REBUILDING FORAGE FISH

By Advancing Ecosystem-Based Fishery Management

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TABLE OF CONTENTS

DISCLAIMER

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DEDICATION

This report represents more than the words on the page, but rather is the final product of years of support from my family, friends, and mentors. Thank you to all who have ever edited one of my papers, talked policy with me, or provided guidance, especially my Mom and Dad.

EXECUTIVE SUMMARY

Forage fish are critical to the health of Atlantic coastal ecosystems, serving as the primary food source for numerous culturally and commercially valuable marine predators. Despite longstanding advocacy, these stocks are overfished due to the limitations of single-species fishery management approaches.

Growing literature and the successes of Atlantic menhaden present a new path forward for management called ecosystem-based fishery management (EBFM). EBFM is a holistic framework that accounts for ecological, social, and economic dynamics in marine management. This report, developed in collaboration with *Wild Oceans*, evaluates strategies to accelerate the adoption of EBFM as a strategy for better conserving forage fish populations.

Using a set of evaluative criteria—including cost, cost-effectiveness, implementation timeline, administrative burden, and composite political feasibility—the report analyzes four policy alternatives: a trade off survey, an EBFM Scorecard, investment in new or updated scientific research, and gear restrictions.

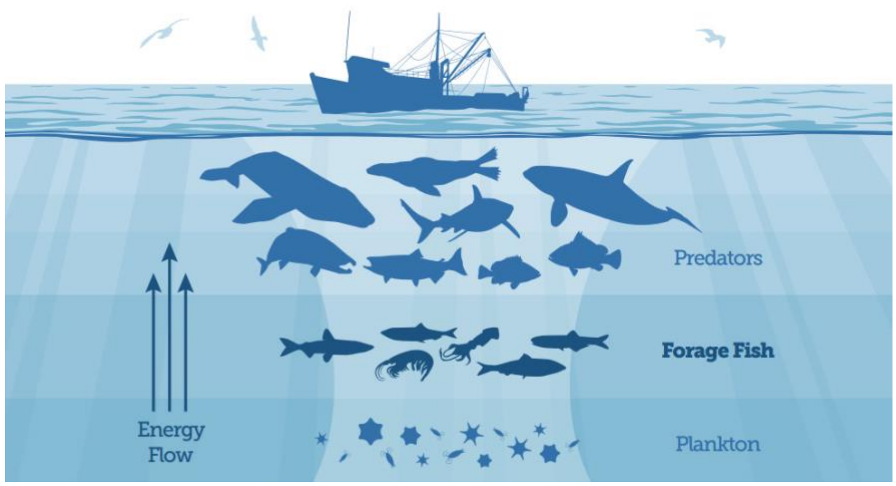
The EBFM Scorecard is recommended for its balance of impact and feasibility. The scorecard offers a standardized, collaborative tool to assess fishery management bodies' progress toward EBFM implementation and to guide future actions.

The Scorecard implementation plan emphasizes stakeholder collaboration, credibility building, and institutionalization. The findings support *Wild Oceans*' mission to protect marine ecosystems and demonstrate that targeted, strategic initiatives can play a key role in rebuilding forage fish populations and improving ocean governance practices.

INTRODUCTION

PROBLEM AND REPORT OVERVIEW

Humans are the most influential ocean predator, harvesting fish by the ton for the dinner table, recreation, pet food, cosmetics, and much more. In 2020 across the coastal states, commercial landings of all fish totaled 8.4 billion pounds, equating to $4.8 billion in revenue (Cody, 2022). The fate of the delicate marine ecosystems supporting these fisheries rests firmly in the abundance of schools of forage fish.



Forage fish, including small species like herrings and mackerels, play a pivotal role in marine ecosystems and economies around the world directly and indirectly. Forage fish transfer energy from primary producers up the food web, supporting a wide range of predators such as tuna, striped bass, cod, seabirds, lobster, and marine mammals (Essington et al., 2015; Pikitch, 2012; Pikitch et al., 2018; Smith et al., 2011; Turcotte et al., 2021). We also harvest forage fish to use as bait for wild caught fish and as fish-meal for aquaculture. As a result, forage fish are the foundation for many of the world's largest wild and farm fisheries. Worldwide, forage fish are worth about $5.8 billion in direct harvest value, but are worth roughly $11.8 billion when left in the sea to support other, more valuable fish (Pikitch, 2012).

However, many Atlantic Coast forage fish species are overexploited and at risk of collapse, with cascading impacts on dependent predators and human communities. Atlantic herring and Atlantic mackerel are two critical forage fish in New England and Mid-Atlantic waters that have provided for thriving fisheries. However, both have recently shown a dramatic freefall in population biomasses.

Only 18 years ago fishermen caught 268.533 million pounds or 121,804 metric tons of Atlantic herring (ASMFC Plan Review Team, 2019). But this was unsustainable and the most recent stock assessment released this summer concluded that Atlantic herring are overfished and at only 26% of its target biomass (ASMFC, 2024a). The 2025 catch limit has been set at less than 7,000 metric tons, or a 93% decline in 15 years (NOAA, 2024b). Similarly, the 2021 Atlantic mackerel stock assessment found that mackerel were overfished and overfishing was occurring (NOAA, 2024d). The assessment also concluded that previous assumptions about recruitment were overly optimistic, thus mackerel would not be able to rebuild as hoped by 2023. A new rebuilding plan was implemented in 2023 and today mackerel is at only 12% of its target biomass with a commercial quota of only 868 metric tons (Mid-Atlantic Fishery Management Council, 2021; NOAA, 2024a). As recently as 2007 U.S. commercial catch of mackerel was nearly 26,000 metric tons (Mid-Atlantic Fishery Management Council, 2006). River herring and shad are two additional forage fish which have experienced similar drastic downturns and carry a depleted status.

Given the literature and the Atlantic menhaden example, it is evident bringing forage fish populations back from collapse is synonymous with implementing ecosystem-based fishery management (EBFM), which is a holistic approach that recognizes all the interactions within an ecosystem rather than considering a single species or issue in isolation (Bakun et al., 2010; Gamble & Link, 2009; Hornborg et al., 2019; NOAA Fisheries, 2024a; Thayer et al., 2020). However, EBFM implementation has been a goal for management agencies for at least 30 years. Therefore, the following document details and evaluates four potential strategic paths forward for *Wild Oceans* to follow to assist management agencies in achieving this goal.

This document is organized into three sections:

1. **Introduction**, which includes a problem statement, root cause analysis, overview of *Wild Oceans*, relevant background, a literature review of EBFM, including a case study on Atlantic menhaden, and the criteria used to evaluate paths forward;
2. **Paths Forward**, which includes a description of the alternatives considered and an evaluation of the alternative based on the established criteria; and
3. **Recommendation and Next Steps**, which includes an outcomes matrix, recommendation, and detailed description of the implementation steps needed to make the final recommendation a reality.

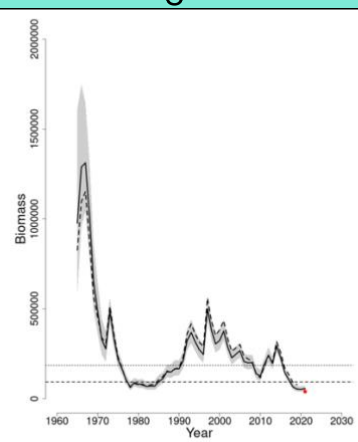
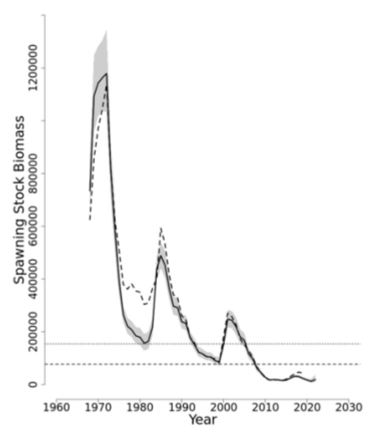
Paths forward are broken into three policy types: (1) human management improvements, (2) filling research gaps, and (3) on the water regulations. These policy bins were chosen based on the three major parts of the fishery policy process–science, management, and fishing. Alternatives recommended include a trade off survey, creation of an EBFM Scorecard, investing in new and updating fishery studies with management implications, and gear restrictions.

Evaluative criteria utilized include total cost, cost-effectiveness for advancing EBFM, administrative burden, implementation timeline, and composite political feasibility. These criteria were chosen based on *Wild Oceans*' organizational values, goals, and challenges, project goals, and the importance of operationalization feasibility. Composite political feasibility was scored out of 10, while all other criteria were scored out of 6. This reflects *Wild Oceans*' desire to ensure that their efforts are politically achievable and have lasting impacts.

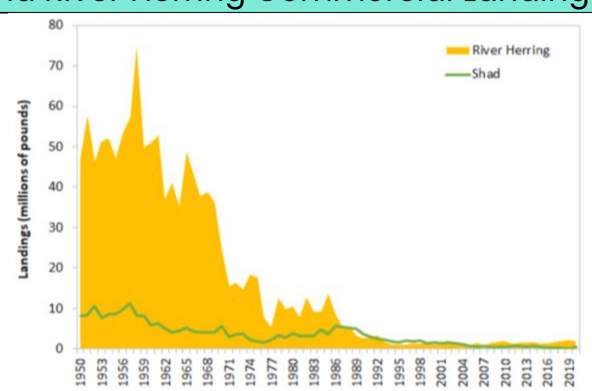
It is recommended that *Wild Oceans* proceed with the EBFM Scorecard. This decision was primarily influenced by the alternative's relative strength in total cost and cost effectiveness compared to other alternatives. Additionally, the alternative demonstrated relatively high composite political feasibility, though it did not score the highest in this category. Updating research and the trade off survey were close second and third place options.

