystem.
    a. Modeling Capacity for Trade-offs
    b. Management Strategy Evaluations
5. Implement ecosystem considerations into management.
    a. Ecosystem-Level Reference Points
    b. Ecosystem Considerations for Living Marine Resources

c. Integrated Advice for Other Management Considerations

6. Support ecosystem resilience via monitoring and adjusting of management actions.
    a. Resilience
    b. Community Well Being

This implementation plan of EBFM encompasses all aspects of climate adaptive fisheries management, except the reduction of non-climate related stressors on marine resources. This aspect of climate adaptive management, while not specifically mentioned, can be obtained through reducing by-catch and gear restrictions under the third guiding principle, *prioritize vulnerabilities and risks to ecosystems and their components.*

2. STATE GOVERNMENTS

Research indicates that states lacking climate action plans specifically tailored for fisheries, beyond the mandated Wildlife Action Plan, lack comprehensive strategies to address climate-related stressors affecting their marine resources. Multiple states produced climate informed reports or action plans that focus on eliminating or reducing non-climate change stressors such as greenhouse gas emissions and pollution. The State Wildlife Action Plans often served as the sole management plan with a climate-adaptive approach for fisheries. All state management plans stem from the Fish and Wildlife Act of 1956, but specifically through amendments made to the Act in 2000. The amendment created funded actions through grants to conserve declining fish

and wildlife species before they reached the stage of threatened or endangered (*Public Law 106-408, 2000*). The law requires specific elements to be addressed in each action plan: species of greatest conservation needs; key habitats; problems; research needs; and conservation actions. To be eligible for grants to conserve natural resources, states must complete, update, and revise a SWAP every 10 years. In 2005, Rhode Island, Massachusetts, Maine, New Hampshire, and Connecticut completed and released their first SWAP. The second revision/update was released in 2015 and with 2025 approaching, the revision of new Wildlife Action Plans is currently underway. Climate change is recognized as a threat to fisheries in all state action plans, although the level of priority given to addressing climate change impacts on fisheries varies among states.

a. Rhode Island

The three management and action plans developed by Rhode Island Division of Marine Fisheries: Rhode Island Department of Environmental Management Division of Marine Fisheries Strategic Plan (2021-2025); DEM Rhode Island Strategic Plan FY 2024-2026; and the Rhode Island Wildlife Action Plan (RIWAP) (2015) depict clear goals yet does not necessarily provide a clear outline or strategy to accomplish those goals. In the Strategic Plan for 2021-2025, each goal listed offers vague direction on how to accomplish them, lacking a clear pathway. This does not imply a lack of effort, but rather that the efforts made are unclear in their implementation.

Throughout these management plans, Rhode Island acknowledges a clear need for more research, monitoring, and assessments of the future implications of climate change on key species and habitats. Additionally, throughout these management plans there is no mention of resource allocation to accomplish their need for additional research. Adequate allocation of resources, including funding, personnel, and technological support is essential to implement and sustain the climate adaptive measures effectively.

b. Massachusetts

Like other Wildlife Action plans, the 2015 Massachusetts State Wildlife Action plan centered around wildlife with less emphasis on fisheries and their threats. This plan acknowledges that while natural systems are complex the solution for adaptive management does not have to be and encourages the use of the simple results chain as well as the multi-action results chain. This type of management strategy does not take into consideration all aspects of the marine environment including the consideration of climate change impacts. Seen in Figures 3, the multi-action results chain, depicts multiple conservation actions for one target species. The plan highlights that these chains can be used to clarify the connections between an initial population or habitat, conservation actions aimed at the resource, and the desired outcome. While this plan could prove to be effective for wildlife and other resources not affected by climate change, it is not effective for fisheries management.

Additionally, the plan acknowledged the importance of monitoring climate-related data on resources, but there is no mention of management strategies to combat climate related effects besides the need for conservation. The conservation efforts mentioned are primarily aimed at wildlife resources, not necessarily fisheries. This action plan does however mention community engagement and stakeholder involvement specifically to discuss issues, solicit public comments, and set regulations and policies, which is a key element in climate adaptive management. One aspect of action plan missing is addressing the social and economic implications of climate change on fisheries-dependent communities and industries, which is crucial for ensuring the resilience and sustainability of marine fisheries in Massachusetts. While direct mention of fisheries may be limited within this plan, leveraging the conservation framework alongside enhanced research and monitoring initiatives outlined can significantly benefit the Massachusetts DMF's strategic approach.

Massachusetts took an initiative towards flexible management strategies by initiating the transition to EBFM to increase coordination in regional priorities (NEFMC) through the Marine Fisheries Strategic Plan in 2019. This connects the goal of NOAA Fisheries Ecosystem-Based Fisheries Management Policy published in May of 2016, just three years prior to this Strategic Plan. Steps to achieving EBFM take the form of “management plans that integrate ecosystem services, socio-economic impacts, habitat protection, bycatch reduction and protected species interactions with fair, scientifically

defensible allocations of fishery resources." The plan mentions that to achieve this, the DMF will collaborate with the Commonwealth's Marine Fisheries Advisory Commission (MFAC). This strategic plan acknowledges the complex challenges that fisheries will face with climate change including changing ocean conditions, complex interstate, and federal management systems, and achieving and maintaining sustainable fisheries. The five goals in this plan are comprehensive, providing clear steps necessary to achieve them and encompassing all elements of climate adaptive management. While this plan was released in 2019, and ranges until 2023, it is unclear if the MADMF has accomplished the steps set forth by this plan due to the lack of information on management plans and initiatives.

Additionally, MADMF released a Climate Change Policy Statement (date released unclear) that lists strategies and priorities to address ecosystem changes and impacts on fisheries as a result form changing environmental conditions. The key strategies mentioned focus on increasing data collection of climate related impacts, including the development of additional workgroups and partnerships, developing outreach materials to foster an informed community and stakeholders, and the creation of an in-house committee to support and coordinate the increase of collected data. This statement acknowledges the need for increased data assessments of climate change and its' impacts on marine resources along with establishing the expectation of developing strategies to address future impacts of climate

change. MADMF is calling for an increase in data availability to produce a "comprehensive response" to climate change.

c. Maine

The threat of climate change for Maine's fisheries is evident through experiencing one of the fastest rates of warming of any ocean ecosystem, with global climate projections predicting this region to continue to warm at above average rates (Pershing et al., 2021; Perishing at al., 2015; Saba et al., 2016). Because of this warming economically important species such as lobsters, shrimps, and clams have already experienced the effects of climate change causing migration, disease, and a closure of the (shrimp) fishery from lack of stock biomass. In addition to these species, Maine's groundfish: Cod, Haddock, Pollock, Hake, Flounder, and Redfish are also expected suffer by climate-related effects like warming waters. There have been no plans or reports published from Maine's Department of Marine Resources to prevent or response to this devastation. The only plan found from Maine that included marine fisheries in the assessment was their SWAP in 2015. This action plan was published from MDIFW, while the SWAP was inclusive of marine fisheries, it mostly focused on wildlife and inland anadromous fishes with little mention of marine fisheries. In this action plan, the need for increased research and monitoring data is centered on understanding other stressors faced by marine fisheries such as impacts of bycatch, habitat usage and mortality rates from discards. While these aspects could be considered to fit

under the climate adaptive element of *reducing non-climate related stressors and promote resilience,* it does not specify actions to reduce these stressors, rather it focuses on identifying the impacts of these stressors. Research shows that Maine's priorities for action plans regarding climate change is centered around wildlife, inland fisheries, and anadromous fish. By 2025, Maine is projected to release another State Wildlife Action Plan, which should include an emphasis on marine resources. The 2025 SWAP should prioritize actions to address vulnerabilities to climate change, considering both the economic and biological significance of Maine's marine ecosystem.