PROBLEM STATEMENT

Along the Atlantic Coast, several key forage species such as Atlantic herring, Atlantic mackerel, Shad, and River herring have been designated by the National Oceanic and Atmospheric Administration (NOAA) and Atlantic States Marine Fishery Commission (ASMFC) as “Overfished” or “Depleted” (Atlantic States Marine Fisheries Commission, 2024; NOAA Fisheries, 2024b, 2025). Forage fish are critical for the survival of economically valuable and culturally cherished marine animals such as tuna, striped bass, billfish, dolphins, osprey, and many more (Essington et al., 2015; Skern-Mauritzen et al., 2022; Turcotte et al., 2021; Uphoff Jr. & Sharov, 2018; Watts et al., 2024). ***Current too low forage fish populations put all of these species at risk of population downturns, harming local communities, endangering food supply, and damaging marine environments*** (Konar et al., 2019; Wathen & Horton, 2019). Atlantic coastal waters need interventions to rebuild forage populations, allowing them to support themselves, predators, and humans.

Atlantic Herring Biomass Trends	Atlantic Mackerel Biomass Trends
	

Shad and River Herring Commercial Landings Trends



WILD OCEANS OVERVIEW

Established in 1973, *Wild Oceans* is a leader among marine conservation advocacy organizations. *Wild Oceans'* mission is to "keep the oceans wild to achieve a vibrant future for fishing by building coalitions and engaging in marine fisheries management using science, law and ecosystem-based solutions". Their guiding core values are *Science-Based, Integrity, Perseverance, Passion,* and *Respect*.

Wild Oceans achieves its mission by building coalitions within the conservation, science, and commercial and recreational fishing communities and engaging with fishery management bodies. Their programs emphasize protecting the ocean's top predators – billfish, tunas, swordfish, and sharks – by preserving forage fish, healthy ocean food webs, and critical habitats. *Wild Oceans* also frequently funds research and graduate degrees for academics studying billfish and forage fish species.

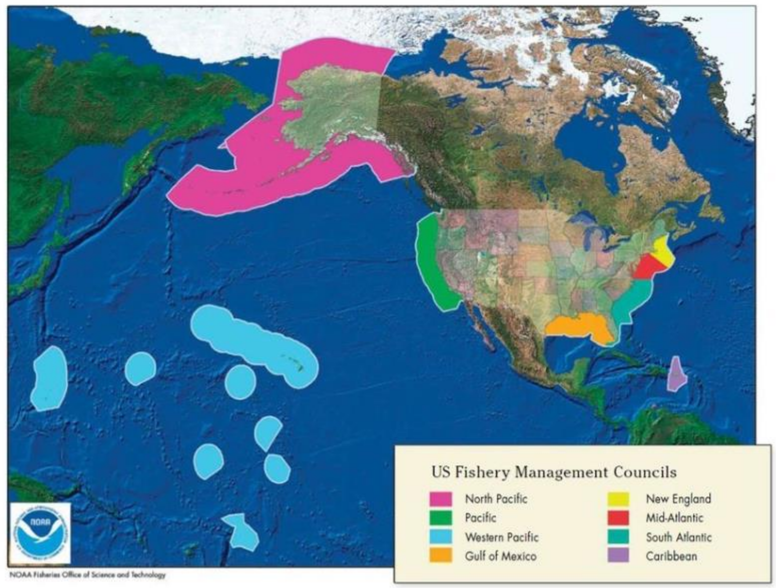
Internally, *Wild Oceans* considers itself to be a "special operations" organization given its small size, well utilized budget, and ability to be highly focused and mobile on issues larger organizations may overlook. *Wild Oceans'* main strengths are in its reputation and the longitudinal relationships it has built in conservation spaces. For example, this has enabled a *Wild Oceans* staff member to hold the Coastwide Conservation seat on the Shad and River herring Advisory Panel in the ASMFC for several years. On fishing issues, *Wild Oceans* is best prepared for grassroots organizing with conservationists and advancing scientific knowledge.

Given that it is expressly in *Wild Oceans'* mission statement to encourage the implementation of EBFM, *Wild Oceans* is acutely equipped to tackle this issue. This project is needed now because *Wild Oceans* and others have been focused on conserving the forage base for more than 50 years, yet the forage populations have still collapsed. Now is the time for the organization to take a step back, take stock of where they have been and where they want to go, and find a path forward as opposed to reacting to each problem separately. By completing this comprehensive review, *Wild Oceans* will ensure that it maintains its efficient organizational resource allocation, provides direction to the coalitions it has formed or is a part of, and speeds up EBFM implementation which is essential for rebuilding forage fish stocks. With proper evidence and action, *Wild Oceans* can turn this time of forage fish population decline into a prime opportunity for impacting critical inputs in the fishery management process.

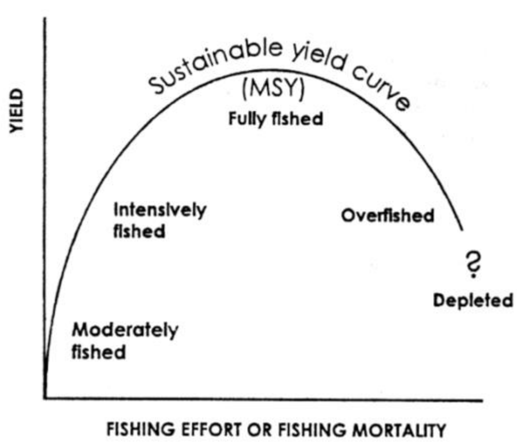
BACKGROUND

FISHERY MANAGEMENT STRUCTURE

The Magnuson-Stevens Act (MSA) passed in 1976 and established the eight Regional Fishery Management Councils who are responsible for several fishery management functions. Regional Fishery Management Councils serve under the jurisdiction of the NOAA and Department of Commerce and at the pleasure of the incorporated states.



The primary objects of the MSA are to foster the long-term biological and economic sustainability of marine fisheries by: (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 habitats the fish need to spawn, breed, feed, and grown to maturity (NOAA, 2024c).



Fishery management is ruled by the "best available science", which is primarily communicated through Stock Assessments and their ensuring actions. Maximum Sustainable Yield (MSY) allocation decisions are one of the main recommendations that comes from a Stock Assessment. MSY is a calculated amount of fish representing the largest number or pounds of fish that can be removed on a continuing basis while maintaining a standing population capable of replenishing itself (Hinman, 2015). MSY lends itself to single-species management whereby every fishes' MSY and total allowable catch is calculated independently, regardless of their roles in and influences from ecosystems.

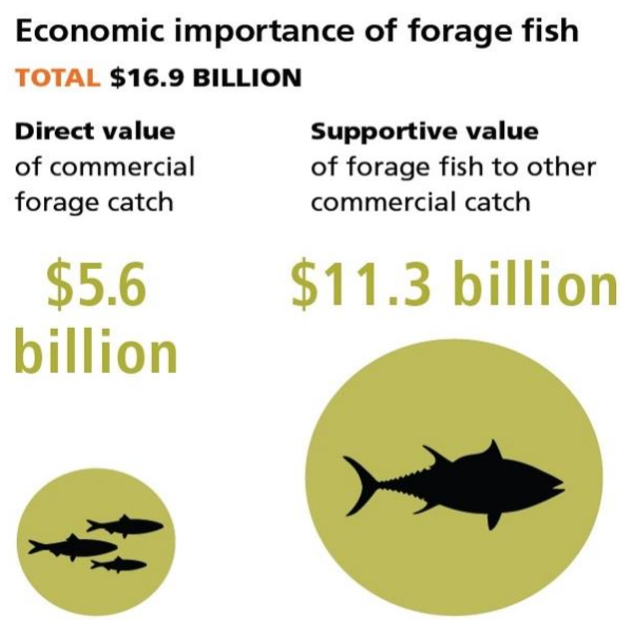
However, given a growing body of literature, the MSA national standards, Regional Councils, and the ASMFC have increasingly adopted EBFM based strategies. Most notably, optimum yield has been adopted which allows for a reduction of the total allowable catch calculated from MSY based on "the greatest benefit to the nation", which could include, but is not limited to or mandated to be, maintaining an adequate forage base for all components of the ecosystem (National Archives, 2024). Another notable enhancement of MSY includes risk-policies to ensure that buffers are included in total allowable catch calculations to account for the uncertainty of catching a specific amount of fish without overfishing.

Lastly, fishery management bureaucracy is complicated and loosely connected. A Regional Fishery Management Council at its most basic level is composed of Council Members and Staffers. Council Members make up the main decision-making body. However, prior an action, Staff will facilitate fact finding, public comment, and advising through consultation with work groups, subcommittees, advisory panels, contractors, other regional councils, federal agencies, interest groups, and other experts. Council decisions relate to total allowable catch, catch limits, gear regulations, spatial restrictions, and size limits. These decisions are made through *specifications* which are measures for upcoming fishing years, *frameworks* which can change the measures decided under a specification, and *amendments* which are novel regulatory measures proposed for a fishery. *Amendments* generally require at least two years from start to finish, but the full processes has taken as many as ten. *Frameworks* provide an avenue of change in the short term as they can be completed within two Council meetings.

FORAGE FISH ECONOMICS

The economic dynamics of forage fish fisheries highlight the intricate balance between resource use and sustainability. In 2021, the price per whole pound of Atlantic menhaden caught in Maine was $0.43 (Maine, 2022). Similarly in 2023, Atlantic mackerel was worth $0.32 per pound and Atlantic herring was worth $0.34 per pound (Maine, 2023b, 2023a). However, regardless of their low value, by volume, forage fisheries support the largest fisheries in the world (Alder et al., 2008). This is because a large volume of catch is needed to offset the low value of individual fish (Davie et al., 2015).

High catch volumes leads to intensified fishing effort and competition as the shared nature of the resource encourages maximizing returns from each fishing trip (Davie et al., 2015; MacKenzie, 1992). This dynamic results in significant pressure on forage fish stocks, especially where regulations fail to account for long-term trajectories. Furthermore, fishing gears used to obtain such high volumes are often extremely efficient but indiscriminate of what they catch, placing more pressure on the ecosystem as a whole.



Studies indicate that forage fish value can be maximized by leaving them in the water as opposed to catching them, as they support predator populations that can be caught and sold for a much higher price (Konar et al., 2019; Pikitch, 2012).