d. New Hampshire

New Hampshire's Wildlife Action Plan was the only management plan found from 2014-2024 that addresses fishery management concerns. This management plan demonstrates a proactive approach to managing its fishery resources through three key initiatives. The WAP outlines comprehensive conservation actions across distinct categories, including species and habitat actions, planning, agency coordination, regulation, policy, and education. These actions demonstrate an effort towards comprehensive approach to managing and protecting marine resources in New Hampshire. This document also highlights an adaptive management approach, emphasizing the importance of monitoring, performance evaluation, and the ability to adapt to management activities based on new scientific findings. Outlined within the document is a flow chart for the adaptive management process including

actions on how to accomplish the goals outlined. This iterative process allows for continuous improvement in conservation environment conditions. Additionally, New Hampshire has established programs like the Fish Conservation Program and released the Ecosystems and Wildlife Climate Change Adaptation Plan, indicating a commitment to addressing environmental challenges and promoting ecosystem health. These initiatives were not included in the research; however, they do demonstrate additional proactive efforts to adapt to climate change impacts on fisheries resources. Actions provided in the WAP highlight proactive fisheries management, yet there are areas within this plan that require further attention and refinement. The WAP acknowledges the importance of conservation actions and adaptive management, however, there is a lack of stakeholder engagement in the development and implementation of conservation actions. Involving stakeholders, including fishers, industry representatives, and local communities, is crucial for ensuring the success and sustainability of fisheries management efforts.

Overall, New Hampshire does provide substantial effort into providing efforts to implement this action plan, yet it is unclear as to whether these efforts have been successful in the management of their resources.

e. Connecticut

Connecticut's management of marine fisheries resources, as outlined in the Wildlife Action Plan, demonstrates both successful measures and potential

areas for improvement. While the WAP identifies climate change as a threat the marine environment, there could potentially be a gap in in explicitly addressing climate adaption strategies for marine fisheries. The document focuses more on non-climate related stressors and lacks specific actions targeting climate change impacts on, specifically fisheries resources.

The WAP acknowledges the lack of scientific knowledge concerning wildlife, fish, and their habitats, yet the efforts mentioned to enhance these initiatives do not prioritize climate research initiatives for fisheries. A successful measure this plan acknowledges is the current insufficient conservation management at a regional level. Aspects of the efforts to combat this challenge include participation in regional conservation efforts; incorporating guidance and information from various levels to enhance stability, connectivity and habitat health so species can better adapt to climate change; develop long-term monitoring protocols consistent with regional efforts; and develop and implement conservation actions that are most effectively addressed at a regional/multi-state scale; and coordinate efforts regionally with the inclusion of key partners to address issues. While these efforts cover aspects aligned with the climate adaptive elements, these aspects are so broad that while they can be applied to fisheries there needs to be specific measures for fisheries. While there is a mention of long-term strategies, there has been no development of such strategies. The document does highlight near-term and mid-term strategies for climate adaptive actions in open water marine habitats such as monitoring marine resource challenges and diversifying fisheries.

However, the lack of long-term strategies may limit the effectiveness of adaptation efforts in addressing the long-term impacts of climate change on marine ecosystems. Another success of this WAP the identification of the management challenges, by recognizing these challenges Connecticut can develop future targeted solutions and guidelines to address them, enhancing the resilience of marine ecosystems and fisheries to various stressors, including climate change.

While there are gaps in explicitly addressing climate adaptive adaption and long-term strategies, Connecticut's Wildlife Action Plan acknowledges the management challenges and prioritizes conservation actions. Continued efforts to integrate climate adaptation strategies and develop long-term strategies could further enhance the resilience of marine ecosystems to climate change impacts.

3. ATLANTIC STATES MARINE FISHERY COMMISSION

Strategic Plans 2014, 2019, and 2024

Every five years the ASMFC reevaluates their strategic plan to articulate the mission, vision, goals, and objectives needed to accomplish the Commissions mission. These plans serve as the basis for annual action plan where the Commission identifies the highest priority issues and activities to be addressed in the upcoming year for the twenty-seven fish species the Commission manages. The past three plans have shown notable

consistencies as well as significant changes and additions to the eight overarching goals of the Commission.

Goal one across all three plans demonstrates a shared emphasis on "rebuilding, maintaining, fairly allocating, and promoting Atlantic coastal fisheries," accompanied by similar objectives and strategies. Both the 2014 and 2019 Strategic Plans advocate for "adaptive management to address emerging issues," while the 2024 Strategic Plan specifically advocates for the creation of "management frameworks that are nimble, adaptable, and robust to climate change," recognizing the necessity for flexible climate adaptive management frameworks within the Commission's purview. Furthermore, the inclusion of the objective "include climate change consideration in our management strategies" in the 2024 Strategic Plan signifies a notable evolution towards incorporating climate-informed data into decision-making processes, a contrast from previous strategic plans where such considerations were absent.