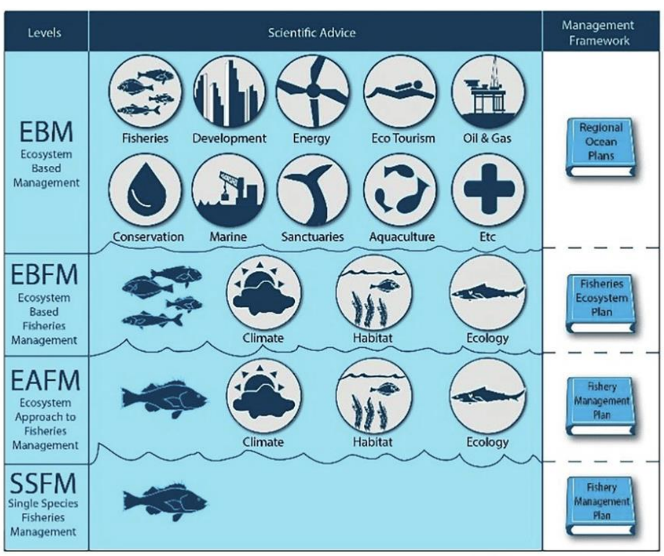
Understanding these dynamics offers insight into the broader implications of forage fish fishery interventions.

LITERATURE REVIEW

ECOCSYSTEM-BASED FISHERY MANAGEMENT

In contrast to single species management, EBFM considers the range of benefits ecosystem components provide. The approach improves decision-making by quantifying trade offs among ecosystem services that emerge through alternative courses of management actions, with the goals of maximizing total system value and improving resilience by anticipating indirect consequences (Sanchirico & Essington, 2021). The underlying ecosystem science must account for the complexity of multiple interacting components within and across coupled natural–human systems, which is where disagreements in EBFM implementation can occur. Nevertheless, since EBFM has a more pronounced ability to include complex trade offs than traditional management, it has been nearly universally accepted that fishery management must shift to this technique (Anstead et al., 2021; Bakun et al., 2010; Chagaris et al., 2020; de Moor, 2024; Dickey-Collas et al., 2022; Dolan et al., 2016; Morrison et al., 2024; Patrick & Link, 2015; Sanchirico & Essington, 2021).

EBMF is a holistic approach that recognizes all the interactions within an ecosystem rather than considering a single species or issue in isolation.



While the concept of EBFM is not new, the existing literature has identified several remaining questions for EBFM as it pertains to forage fish. The most critical of these is how does research help mangers understand the optimal balance between forage fish harvest levels and their ecological role as prey for marine predators (Morrison et al., 2024; Sanchirico & Essington, 2021; Gamble & Link, 2009; Hornborg et al., 2019; Siple et al., 2019).

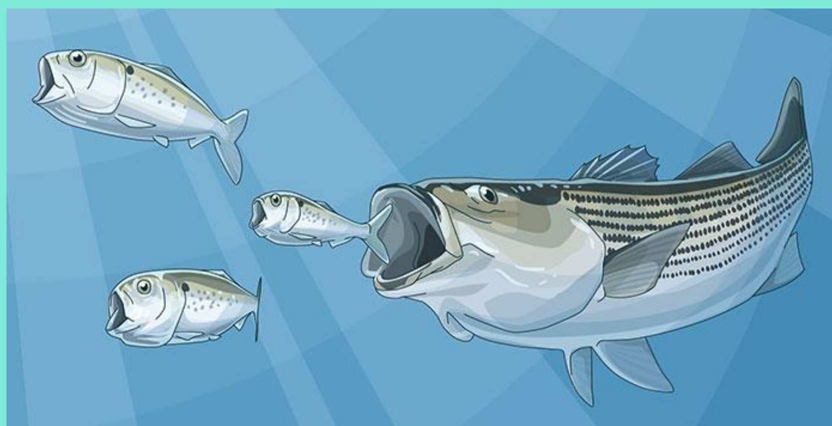
Researchers have used robust ecosystem models, retrospective analysis, and management strategy evaluations (MSE) to refine their understanding of EBFM in action. Ecosystem models simulate interactions between forage fish, predators, and fishing pressures, retrospective analyses evaluate the effectiveness of past management strategies, and MSEs assess trade offs between harvest rules and ecosystem objectives through sensitivity tests. Projected outcomes of EBFM implementation for forage fish management include:

1. **Ecological Outcomes:** EBFM management models can reduce the fishing pressure on forage fish by up to 20% to help ensure there's enough prey available for dependent predators (Sanchirico and Essington, 2021). EBFM can also enhance ecosystem stability, with models predicting a 20–40% reduction in the risk of forage fish collapse under adaptive management strategies (Gamble & Link, 2009; Hornborg et al., 2019). Predator populations may see a 20–30% improvement in survival and reproduction with stabilized forage fish stocks (Bakun et al., 2010).
2. **Economic Outcomes:** Although dynamic harvest rules may reduce peak yields, they provide long-term economic benefits by stabilizing catches and reducing variability by up to 30% (de Moor, 2024). Additionally, fully integrated EBFM could increase long-term fishery profits by 20–40% compared to single-species management (Sanchirico & Essington, 2021).
3. **Social and Cultural Outcomes:** By ensuring sustainable harvests, EBFM supports community well-being and food security, particularly in regions heavily dependent on forage fisheries (Dolan et al., 2016). However, the lack of robust socio-cultural indicators limits the ability to quantify these outcomes.

To continue pressing forward on EBFM implementation, the literature suggests several broad initiatives: (1) improving and increasing age/population surveying (Chui et al., 2024; Lankowicz et al., 2020; Lucca & Warren, 2019), (2) linking forage species to other economically and culturally important predators (Camp et al., 2019; Saraux et al., 2021; Sydeman et al., 2017; Turcotte et al., 2021; Tyrrell et al., 2011), (3) fully integrating forage fish in specific risk policies (Essington et al., 2015; Essington & Munch, 2014; Hobday et al., 2011), (4) tackling climate change, natural mortality, and other environmental factors that lead to uncertainty in fisheries (Arimitsu et al., 2021; Boldt et al., 2022; Jacobsen et al., 2019; Jacobsen & Essington, 2018; Siple et al., 2021; Thompson et al., 2019), (5) dispelling decision maker myths about EBFM, (6) and integrating ecological-economic trade offs analysis in management processes and regulations which accurately account for the value of forage fish in the sea (Koehn et al., 2017; Kroetz et al., 2022; Mid-Atlantic Fishery Management Council, 2019; Schleit, 2024).

CASE STUDY

Transition to Ecosystem Approach to Fishery Management for Atlantic Menhaden



Atlantic menhaden are an Atlantic Coast forage species, supporting large reduction commercial fisheries and the diets of predators like striped bass, bluefish, and marine mammals. Historically, management of Atlantic menhaden relied on single-species approaches, primarily using catch limits based on maximum sustainable yield. This approach prioritized fishery yields without adequately considering the species' ecological role, which proved insufficient to address concerns about the broader ecological effects of menhaden harvests. Striped bass, for example, were reported to suffer biomass declines due to reduced prey availability. As a result, in 2020, the ASMFC shifted to an Ecosystem Approach to Fishery Management, which is a step towards EBFM. This approach was the first quantitative ecosystem-based management strategy implemented for a U.S. forage fish. Learning from this case can help inform the initiatives needed to advance EBFM in other fisheries. See case study references in Works Cited.

Steps Toward EAFM and Ecological Reference Points (ERPs)

1. **Initial Stakeholder Engagement**: Recreational and conservation stakeholders advocated for measures to protect menhaden's ecological role. Concerns over predator populations, particularly striped bass, drove conversations..

2. **Defining Ecosystem Objectives**: The ASMFC formally identified ecosystem management objectives for menhaden, recognizing its ecological role as forage and its impact on predator species. This marked a critical shift from managing menhaden for yield alone to include ecological sustainability.
3. **Interim Measures**: Before advanced models were available, managers adopted ad hoc measures to maintain menhaden biomass for predators. These included conservative catch limits designed to prevent overfishing.
4. **Development of Ecological Models**: Researchers developed the Northwest Atlantic Coastal Shelf Model using Ecopath with Ecosim (EwE) to evaluate trade offs between menhaden harvest and predator biomass. This model incorporated predator-prey relationships between menhaden and striped bass. A survey was conducted to identify public willingness to pay for forage ecosystem services.
5. **Integration of Models**: The ASMFC's ERP Working Group recommended coupling the EwE ecosystem model with other models to align menhaden-specific catch targets with broader ecosystem considerations.
6. **Adoption of ERPs:** ASMFC adopted ecological reference points (ERPs) based on model outputs. These ERPs set fishing mortality (F) targets and thresholds that balanced menhaden harvests with the sustainability of predator species.
7. **Implementation of EAFM-Based Quotas**: Total allowable catches were established using the ERP framework, explicitly accounting for menhaden's role as a forage species.

Outcomes

1. **Ecological Impact**: Predator populations, particularly striped bass, showed signs of recovery as fishing mortality targets aligned with ecosystem objectives. ERPs reduced overharvesting risks while preserving menhaden's role in the food web.
2. **Stakeholder Engagement**: Transparent model selection and validation processes fostered buy-in from a diverse array of stakeholders, including conservationists, recreational fishers, and commercial interests.
3. **Integrated Management**: By combining ecosystem and single-species models, managers we able to formally addressed complex trade offs between harvest and ecological sustainability within existing governance frameworks.

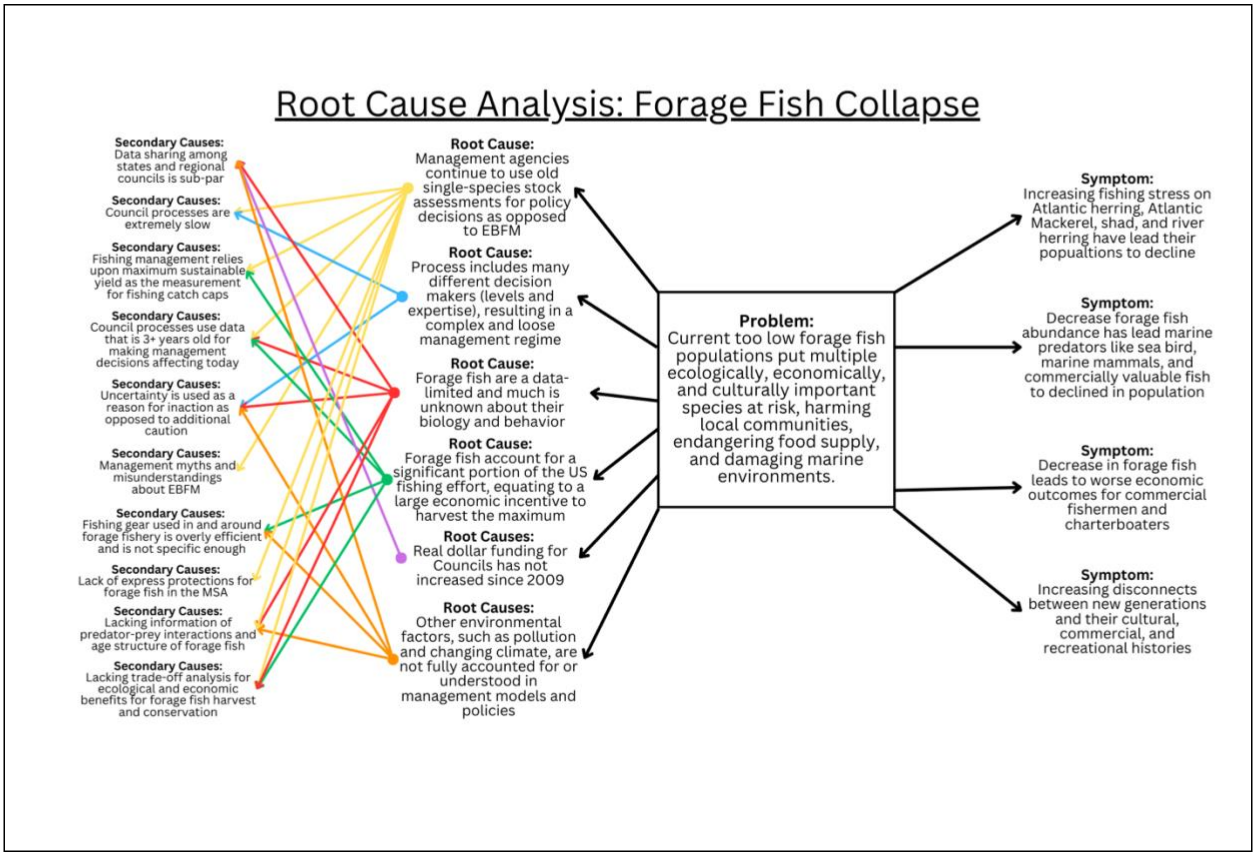
Conclusions

The adoption of EBFM for Atlantic menhaden has been a significant milestone, demonstrating the feasibility of integrating ecosystem considerations into fishery management. Predator biomass targets, especially for striped bass, have approached desired levels, and TACs are now set with greater ecological awareness. Future efforts should take note of how the ASMFC improved model capabilities, enhanced public and policymaker understanding, and incorporated spatial and climate-change considerations into the ERP framework. Furthermore, through the process the importance of recreational community engagement was underscored. This case serves as a valuable model for advancing EBFM in other forage fisheries.

ROOT CAUSE ANALYSIS

A Root Cause Analysis is used to identify workable segments (secondary causes) of a larger, seemingly unmovable problem (root cause). In fishery management, creating change within a sprawling, long fishery management process governed by objective science is a daunting task. This is especially true when the situation may call for quicker action to right a management decision.

The Root Cause Analysis reveals that management agencies continuing to use single-species stock assessments is connected to several difference secondary causes. This helps to inform that finding technical and adaptive leadership methods to move the needle on EBFM can help to gain traction on the greater problem.



CRITERIA OVERVIEW

Criteria	Description	Measurement	Reasoning
Total Cost	Estimation of how much it will cost to prepare for and implement an alternative. Costs are defined as: i. Overhead – incurred by current staff to prepare for the alternative. ii. Capital expenses – payments made to buy, improve, create, or rent assets that will help achieve a mission. iii. Salaries – payments made to current or new staff or contractors to implement an alternative. iv. Travel costs – expenses for any transportation needed.	Translated into a scale from 1-6, six meaning low cost which will be based on standard deviations from the mean cost of all alternatives considered. Standard deviations will allow for a proportional, standard comparison across all alternatives. All total cost estimations will utilize the maximum of any ranges calculated for scoring.	Critical given budget restrictions of *Wild Oceans*, the difficulty in obtaining new grants or donors, and the political climate which has seen federal grants decline. Each alternative will have its total cost calculated for up to 5 years. A yearly cost is also calculated, those this is not explicitly used as a metric of evaluation for this evaluation.
Cost-effectiveness	Estimation of how much it costs to gain a unit of a desired outcome, in this case the units will be for every dollar how many components of the World Wildlife Fund (WWF) *Guidelines*	Table 3 of the Guidelines are broken into 3 categories, Expression in the Fishery, Mechanisms and Enabling Processes, and Performance Indicators. Given each of these	Maximizing benefits per unit cost is a critical metric for understanding what will result in the most significant positive impact for the organization's efforts. This type of

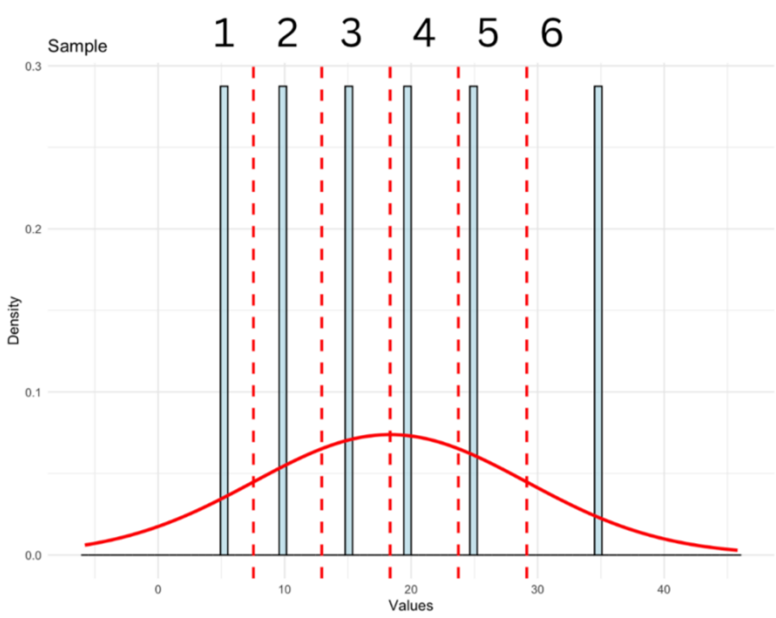
	for implementing Ecosystem-Based Management in a hypothetical coastal fishery are advanced from a given alternative (Ward et al., 2002).	categories have different purposes, they hold different weights in advancing EBFM. The number of met goals will be a weighted sum, with Mechanisms and Enabling Purposes (MEP) being multiplied by 3, Expression in Fishery (EF) by 2, and Performance Indicators (PI) by 1. These weighted were chosen based on their directness at signaling a substantive change towards EBFM. Definitions of each term were created by the author of this report based on the information in the WWF report. See definitions in Appendix 2. The total cost of the alternative will be divided by this weighted sum to provide a cost-effectiveness price. Translated into a scale from 1-6, six meaning high cost-effectiveness (lower number), which will be based on standard deviations from the mean cost-effectiveness of all alternatives considered.	analysis will also help more directly compare each alternative.

Implementation Timeline	Estimation of the number of years each alternative would take to fully implement.	Translated into a scale from 1-6, six meaning a shorter implementation timeline, which will be based on standard deviations from the mean amount of time needed.	Forage fish stocks are overfished and depleted today. Action is needed as soon as possible to change the status quo.
Administrative Burden	Estimation of the administrative burden placed upon *Wild Oceans*. This will be estimated though expected hours of time each alternative would take to develop, implement, and maintain.	Translated into a scale from 1-6, six meaning low administrative burden, which will be based on standard deviations from the mean number of expected hours needed. All ranges will utilize the maximum number of time estimated for scoring.	It is critical that each alternative has detailed information about the administrative time needed to implement since *Wild Oceans* has a small and specialized team.
Composite Political Feasibility	Combined estimation of political feasibility and erasibility.	The addition of political feasibility and erasibility scores, creating a score out of ten.	Given a quickly changing political landscape, it is important to have a robust outlook not only the likelihood something would be implemented, but also how easily/quickly it could be dismantled by an adversary leader or organization.
Political Feasibility	Estimation of practicality and achievability for *Wild Oceans*' to implement a given alternative based on the political contexts from relevant	Translated into a scale from 1-5, five meaning high political feasibility for implementation, which will be based on alignment stated strategic plans, relation to current initiatives, and	The fishery management process is incredibly political in nature given that there are many

	stakeholders and anticipated burdens.	other written communications of priorities.	conflicting interests and relational dynamics. Furthermore, the real dollar value of NOAA's budget has not increased since 2009. It is also not anticipated that funding for management agencies will increase during the current presidential administration. This means that staff capacities are highly protected. It is therefore important to understand the political backdrop of a given alternative.
Erasibility	Estimation of the permanence of a given alternative relating to leadership or fishing condition changes.	Translated into a scale from 1-5, five meaning low erasibility, which will be based on how easy it would be for a management agency to either ignore or remove an alternative.	As demonstrated by the past few months, policy landscapes can change drastically in a short amount of time. Furthermore, there is a tendency for fishery management to have a yo-yo-ing effect, whereby a fishery can quickly become overfished again if regulations are lifted after a stock rebounds. It is therefore critical to weigh how likely successful implementation will

			stand the test of time. For fishery management, this generally means how well an initiative relates to "the best available science".

INTERPRETING STANDARD DEVIATION SCORING CHARTS



The diagram to the left is an example of how the values of a criteria will be evaluated based on standard deviation scoring bins. In this example, the further a value is from the mean to the right, the higher the score.

While in this example there is a value in each bin, in the evaluation multiple paths forward can be within the same bin, thus receiving the same score. This scoring method ensures that initiatives that are similar have the same score, and initiatives that are different are proportionally scored higher or lower.