Goal two in all three strategic plans aligns with the shared objective of "providing robust, actionable science to inform management decisions," and each plan sees an expansion of strategies and guidelines to achieve this aim. The 2024 Strategic Plan, compared to the other two plans, notably emphasizes the importance of enhanced communication and collaboration among stakeholders to optimize data sharing regarding climate and ecosystem products. One proposed action involves the integration of environmental data from both estuarine/state waters and federal waters to

enhance stock assessments. Additionally, there is a focus on proactively addressing research priorities through cooperation and collaboration among state and regional data collection programs, as well as stakeholder involvement in collaborative research projects. The 2024 Strategic Plan presents more precise and specific guiding objectives for the Commission to accomplish, recognizing the critical role of data collection and inclusion in management decisions compared to previous plans.

Goals three through seven are relatively all the same throughout all three Strategic Plans with little to no additions in verbiage, guiding objectives, and strategies to help the Commission achieve the goals listed (Table 2).

Goal eight, which aims to "advance Commission and member states' priorities through a proactive legislative policy agenda," represents a novel addition to both the 2019 and 2024 Strategic Plans. Previously, the promotion of "member states' collective interests at the regional and national levels" was merely addressed as a strategy within Goal 6 in the 2014 Strategic Plan. The 2019 plan elevated this concept to its own distinct goal, underscoring the importance of consistent engagement with the federal government to foster alignment between state fishery interests and federal objectives. The 2024 plan retained this goal, along with the same supporting objectives outlined in the 2019 iteration.

4. NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Fishery Management Plans

A key component in the climate adaptive management elements driving this research, *promote principled flexibility in regulatory goals and resource management,* acknowledges flexibility within fishery management initiatives. Flexibility within fisheries management can be acknowledged through the potential scope of action and the speed at which it occurs (Pacific Fishery Management Council, n.d.). A key component of flexible fisheries management stems from the need to quickly respond to fish stocks when they are affected by changing environmental conditions such as stock distribution shifts or decreases in stock biomass and when analyzing the FMPs' framework adjustments/plan amendments, I identified examples of allocation shifts, bycatch mitigation, stock rebuilding or measures to mitigate the effects of permanent depletion or commercial depletion as well. Over the course of a decade (2014-2024), the NEFMC published a variety of FMPs along with the creation of the Ecosystem-Based Fishery Management Committee. A commonality between all FMPs included the rebuilding plans to mitigate the effects of depletion.

After reviewing all nine FMPs, it is evident that the Northeast Multispecies (Groundfish) has not only the most species biologically vulnerable and sensitive to climate change exposure but the most species that require stock rebuilding due to overfishing. Since implementation of the Northeast groundfish FMP, there have been various efforts aimed at rebuilding

fish stocks and eliminating overfishing. Amendment five, implemented in 1944, marked the beginning of an effort reduction program by establishing DAS to limit the number of fishing days for each vessel including increased mesh size requirements, expanded closed areas, and a moratorium on new entrants to reduce fishing effort that lasted over a span of five years. Over the years, despite additional framework adjustments and plan amendments, several depleted Northeast groundfish populations have failed to show signs of recovery. Since the implementation of the sector-based approach from a system of catch share management, discards of regulated groundfish species have been reduced due to the regulation that sector vehicles are required to retain all legal-sized groundfish catch. Sector-based catch shares are regarded as an output control strategy in fisheries management, offering a promising solution for effective resource stewardship by prioritizing biological considerations. They achieve this by mitigating bycatch and alleviating the "race-to-fish" mentality among fishers. However, this approach has drawn criticism for potentially empowering powerbrokers, notably large commercial or industrial fishing sectors, who can acquire annual catch entitlements or quotas from other sectors. This aspect of fisheries management raises concerns about environmental justice, as it may marginalize and exclude small-scale fishers while potentially erecting barriers to entry for new sector vessels, thereby driving them toward fishing in the common pool.

With little criticism, the sea scallop FMP is a success in every aspect through the implementation of a rotational program. Not only does this

promote the recovery of sea scallops but also the inclusion of research in informed management decisions and improved stock assessments. This stock is successful both economically and biologically, landing approximately $570million in 2019 and the result of rebuilt sea scallop stocks (NOAA Fisheries, n.d.).

Ecosystem-Based Management

Ecosystem-Based Fisheries Management (EBFM) is a holistic approach to fisheries management that considers the physical, biological, economic, and social interactions between the various parts of the ecosystem related to fisheries. The EBFM process considers the diverse needs and pressures on fish, fish habitat, and the food web within a geographically specific area, while also accounting for the needs of fishers, communities, and the economy (New England Fishery Management Council & Ecosystem Based Fishery Management Plan Development Team, 2019). The memorandum sent to the NEFMC in 2015 develops and identifies approaches the council might take to implement EBFM into fisheries management along with ramifications of these actions and various favorable attributes to these actions as well. With an EBFM approach there are several benefits: simplification of management structures; coordination of management actions for stocks, protected species, biodiversity, and habitat; comprehensive consideration of fishery and biological interactions; accounts for various ecosystem constraints on rebuilding; and coordinates with State EBM efforts. Throughout the various approaches

(EAFM, eFEP, iFEP, and bFEP), each approach presents distinct advantages and limitations. The specific elements that are acknowledged within the approaches include: scoping; MSA constraints; management authorities; fishery allocations; migration of stocks across boundaries; MSA reauthorization; and Council approval. Of these approaches, EAFM and eFEP are the plans with the least number of limitations to the elements mentioned above due to their incremental framework. With both management plans, they include broad management objectives that do not necessarily require changes to regulations but could be used as future examples or templates to be implemented into current existing management frameworks or individual FMPs when amended. These approaches are projected to be quickly accepted by council by requiring little additional work to implement. The most integrated approach is the Implemented Fishery Ecosystem Plan (iFEP) which goes further than the EAFM and eFEP because this plan would dissolve all current FMPs and integrated in the appropriate Fishery Ecosystem Plan and would require considerable reorganization of fishery management of the council, NMFS, and various partners. This plan however would have to comply with and adhere to all applicable laws and regulations, which could pose to be a limitation with current laws, such as the MSA. The blended Fishery Ecosystem Plan (bFEP) has the same priorities as the iFEP, but would look past jurisdictional issues, but may implement EAFM policies in management plans. A major difference between iFEP would align more with the bFEP and EAFM policy documents by simple augmenting allocations instead of replacing them.

Because this plan has fewer jurisdictional and allocation issues, it could take less time to develop.

The plan that fully encompasses climate adaptive fishery management elements is the comprehensive approach, iFEP. This plan requires coordination across all sectors by involving communities, industry members, stakeholders, and councils in the revision of regulations. The iFEP promotes a framework of flexibility by requiring a restructuring of council frameworks to foster enhanced collaboration among states, NFMS, and councils. Additionally, for this plan to be successful, there needs to be an increase in data assessments to accurately assess and develop successful allocation measures as well as the acceptable biological catch (ABC) limit.

To effectively implement management strategies like EBFM through plans such as iFEP, eFEP, EAFM, and bFEP, it is crucial to address various limitations at both the federal and regional levels to ensure success.

Federal Management Concerns and Limitations

Limitations seen on a federal level are seen through the Magnuson-Stevens Fishery Conservation and Management Act (MSA), which is the foundational law that governs marine fisheries management in U.S. was first implemented in 1976 that focuses on five main objectives: (1) Preventing overfishing; (2) Rebuilding overfished stocks; (3) Increasing long-term economic and social benefits; (4) Ensuring a safe and sustainable supply of seafood; and (5) Protecting habitat that fish need to spawn, breed, feed, and

grow to maturity. In 2007, the MSA Reauthorization Act was passed to further refine and strengthen fisheries science, management, and conservation. This act established annual catch limits and accountability measures, promoted catch shares, addressed illegal, unregulated, and unreported (IUU) fishing and bycatch, and strengthened the role of science through peer review, the scientific and statistical committees (SSC) and the Marine Recreational Information Program (MRIP). This law is the foundation of which all State and Regional fishery management must comply to ensure consistency with federal regulations and management goals. While this law establishes 10 National Goals to aid in achieving the five main objectives, certain constraints are now becoming evident considering climate change. The current laws and regulations could inhibit efforts to implement adaptive management to respond to changing ocean and fishery conditions.