PATHS FORWARD

HUMAN MANAGEMENT IMPROVEMENTS

TRADE OFF SURVEY

Wild Oceans should conduct a forage fish trade off survey(s) to inform management agencies about community preferences and enable continued work by managers to conduct multi-species ecological-socioeconomic tradeoff analysis for forage fish.

Currently, management agencies lack robust processes for modeling predator-prey interactions nor ecological-socioeconomic tradeoff analysis. However, the case study of Atlantic menhaden demonstrates that advancing EBFM necessitates a process to trade off fishery yields with ecological health and social benefits (Anstead et al., 2021). Successful menhaden trade off analysis included testing ecosystem models, integrating quantitative and qualitative economics data, and deploying a Management Strategy Evaluation to test management options in a simulated environment (Karp et al., 2023; Koehn et al., 2017; Natugonza et al., 2020; Peterson et al., 2025; Zahner & Branch, 2024).

While testing ecosystem models is an ongoing process and Management Strategy Evaluations continue to be integrated, conducting economic analysis has proven to be more contentious. For example, based on personal communications, the NEFMC's subcommittee on EBFM was discontinued given an inability to reach a consensus about how to conduct ecological-economic trade offs. This is striking because the NEFMC had gone as far to create a draft Ecosystem Plan for George's Bank (NOAA Fisheries, 2022). Relatedly, MAFMC EAFM Guidance Document calls for ecological-economic trade off analysis, yet personal communications indicated this has been aspirational or addressed by proxy rather than a firm practice (Mid-Atlantic Fishery Management Council, 2019).

During the Atlantic menhaden ecological-socioeconomic trade off analysis, the ASMFC conducted a trade off survey of coastwide stakeholders to develop a Willingness to Pay model of public opinion (Whitehead & Harrison, 2017). The ASMFC survey received 2,000 responses, had 31 questions, and utilized the Survey Sampling International panel for collection of internet responses. Their results "suggested that respondents were willing to trade off $13 million, $5 million and $5 million in coast-wide ex-vessel revenue in exchange for a change in the impacts on water quality, gamefish and water birds, respectively [and]…. respondents were also willing to trade off 610, 228 and 234 commercial fishing jobs in exchange for a change in the impacts on water quality, gamefish and water birds, respectively" (Whitehead & Harrison, 2017). This type of information was critical in calibrating models and conversations around the value of menhaden as a forage fish (Anstead et al., 2021; Buchheister et al., 2017; Cardin, 2020).

While management agencies conducting ecological-socioeconomic trade offs is the ultimate goal, *Wild Oceans* has the ability to conduct a similar survey and deliver this information to management agencies. By leading this survey *Wild Oceans* stands to undeniably demonstrate the forage fish matter to the public, aiding in current and future advocacy efforts. A chief assumption of this alternative is that management agencies will be able to use this survey to inform its actions.

EVALUATION

Cost: $47,730.70. Significant costs stem from salary costs and hiring a survey researcher capable of collecting responses and analyzing the survey. This resulted in it having the highest overhead costs out of any alternative, meaning much of the money spent would not be used directly on the alternative's implementation. Received a 4 out of 6 score.

Cost-effectiveness: $3,671.59 per WWF EBFM goal achieved. Lacked satisfaction of any Mechanisms and Enabling Practices, significantly reducing its overall cost effectiveness. Received a 4 out of 6 score.

Implementation timeline: Estimated to be completed within 1 year, causing it to have a significantly shorter timeline that other alternatives on the list. Received a 5 out of 6 score.

Administrative burden: 1200 hours. While implementation timeline was relatively speedy, this alternative had the highest administrative hours before any services would be rendered. Received a 4 out of 6.

Composite Political Feasibility: While the alternative tackles a particularly contentious issue, helping free up political issues, the alternative scores poorly in erasibility because it is not immediately apparent how management agencies would integrate the data. Realistically, the survey would be used to spark conversations. An ideal scenario would be that the MAFMC would use this information and a model for their own analysis, NEFMC would use the information to reinstate their EBFM Subcommittee. However, this would provide *Wild Oceans* with more information in public comment letters regarding appropriate risk policies. In the worst-case scenario, the survey demonstrates that individuals value taking forage fish out of the water more than keeping it there. Received a 5 out of 10.

Total Score: 22

See evaluation details in Appendix 3 and Appendix 4.

EBFM SCORECARD

Wild Oceans should collaboratively develop and release a tri-annual ecosystem-based fishery management Areas of Need report for the Atlantic Coast Councils and Commissions delineating each management system's most pressing steps for implementing EBFM.

Wild Oceans can collaboratively develop and release an "EBFM Areas of Need Report" with other EBFM-interested organizations, such as the Marine Stewardship Council, Natural Resource Defense Council, Ocean Conservancy, International Gamefish Association, and Theodore Roosevelt Conservation Partnership. This report will serve as a performance assessment tool, offering standardized insights into each of the Atlantic Coast's management organizations' progress in implementing EBFM. By identifying areas of strength and need, the initiative will drive accountability, foster collaboration, guide adaptive management, and provide next steps for management agencies when they are priority setting for management and research needs during annual or strategic planning phases.

The idea for this Scorecard is rooted in global scorecard diplomacy, a method for holding nations accountable to their climate promises, though scorecards have been utilized for more localized issues (Baker, 2024; Kelley, 2017; Sam Geldin et al., 2015; US Agency for International Development, 2018; Wheelock, 2022). Furthermore, there is some literature that indicates that performance metrics of management organizations are needed for advancing EBFM (Hornborg et al., 2019).

The Scorecard could include sections for management and research integration of ecosystem health indicators, climate resilience and adaptation, socioeconomic integration, and management performance. Each section will need significant development with input from all stakeholders to ensure the Scorecard's credibility. The development and release of the Scorecard would be on a three-year cycle, ensuring that management organizations have ample time to research and implement feedback from the previous cycle. While this alternative will require a significant lift in the first iteration for Scorecard development, later versions will simply need tracking and updating. By instituting this report card, *Wild Oceans* stands to set a national standard for ecosystem-based fisheries management implementation status assessment.

This initiative could draw from the World Wildlife Fund's *Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries* which worked to define a similar checklist on the global level for implementing fishery management (Ward et al., 2002). Other examples include the Environmental Defense Fund Fishery Solutions Center's Diagnostic Scorecard, and the Sustainable Fisheries Partnership's FishSource scorecards (Envrionmental Defense Fund, 2025; Sustainable Fisheries Partnership, 2007). A chief assumption of this alternative is that management agencies will use this guide, however, their use of the report will be entirely dependent on how *Wild Oceans* is able to frame the document given community engagement and formatting.

EVALUATION

Cost: $36,731.51. Significant costs stem from salary costs. However, overhead costs remained low since *Wild Oceans* would not have to hire a new staff and could instead use existing staff capacities. Received a 5 out of 6 score.

Cost-effectiveness: $1,933.24 per WWF EBFM goal achieved. Would address a high number of Mechanisms and Enabling Practices, driving its score upwards. Received a 5 out of 6 score.

Implementation timeline: Estimated to be completed within 2 years, causing it to have a significantly shorter timeline than other alternatives on the list. Though, it is relevant to note that this would be repeated over multiple years as an ongoing process. Received a 4 out of 6 score.

Administrative burden: 920 hours. This alternative was the second lowest in terms of administrative burden, with the majority of time spend collaborating with partners and in implementation. Received a 4 out of 6.

Composite Political Feasibility: Completing this alternative has high political feasibility given that educating decision makers on EBFM fits well into *Wild Oceans*' mission and could help save time for management agencies in identifying EBFM priorities and educating their members. However, given that this alternative results in a report that could be ignored, it scores low on erasibility. The report's credibility directly relates to the implementation process.

Total Score: 25

See evaluation details in Appendix 3 and Appendix 5.

FILLING RESEARCH GAPS

NEW AND UPDATING RESEARCH

Wild Oceans should fund forage fish research that has direct management implications to 1) fill known knowledge gaps in forage fish biology, life history, and predator-prey relationships and/or 2) provide updates to outdated studies that play central roles in management agencies' models or decision-making.

The fishery management process is ruled by the best available science. Compared to other fish stocks, forage fish are extremely data limited and have several significant research gaps. During the Atlantic menhaden process, there was significant scientific research that provided enough evidence of fish life history, predator-prey interactions, and biology to create accurate models (Anstead et al., 2021).

Wild Oceans should fund research to ensure that forage fish stocks have just as extensive research as was available to Atlantic menhaden managers. This would include full identification of research gaps and establishing a research or granting program. Funded research must have direct management implications.

Based on personal communications with Atlantic herring and Atlantic mackerel fishery scientists, as well as consultation of relevant literature reviews extending the available research on these forage fishes' recruitment conditions would provide valuable information to directly improve management models, establish forage fish indexes, or more robust harvest control rules (Burbank et al., 2023). Research gaps include:

- Updating the spawning location maps created in studies such as Messiah et al. 1985 or Chenoweth et al. 1989, which dictate where scientific surveys search for herring abundances that could have changed due to changing ocean conditions and fishing pressures (Chenoweth et al., 1989; Messieh et al., 1985). This could be accomplished through tagging studies, drone/plane photo analysis studies, or fishermen surveys.
- Creation of an Atlantic herring or Atlantic mackerel egg and larval database, including the environmental conditions associated with their collection. This would help to establish the oceans conditions under which egg and larvae

survive and provide more information for stock structure. Currently Atlantic herring and Atlantic mackerel information severely lacks in information on age 0 through age 2 fish given current broad sampling methods used in standard trawl surveys. However, it is possible to obtain this type of information, as demonstrated by the robust age 0 through age 2 data regarding Baltic Sea Atlantic herring (ICES & WGSINS, 2024). This would be accomplished through consistent sampling of forage fish during spawning season in a field study.

- Creating a multispecies model based on research tracks information from the most recent research tracks assessment to combine the haddock-egg predation, food availability, and temperature covariates investigated (Burbank et al., 2023). This could be accomplished through modeling with existing data.
- Further defining the predator-prey relationship that forage fish have with species such as haddock and cod through diet studies, potentially through defining the consumption rate and energy flows of haddock and/or cod consumption of Atlantic herring or Atlantic mackerel eggs (Burbank et al., 2023).