CHAPTER 6: CONCLUSION

Ocean policy has been a consistent focus across various political landscapes over the years, with fluctuations in the level of emphasis from one administration to another. However, it remains a persistent theme across party lines, indicating a collective commitment to establishing comprehensive ocean policy frameworks. The MSA spearheaded the movement of sustainable fisheries management, and since then notable efforts have been made, but the federal government has set modest expectations, primarily focusing on increased research into the impacts of climate change on marine resources. However, specific strategies for implementation are lacking, with broad actions and guidelines being the predominant approach (Table 3). While these actions are important, the expectation of developing an all-inclusive climate adaptive management plan is equally important. The creation of the Ocean Climate Action Plan, while it was a step forward in the right direction of climate adaptive management it lacks specific deadlines, expectations, or directives for implementing actions that support climate adaptive management elements within fisheries, aquaculture, and fishing communities. The plan contains broad statements and actions aimed at addressing these issues, but it does not provide clear guidance or detailed plans for implementation.

Federal Documents	Climate Adaptive Management Elements				
	Scientific Data & Assessment Availability	Eliminate or Reduce non-Climate Related Stressors	Increased Coordination across Media, Sectors, Interests, & Governments	Promote Flexibility in Regulatory Goals & Management	Strategies for Implementation
NOAA Fisheries Climate Science Strategy 2015	✓	✓	✓	✓	×
Federal Fisheries Management Report 2016	×	×	×	✓	×
NOAA Fisheries Ecosystem-Based Fisheries Management Policy 2016	✓	×	✓	✓	✓
NOAA Fisheries Ecosystem-Based Fisheries Management Road Map 2017	✓	✓	✓	✓	✓
Department of Commerce 2021 Climate Action Plan for Adaptation and Resilience 2021	✓	×	✓	×	×
Federal Fisheries Management: Opportunities Exist to Enhance Climate Resilience 2022	✓	✓	✓	✓	✓
Ocean Justice Strategy 2023	✓	×	✓	×	×
Ocean Climate Action Plan 2023	✓	✓	✓	✓	×
Northeast Regional Action Plan 2024	✓	✓	✓	✓	×

Table 3: Comprehensive table depicting the climate adaptive elements (Craig, 2010) outlined in each federal document from 2014-2024.

The NOAA Fisheries Ecosystem-Based Fisheries Management Policy (effective 2016) and the NOAA Fisheries Ecosystem-Based Fisheries Management Road Map (effective 2017) established the only clear expectation of an all-inclusive climate adaptive management framework. It is evident that future SWAPs should be inclusive of this when mentioning their management strategies and lean into this expectation of the federal government. Efforts made by State governments are slow to develop the EBM strategy, yet effort can be seen through allocation opportunities due to a change in the distribution of a stock, bycatch mitigation, the inclusion of transboundary stock shifts in fishery participation limit adjustment, and measures to mitigate the effects of depletion or extinction of a stock.

The NEFMC has initiated efforts through their draft eFEP for Georges Bank, aimed at implementing a more flexible and adaptive management strategy. This plan achieves the following objectives: considers a broader range of goals, objectives, and ecosystem service enhancements; establishes a limit on total ecosystem catches based on system-wide primary productivity; implements harvest control rules for stock complexes to provide flexibility for vessels to catch and land various species within a complex, thereby reducing inefficiencies; and eliminates the static value of maximum sustainable yield (MSY). The removal of MSY directly contradicts that of which the MSA promotes. The implementation of MSY into fisheries management through the MSA promotes the idea that fisheries are stable in their current conditions, with a baseline of fisheries stock not changing, yet now under changing

environmental conditions MSY is no longer sustainable. These standards of sustainable yield tend to favor human use and extraction instead of in favor of the ecosystem (Craig, 2010). Changing the standard of which MSY favors or removing MSY completely could result in an increase of ecosystems' resilience and in turn help rebuild fish stocks that are currently overfished or are being overfished. The NOAA Fisheries Ecosystem-Based Fisheries Management Policy and the NOAA Fisheries Ecosystem-Based Fisheries Management Road Map represents fundamental steps in the direction of climate adaptive fisheries management that can in turn be a foundational framework used to manage future marine areas, yet there may be federal limitations hindering the Council from implementation. Under the MSA, the ability to implement strategies like EBFM that promote place-based management might face limitations by National Standard 2 that requires "conservation and management measures shall be based upon the best scientific evidence." The current management framework does not necessarily support the application of management strategy evaluations, of managing species as functional groups as opposed individual stocks may require additional scientific support beyond the "best scientific evidence" required per MSA. EBFM requires substantial research and data assessments for the ecological, social, and economic variabilities that influence fisheries and the MSA does not specify the inclusion of all aspects in this national standard leaving a wide range of definitions for "best scientific evidence" which could lead to a lesser effective management of marine fisheries with the broad

expectation established. Additionally, the requirement that a fish stock be managed throughout its range (NS3, “To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination”) implies the geographic term of range, yet there is currently no specific mandate facilitating the level of coordination necessary for EBFM implementation. While there are committees for shared fish stocks, collaboration is limited, primarily involving input and participation in joint FMPs between councils.

The DARA approach proposed by the ASFMC for Black Sea Bass was not implemented. This approach was inspired by the Transboundary Resources Assessment Committee (TRAC), which was established in 1998 and consists of personnel from the Department of Fisheries and Oceans Canada and NOAA’s Northeast Fisheries Science Center. TRAC's mandate is to provide scientific advice to ensure that management efforts by both countries, pursued independently or cooperatively, are based on a shared understanding of the status of shared fishery resources. Specifically focusing on Atlantic Cod, Yellowtail Flounder, and Haddock, TRAC proposes management recommendations that involve gradually adjusting state-specific allocations based on a combination of historical allocations and current stock distribution levels. This approach has been acknowledged as a successful model for flexible management strategies, particularly in handling trans-jurisdictional fish species. However, there may be constraints for regional councils operating under the MSA.

Black Sea Bass is a significant species for both commercial and recreational purposes along the U.S. East Coast. Currently, management falls under the authority of the Mid-Atlantic Fisheries Management Council, with recreational allocations managed regionally and commercial quotas managed on a state-by-state basis. TAC for Black Sea Bass is split into recreational (51%) and commercial (49%) sectors, with each state implementing varying regulations such as possession and bag limits, and size restrictions to stay within the harvest limit. However, these quotas may not accurately reflect the shifting distribution of stock biomass due to changing environmental conditions. The Vulnerability Assessment identifies Black Sea Bass as having a high potential for distribution change due to its high climate exposure and moderate sensitivity (Hare et al., 2016). Over the past decade, landings of Black Sea Bass have increasingly occurred in northern waters as warming trends extend their range further northward. This expansion has led to discrepancies between state allocations, current abundance, and resource availability. The Atlantic States Marine Fisheries Commission (ASMFC) has responded by adopting a plan to adjust state allocations of the commercial quota based on updated information on species abundance and distribution. However, discrepancies persist in recreational fisheries management. Implementing approaches like TRAC or DARA could significantly enhance both the biological condition of the species and the economic viability of commercial and recreational fishing sectors, while increasing coordination between management sectors. While the ASMFC's current measures suffice

for now, ongoing northward expansion of Black Sea Bass distribution is expected to strain management efforts further in the future. Challenges to implementation include the increased need for cooperation among regional councils and the necessity to base allocations on current stock distribution rather than solely historical abundance or catch which is currently limited through management frameworks, like the MSA.