NEW EVALUATION

Cost: $457,172.81. This alternative had the highest total cost of any alternative evaluated. Its high cost is mostly attributed to its high salary costs, which span 5 years. Additionally, this alternative had the most capital and travel costs. Received a 1 out of 6 score.

Cost-effectiveness: $20,780.58 per WWF EBFM goal achieved. While this alternative would address a high number of WWF criteria, the alternative's high cost pulls its cost-effectiveness ratio upwards. Received a 1 out of 6 score.

Implementation timeline: Estimated to be completed within 5 years, causing it to have one of the longer implementation timelines. Received a 1 out of 6 score.

Administrative burden: 12,070 hours. This alternative had the highest administrative burden, though most of this is concentrated in the implementation category. Received a 1 out of 6.

Composite Political Feasibility: Completing this alternative received full marks on this alternative because 1) advancing science is in *Wild Oceans*' wheelhouse 2) fishery management is ruled by the best available science, which this alternative directly addresses and 3) this alternative would pick up the monetary deficits management agencies actively experience. A pursued research project should have direct management implications with the end goal of a new forage fish index, harvest control rule, or other ecosystem-integrated management action. Received a 10 out of 10.

Total Score: 14

See evaluation details in Appendix 3 and Appendix 6.

UPDATING EVALUATION

Cost: $85,843.20. This alternative had the second highest total cost of any alternative evaluated. Its high cost is mostly attributed to its high salary costs. However, contrary to new research, this alternative does not require as much capital costs and no travel costs. Received a 4 out of 6 score.

Cost-effectiveness: $3,732.31 per WWF EBFM goal achieved. This alternative addressed the most WWF criteria, resulting in its higher cost-effectiveness score. Received a 4 out of 6 score.

Implementation timeline: Estimated to be completed within 2 years, causing it to have a relatively short timeline. Received a 4 out of 6 score.

Administrative burden: 1,780 hours. This alternative had the second most administrative burden by hours. Received a 4 out of 6.

Composite Political Feasibility: While updating research would help to improve the *best available* science and fits into *Wild Oceans*' mission, this alternative is limited in two key ways. First, it is very difficult to identify a research study that can updated simply by re-digitizing a data source or enhancing its existing data set with new data. Second, based on the outcomes of recent work to update the natural mortality rate of Atlantic menhaden, updating research will likely not result in a full reversal, but rather a middle ground of past and updated studies as managers work to synthesize management issues. Furthermore, these updates will likely only move the needle slightly and not result in new, more conservative rules. Received an 8 out of 10 score.

Total Score: 24

See evaluation details in Appendix 3 and Appendix 7.

ON THE WATER REGULATIONS

GEAR RESTRICTIONS

Wild Oceans should provide program evaluations to management agencies about the effectiveness of time-area closures and/or gear restrictions for non-specific and overly efficient gear types that result in significant bycatch during periods when forage fish are vulnerable, especially mid-water trawlers.

The implementation of time-area closures and gear restrictions targeting non-selective and highly efficient gear types, especially during vulnerable seasons for fish populations, offers a direct way to protect forage fish. Time area closures restrict fishing activities in designated areas during critical periods, such as breeding or nursery seasons, to protect key habitats and life stages of forage fish (Smith et al., 2021). Total gear restrictions have a similar goal, but would keep certain destructive or non-specific gear types, like midwater trawlers, out of the water altogether (United Nations Economic and Social Commission for Western Asia, 2006). Scientific studies and case studies have demonstrated the effectiveness of these measures to enable stock recovery, improve ecosystem health, and increase predator abundance (Cashion, 2020; Grieve et al., 2014; Hall, 2002; Searle et al., 2023; Zhang et al., 2016).

Additionally, environmental stewards along the Atlantic Coast have noted that River herring stocks have returned and thrived where midwater trawling has been restricted, but areas where midwater trawlers are allowed to fish have not had the same results (Bruce, 2024; Hare et al., 2021; Jobs, 2023). Restrictions of this kind must go through the amendment process in Regional Fishery Management Councils and require extensive scientific evidence and community engagement. However, Amendment 10 in the NEFMC, which is about midwater trawl vessel restrictions, is already in the alternatives development process, providing a more immediate opportunity for this alternate (New England Fishery Management Council, 2023). Time area closures and gear restrictions are an important aspect of ecosystem-based fishery management because understanding how fishing pressure and gear interact with the environment aids in holistic management practices.

An example difference-in-difference program evaluation of midwater trawl gear restrictions on River herring populations, using real data, can be found in Appendix 9. Based on the impact evaluation, differences in River herring across the treatment and control groups became statistically significant in 2015, with a positive magnitude of 143,819.2 more fish in the rivers connected to Herring Management Area 1A. The differences peaked in 2018, with an estimated 382,361.7 more fish in the rivers connected to Herring Management Area 1A than in the river outside of this area.

EVALUATION

Cost: $21,256.85. This alternative had the lowest total cost of any alternative evaluated. Received a 5 out of 6 score.

Cost-effectiveness: $1,518.35 per WWF EBFM goal achieved. This alternative satisfied the second least WWF criteria, resulting in a worse cost-effectiveness score than it could have had if the alternative was more expansive. Regardless of this, it still had the best cost-effectiveness ratio. Received a 5 out of 6 score.

Implementation timeline: Estimated to be completed within 2 years, causing it to have a relatively short timeline. Received a 4 out of 6 score.

Administrative burden: 595 hours. This alternative had the lowest administrative burden by hours. Received a 5 out of 6.

Composite Political Feasibility: While this alternative scored well in other categories, it had the worst composite political feasibility score. This is due to the difficulties in proving that fishing pressures are directly to blame for declining fish populations. As a result, this type of analysis is hard to conduct. Furthermore, even if an analysis has strong validity, the power of industrial fishing in management agencies cannot be understated. For example, a past mid-water trawl buffer zone was removed due to industrial fishermen's powerful legal team in 2018. Furthermore, adoption of a gear buffer in an amendment is a very difficult process. Without the previous existence of Amendment 10, this alternative would score even lower in this category—Amendment 10 would need to be capitalized on as a unique window of opportunity for change.

Total Score: 24

See evaluation details in Appendix 3 and Appendix 8.

RECCOMENDATION AND NEXT STEPS

OUTCOMES MATRIX AND RECCOMENDATION

Based on the above evaluations and detailed analysis in the appendix, it is recommended that *Wild Oceans* proceed with the EBFM Scorecard initiative. The below matrix succinctly demonstrates the final scores of each alternative for ease of comparison. In addition to the analysis, this recommendation robustly contributes to *Wild Oceans* mission because it adds to both of *Wild Oceans*' role as a servicer and advocator in the marine management space. To expand, *Wild Oceans* can provide a needed service to management agencies and other NGOs, which will enhance its advocacy efforts in other respects. Furthermore, this will help provide more certainty to any research *Wild Oceans* funds in the future that any given project will have direct management connections.

Outcomes Matrix						
Alternative	Administrative Burden	Total Cost	Cost-Effectiveness	Implementation Timeline	Composite Political Feasibility	Total
Trade Off Survey	4	4	4	5	5	22
EBFM Scorecard	4	5	5	4	7	25
Filling Research Gaps: New	1	1	1	1	10	14
Filling Research Gaps: Updating	4	4	4	4	8	24
Gear Restrictions	5	5	5	4	4	23

IMPLEMENTATION

The following implementation steps outline how *Wild Oceans* can accomplish the Scorecard, with explicit consideration for the ecosystem of collaborators needed to ensure that the Scorecard is viewed as a reputable resource.

STEP 1. SCOPING AND DEVELOPMENT

CREATING A PROPOSAL (1-2 MONTHS)

In anticipation of conversations with Board Members as well as potential partners in implementation, *Wild Oceans* must first create a Scorecard proposal. To create this proposal the *Wild Oceans* coastal programs staffers must conduct extensive research on the successes and failures of similar initiatives as well as information on the critical characteristics and steps towards implementing EBFM. While *Wild Oceans* should be thorough in its research, it should refrain for creating a proposal which is overly prescriptive such that there would be little room for meaningful collaboration with partners. The proposal should include information about the proposed scope, audience, general evaluative bins, and timeline of the Scorecard. A key challenge during this step will be being comprehensive but not overly prescriptive.

STEP 2. COLLABORATION WITH PARTNERS

IDENTIFYING POTENTIAL PARTNERS (1 MONTH)

Wild Oceans should spend time considering what stakeholders should be included. Those involved should cut across all generally relevant stakeholders including recreational fishermen, commercial fishermen, fishery scientists, Indigenous Peoples, environmental stewards, charter boaters, and fishery management organization staff and members. It is important that *Wild Oceans* be comprehensive in the membership of partners to ensure a representative cross-section of the fishery management ecosystem, but that the membership is not so sprawling that progress would be cumbersome. Furthermore, the core competencies of each patterned organization/member must be considered as time must be spent identifying partner roles and anticipated effort.

OUTREACH AND PARTNERSHIP PROPOSAL (1-3 MONTHS)

Once all partners have been identified, *Wild Oceans* will need to reach out. This will include emailing individuals and organizations extending them invitations and, for some, may require one-on-one meetings to explain the details of the Scorecard. A worst-case scenario in this step is that no other significant organizations have an interest in contributing to this work. The best way to ensure that this does not occur would be first asking perennial partners of *Wild Oceans*, such as the International Gamefish Association or Florida Forage Fish, for their participation. By obtaining a few immediate "yeses", *Wild Oceans* can leverage these when talking to others to demonstrate broad interest, encouraging the partnership by other organizations that could be hesitant but not want to be left behind. The risk of this worst-case scenario occurring is relatively low as the next four years present a period of defense and planning rather than forward action for most NGOs.

CONVENING OF PARTNERS (.5 MONTHS)

After a critical mass has been achieved of accepted invitations, *Wild Oceans* will need to organize an initial meeting and workflow structure in tandem with identified partners. Initial meetings will be used to introduce individuals to one another, allow individuals to express how their expertise can be utilized, and outline general consensus on Scorecard characteristics. A critical part of the initial meetings will be determining what the Scorecard evaluation bins should be, which will allow individuals to filter into topics they identify with strongest.