Summer Flounder and Winter Flounder stand out as two of the most sought-after species recreationally and commercially on the East Coast. During the warmer months Summer Flounder migrate into coastal bays while Winter Flounder inhabit shallow coastal waters during spring and winter. In the Climate Vulnerability Assessment (Hare et al., 2016), summer flounder exhibit a moderate vulnerability to climate change with high species distribution change potential while winter flounder have a “very high” climate exposure with a similar expectancy of high species distribution change potential (Hare et al., 2016). Both flounder species have been observed shifting their populations northward in recent decades, a trend correlated with increasing temperatures. Since the 1970s the center of summer flounder populations has shifted approximately seventy miles northward, while winter flounder have shifted about twenty miles northward (Perretti & Thorson, 2019). Projections indicate that by the end of the century, the summer flounder population could shift an additional eighty-five miles northward, while winter flounder could shift nearly 250 miles under a scenario with increased emissions contributing to changing environmental conditions (Perretti & Thorson, 2019). These shifts pose

significant challenges, prompting questions about how catch allocations among states and fleets should be managed. Not only are these species experiencing stock distribution shifts, but they are also experiencing a reduction in recruitment resulting from temperature affecting the spawning ability of these fish stocks (Bell et al. 2014) resulting in a depletion of the stock and leading the population to becoming overfished (National Marine Fisheries Service, 2020). Winter Flounder is currently managed jointly by ASMFC and NEFMC as three separate stocks; Georges Bank (GBK), Gulf of Maine (GOM); and Southern New England/Mid-Atlantic (SNE/MA) and under the NEFMC Northeast Multispecies FMP. Summer flounder is currently jointly managed by the ASMFC and MAFMC under an FMP along with the additional species Black Sea Bass and Scup. The ASMFC manages fisheries covering state waters (up to three miles offshore), while the NEFMC/MAFMC manage federal waters ranging from 3 to 200 miles offshore. With both species, they are managed with limits such as ACL and ABC, with no specific mention of climate considerations as impacting their potential fish stock biomass distribution. As management currently stands, current triggers including TAC, ABC, and ACL are not sophisticated enough to reflect the changes currently being seen from climate change (Farady & Bigford, 2019). Each FMP includes specific triggers, and with the threat of climate change each stock has varying vulnerability to changing ecosystem conditions with ranging needs of management responses that are not supported by traditional stock assessments based on historical location and fishing patterns. Most stock

assessments are based on whether a species has been “overfished,” “not overfishing,” and “unknown (cannot quantify)” with no consideration of the environmental impact climate change has on these species. The inclusion of how climate change affects fisheries such as: reproduction rate, growth rate, and shift in stock distributions needs to be included into stock assessments and in the triggers set for each species. Among the species discussed, although most are not currently under the authority of the NEFMC, they still pose potential future management challenges. Tensions within fishing sectors (commercial, fleet, and recreational) are expected to increase as these species may eventually migrate into the NEFMC's jurisdictional area, highlighting the need for climate adaptive fisheries management.

While both science and NOAA Fisheries strongly advocate for transitioning towards EBFM, MSA may not be flexible enough to fully accommodate management approaches aimed at safeguarding overall ecosystem structure and function. The MSA may not prioritize habitat features unrelated to essential fish habitat or endangered species, nor does it adequately address the need to balance trade-offs among various ocean uses, which could impede the implementation of climate adaptive measures within regional management councils. The need for climate-adaptive fisheries management is clear. Councils should be incentivized to meet federal expectations set by NOAA Fisheries, particularly in embracing EBFM, and to proactively address species facing potential shifts in stock biomass distribution towards northern waters. Although the NEFMC has made strides with the

eFEP for Georges Bank, this represents just one management plan, laying the groundwork for addressing potential shifts in other species. The NEFMC, along with other Councils on the east coast, have an opportunity to be the front runners in establishing climate adaptive management strategies wherever applicable to better conserve and manage species that are at risk of distribution shifts due to climate change.

Future Research

To further understand why climate adaptive management measures have not been fully implemented and accepted, interviews with various marine fishery managers could be conducted to uncover any barriers or limitations they face. Limitations may manifest as political, economic, or structural constraints, such as management frameworks lacking the necessary flexibility to accommodate climate adaptive measures. In addition, research should be conducted on members of the fishing industry to assess their concerns of climate adaptive measures within the management of their fishery resources that provide economic security for their livelihood. Finally, as depicted by both State and Federal governments, an increase of data for species at risk for shifting stock distribution changes on the east coast should be researched to aid in the management efforts of creating effective and climate adaptive fisheries management initiatives. All aspects of future research could shed light on the complexity of fisheries management amidst climate change, with

the aim of implementing more climate adaptive and inclusive management measures for our marine resources.

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