STEP 3. IMPLEMENTATION

CREATING THE CONTENT (4-5 MONTHS)

Through a series of meetings and individual work with partnered organizations, decisions about the specific management, science, regulation, and engagement criteria/steps to evaluate each management agency will be created. These criteria should be comprehensive, but intuitive. While it is ok if there is some sprawling metrics that can be explained in a larger report, ideally each criterion will be explainable in a short phrase or sentence that can be placed into an accessible Scorecard format. This step will likely take several months to fully complete as *Wild Oceans* and partners move through several iterations of criterion.

DESIGNING THE SCORECARD AESTHETIC (1 MONTHS)

Once the evaluation tool content has been created, *Wild Oceans* and partners will need to determine what information will appear on a longer report and what information will be placed into an abridged Scorecard. The formatting of the Scorecard will matter significantly as sufficient information should be available to support scores, but it must be aesthetically pleasing for reading and quick comprehension. This could include the development of an externally facing interactive dashboard, which would allow interested parties to view comprehensive information and past Scorecards.

SCORING THE SCORECARD (3-5 MONTHS)

After the Scorecard has been developed, *Wild Oceans* and partners should move to immediately score it. Ideally this would occur in time for any relevant yearly reviews or long-term strategic plans of management organizations so the Scorecard can have as immediate of an effect as possible. This will likely take considerable time in the first iteration as the first year will set the baseline for all future years.

Wild Oceans and partners will also have decisions about how the Scorecard should be scored. There are three main manners which are immediately apparent.

1. Wild Ocean could assume responsibility for the Scorecard, grading each Council itself and then seeking out partners for their thoughts.
2. *Wild Oceans* could work to assemble a committee of knowledgeable individuals and partners to score the Scorecard together in direct collaboration.
3. *Wild Oceans* could send out the Scorecard to knowledgeable individuals, collect them, and then conduct analysis of the cohort's decisions to come up with a final Scorecard.

Each of these has strengths and weaknesses in terms of efficiency, collaboration, robustness, and external validity. Ultimately, the scoring of the Scorecard should be a collaborative decision with the group of partners that assists in its creation.

STEP 4. COMMUNICATION

CREATING FINAL REPORT (1-2 MONTHS)

After the Scorecard analysis has been completed, a Scorecard findings and simple Scorecard should be developed to communicate the status of EBFM in each management agency. This will include pulling together all the information from the scoring process and citing all relevant literature and management documents.

Furthermore, *Wild Oceans* and its partners should also identify the top five to ten next steps management organizations could take (such as a specific research priority, technology improvement, institution of management practice, or otherwise) to improve their score for the next scoring time. These priorities should be written in plain language and ideally are short phrases or sentences.

COMMUNICATING TO THE PUBLIC (1 MONTHS)

After the long-form findings and simple Scorecards have been developed, *Wild Oceans* and partners should develop materials to communicate to management organizations and practitioners. This could include sending parties the findings and Scorecard documents, publicly commenting at appropriate meetings or during written opportunities, creating press releases, drafting newsletter articles, publishing materials on websites, or other campaign materials as needed. The worst-case scenario in this step is that management organizations do not acknowledge the Scorecard. To combat this possibility *Wild Oceans* and its partners must ensure that its communication materials are of the highest quality in aesthetics as well as content. Additionally, after a scoring period, *Wild Oceans* and its partners should promote the Scorecard early and often, ideally gaining recognition for the initiative in notable fishery magazines or article hubs, such as the Marine Conservation Network or Sportfishing Magazine.

STEP 5. SUSTAINING THE SCORECARD

FINAL MEETING (.5 MONTHS)

At the final scoring meeting in a scoring year, *Wild Oceans* and its partners should establish when they will next meet to rescore the management organizations based on their progress. This should be specific and establish the next year and month for the next scoring meeting. At this meeting, *Wild Oceans* and its partners should also discuss what went well and what could be improved for the future in terms of the scoring process and materials created. While the Scorecard should remain rather unchanged to preserve the quality and consistency of scores over time, participants should also briefly discuss the relevance of any suspect criteria or additions.

INSTITUTIONALIZING THE PROCESS (.5 MONTHS)

Wild Oceans and each organization should establish a Scorecard point of contact – either a person or a specific position title. For *Wild Oceans* specifically, this would include adding the Scorecard as a duty in their current and future staff contracts. Other organizations should be encouraged to account for the Scorecard in a similar fashion such that the Scorecard becomes an innate institutional tool across stakeholders.

PROGRAM EVALUATION (ONGOING)

Wild Oceans and its partners should evaluate the effectiveness of the Scorecard in encouraging EBFM management practice adoption. Suggested metrics of evaluation include the overall progress of the management organizations towards EBFM, the number of references made to the Scorecard during management organization meetings or in prepared materials, the number of references made to the Scorecard in advocacy materials such as public comments, or uptake of specifically identified EBFM priorities. *Wild Oceans* should establish realistic goals for these metrics. If goals are not being consistently met after two or three iterations, then *Wild Oceans* should consider if the Scorecard is a worthwhile investment for them moving forward.

CONCLUSION

The decline of Atlantic Coast forage fish populations represents a critical threat to marine ecosystems, coastal economies, and long-term fisheries sustainability. As foundational species in ocean food webs, lacking forage fish imperils not only their own survival but also the viability of predator species and the communities depending on them. Traditional, single-species management approaches have proven insufficient, and the time for a bold, ecosystem-based shift is now.

This report has outlined and evaluated four strategic pathways to accelerate the implementation of EBFM. After a comprehensive analysis, the EBFM Scorecard emerges as the most effective, feasible, and cost-efficient recommendation. By offering a transparent and collaborative tool to assess fishery management performance, the Scorecard has the potential to drive accountability, guide decision-making, and foster a shared understanding of what successful EBFM implementation looks like across Atlantic Coast management agencies and stakeholder groups.

If *Wild Oceans* and its partners act decisively on this recommendation, the organization can help set a new standard for ecosystem-based advocacy, catalyze more informed and equitable management practices, and ultimately contribute to the recovery of forage fish populations. In doing so, this initiative supports not only the mission of *Wild Oceans* but also the resilience of marine ecosystems for generations to come.

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Forage Fish Energy Flow Chart

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Page 10

Atlantic Herring Biomass Trends Graph

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- Atlantic States Marine Fisheries Commission. (2025, March 14). *River Herring: Commercial & Recreational Fisheries*. Atlantic States Marine Fisheries Commission. https://asmfc.org/species/river-herring/

Page 12

Regional Fishery Management Council Map

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- The Fisheries Secretariat. (2021). *MSY Objective*. https://www.fishsec.org

Page 13

Overfishing Limit Bar Chart

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Page 14

Economic Importance of Forage Fish Graphic

- Lenfest Forage Fish Task Force. (2012, April 1). *The Economic Value of Forage Fish*. http://pew.org/2pBtIfU

Page 15

EBFM Flow Chart Graphic

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Page 17

Striped Bass Eating Menhaden Art

- The Pew Charitable Trusts. (2020). *It's Time to Account for Menhaden's Role in the Ecosystem*. https://www.cbf.org/blogs/save-the-bay/2020/03/its-time-to-account-for-menhadens-role-in-the-ecosystem.html

Back Cover

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APPENDIX

APPENDIX 1: CALCULATION MATERIALS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	1.6	1.7	1.8	1.8	1.7	1.8	1.8	1.8	1.9	1.9	2	2.1
2016	2.2	2.3	2.2	2.1	2.2	2.2	2.2	2.3	2.2	2.1	2.1	2.2
2017	2.3	2.2	2	1.9	1.7	1.7	1.7	1.7	1.7	1.8	1.7	1.8
2018	1.8	1.8	2.1	2.1	2.2	2.3	2.4	2.2	2.2	2.1	2.2	2.2
2019	2.2	2.1	2	2.1	2	2.1	2.2	2.4	2.4	2.3	2.3	2.3
2020	2.3	2.4	2.1	1.4	1.2	1.2	1.6	1.7	1.7	1.6	1.6	1.6
2021	1.4	1.3	1.6	3	3.8	4.5	4.3	4	4	4.6	4.9	5.5
2022	6	6.4	6.5	6.2	6	5.9	5.9	6.3	6.6	6.3	6	5.7
2023	5.6	5.5	5.6	5.5	5.3	4.8	4.7	4.3	4.1	4	4	3.9
2024	3.9	3.8	3.8	3.6	3.4	3.3	3.2	3.2	3.3	3.3	3.3	3.2
2025	3.3											
							Average 10 Year Inflation			2.986777		

Inflation data sourced from U.S. Bureau of Labor Statistics Consumer Price Index for All Urban Consumers dashboard.

Standard Deviation Visualizations Code:
https://docs.google.com/document/d/1DoctDpBUp-LKRX8Riw8CGTVi_OH3qAiJ17ENu9hTqil/edit?usp=sharing

Notes:
* For all final calculations, the highest number of any given range for money or hours is used for scoring.
** Repeated costs are highlighted in purple and discounted accordingly to account for inflation.

APPENDIX 2: WWF COST-EFFECTIVENESS MATERIALS

WWF Scorecard for Cost Effectiveness:
https://docs.google.com/document/d/1JZ6dg8cYDOzK3o1OlTY_LtViAoONs89HAmYb7ceeegs/edit?usp=sharing

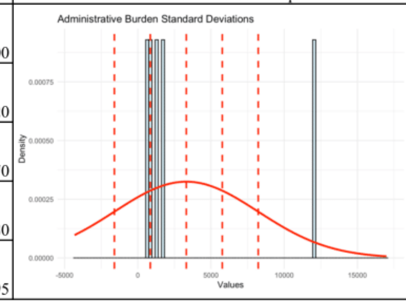
Expression in the Fishery: Articulation of the management system's objectives within the fishery, ensuring alignment with conservation and socio-economic policies. It involves setting agreed-upon objectives, targets, strategies, and performance indicators for both stock management and ecosystem integrity. These objectives should be reflective of national and international conservation goals, encourage stakeholder participation, and integrate long-term social, economic, and ecological benefits.

Mechanisms and Enabling Processes: Institutional and procedural elements that facilitate effective fisheries management under an ecosystem-based management framework. They include policy reviews, stakeholder participation mechanisms, transparent management procedures, periodic assessments, and precautionary strategies to address ecological risks. Mechanisms also ensure that management decisions are accountable, inclusive, and adaptive to new scientific and ecological information.

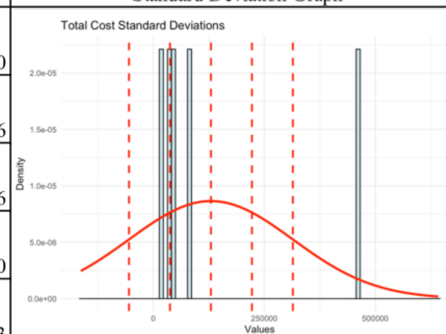
Performance Indicators: These are measurable benchmarks used to assess the effectiveness of fisheries management in achieving ecosystem-based management goals. They include factors such as the absence of policy inconsistencies, effectiveness of inter-agency cooperation, ecological integrity of habitats, stock assessments, and bycatch reduction. Performance indicators help in tracking progress, ensuring transparency, and enabling corrective actions based on ecosystem health and fisheries sustainability.

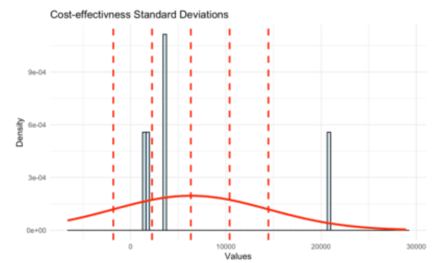
APPENDIX 3: DISAGGREGATED CRITERIA MATRIXES

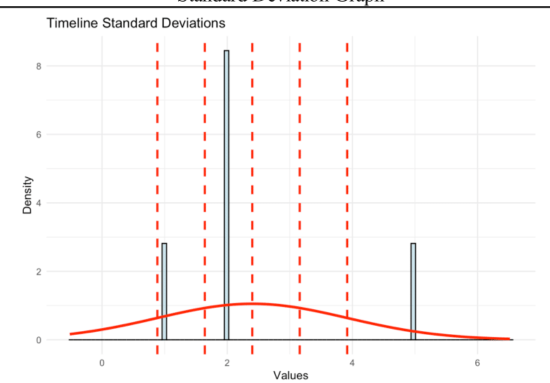
Alternative	Maximum Administrative Burden (Hours)								
	Formula: (Administrative + Scoping and Development + Collaboration + Implementation + Communication)							Score out of 6	
	Adminstrative	Scoping and Development	Collaboration with Partners	Implementation	Communication	Repeated Hours	Total	Standard Deviation Graph	Standard Deviation Score
Trade Off Survey	330	180	100	440	150	0	1200		4
EBFM Scorecard	80	90	110	440	60	140	920		4
Filling Research Gaps: New	240	530	40	2560	540	8160	12070		1
Filling Research Gaps: Updating	240	480	40	480	540	0	1780		4
Gear Restrictions	20	40	30	120	385	0	595		5



Alternative	Maximum Total Cost (Dollars)							
	Formula: (Overhead + Capital + Salary + Travel)						Score out of 6	
	Overhead	Capital	Salary	Travel	Total Cost	Cost Per Year	Standard Deviation Graph	Standard Deviation Score
Trade Off Survey	$18,612.00	$3,750.00	$25,368.70	$0.00	$47,730.70	$47,730.70		4
EBFM Scorecard	$8,592.00	$2,000.00	$26,139.51	$0.00	$36,731.51	$18,365.76		5
Filling Research Gaps: New	$13,536.00	$15,719.65	$410,209.64	$17,707.51	$457,172.81	$91,434.56		1
Filling Research Gaps: Updating	$13,536.00	$1,272.00	$71,035.20	$0.00	$85,843.20	$42,921.60		4
Gear Restrictions	$1,128.00	$1,272.00	$18,856.85	$0.00	$21,256.85	$10,628.43		5



Alternative	Cost Effectivness						
	Formula: (PI*1)+(EF*2)+(MEP*3)				Formula: (Total Cost/Weighted Sum)	Score out of 6	
	Performance Indicators	Expression in the Fishery	Mechanisms and Enabling Processes	Weighted Sum	Cost Effectivness	Standard Deviation Graph	Standard Deviation Score
Trade Off Survey	1	6	0	13	$3,671.59		4
EBFM Scorecard	2	4	3	19	$1,933.24		5
Filling Research Gaps: New	1	6	3	22	$20,780.58		1
Filling Research Gaps: Updating	3	7	2	23	$3,732.31		4
Gear Restrictions	3	1	3	14	$1,518.35		5

Alternative	Maximum Implementation Timeline		
	No More Than 5 Years	Score out of 6	
	Years	Standard Deviation Graph	Standard Deviation Score
Trade Off Survey	1		5
EBFM Scorecard	2		4
Filling Research Gaps: New	5		1
Filling Research Gaps: Updating	2		4
Gear Restrictions	2		4

Alternative	Composite Political Feasibility		
	Score out of 5	Score out of 5	Score out of 10
	Political Feasibility	Erasibility	Composite Score
Trade Off Survey	2	3	5
EBFM Scorecard	5	2	7
Filling Research Gaps: New	5	5	10
Filling Research Gaps: Updating	4	4	8
Gear Restrictions	2	2	4

APPENDIX 4: TRADE OFF SURVEY ADMINISTRATIVE BURDEN AND COSTS

Trade Off Survey						
	Administrative Burden			Overhead and Salary Costs		
Item	Category	Hours Low Estimate	Hours High Estimate	Salary Rate	Hours Low Estimate Cost	Hours High Estimate Cost
Identification of surveying company	Administrative	40	80	$56.40	$2,256.00	$4,512.00
Discussion meetings with Board members	Administrative	10	20	$56.40	$564.00	$1,128.00
Fundraising or grant applications	Administrative	20	80	$56.40	$1,128.00	$4,512.00
Hiring survey result analyst	Administrative	100	150	$56.40	$5,640.00	$8,460.00
	Administrative Total	**170**	**330**	**Total Overhead**	**$9,588.00**	**$18,612.00**
Developing survey questions based on ecological-socioeconomic tradeoff objectives using the Atlantic Menhaden questions as a base	Scoping and Development	40	60	$29.31	$1,172.40	$1,758.60
Pilot testing and refining survey questions	Scoping and Development	40	60	$29.31	$1,172.40	$1,758.60
Identifying the appropriate target audience	Scoping and Development	40	60	$29.31	$1,172.40	$1,758.60
	Scoping and Development Total	**120**	**180**			
Finding and communicating with partnered organizations interested in assisting with the survey	Collaboration with Partners	40	60	$28.00	$1,120.00	$1,680.00
Creation of survey campaign materials	Collaboration with Partners	30	40	$28.00	$840.00	$1,120.00
	Collaboration with Partners Total	**70**	**100**			
Launching the survey online and monitoring responses	Implementation	20	30	$29.31	$586.20	$879.30
Addressing any technical issues or respondent concerns	Implementation	20	30	$29.31	$586.20	$879.30
Ensuring sufficient response rates, including survey promotion (at least ~2,000 responses like the ASMFC survey)	Implementation	50	80	$29.31	$1,465.50	$2,344.80
Ensuring appropriate representation across different stakeholder groups	Implementation	50	80	$29.31	$1,465.50	$2,344.80
Reviewing data for inconsistencies or incomplete responses	Implementation	10	20	$29.31	$293.10	$586.20
Preparing datasets for economic modeling and analysis	Implementation	50	80	$29.31	$1,465.50	$2,344.80
Analyzing responses using statistical and econometric methods	Implementation	80	120	$29.31	$2,344.80	$3,517.20
	Implementation Total	**280**	**440**			
Summarizing findings in a comprehensive report	Communication	40	60	$29.31	$1,172.40	$1,758.60
Identify opportunities to present findings through public comment	Communication	10	30	$29.31	$293.10	$879.30
Meeting with Regional Fishery Management Council Staff one-on-one	Communication	10	20	$29.31	$293.10	$586.20
Preparing presentations and policy briefs for Regional Fishery Management Councils	Communication	30	40	$29.31	$879.30	$1,172.40
	Communication Total	**90**	**150**			
	Total Hours	**730**	**1200**	**Total Salary**	**$16,321.90**	**$25,368.70**

APPENDIX 5: EBFM SCORECARD ADMINISTRATIVE BURDEN AND COSTS

EBFM Scorecard						
	Administrative Burden			Overhead and Salary Costs		
Item	Category	Hours Low Estimate	Hours High Estimate	Salary Rate	Hours Low Estimate Cost	Hours High Estimate Cost
Dicussion meetings with Board members	Administrative	10	20	$56.40	$564.00	$1,128.00
Internal discssions for scorecard alignment with Wild Oceans mission while making the scorecard meaningful to outside stakeholders	Administrative	40	60	$124.40	$4,976.00	$7,464.00
	Administrative Total	**50**	**80**	**Total Overhead**	**$5,540.00**	**$8,592.00**
Researching other scorecard examples	Scoping and Development	10	30	$28.00	$280.00	$840.00
Outlining general scorecard bins and structure	Scoping and Development	20	40	$28.00	$560.00	$1,120.00
Determination of scorecard audience (e.g all Counils, only Atlantic Councils, inclusion of Commisson, etc)	Scoping and Development	10	20	$28.00	$280.00	$560.00
	Scoping and Development Total	**40**	**90**			
Identifying potential partners	Collaboration with Partners	5	10	$28.00	$140.00	$280.00
Outreach to potential partners	Collaboration with Partners	10	15	$28.00	$280.00	$420.00
Meetings and follow up with partners	Collaboration with Partners	80	100	$28.00	$2,240.00	$2,800.00
	Collaboration with Partners Total	**85**	**110**			
Creating specific management, science, regulation, and engagement criteria/steps by which each fishery management organization could be analyzed	Implementation	70	120	$28.00	$1,960.00	$3,360.00
Designing an accessible yet robust format for the scorecard	Implementation	60	100	$28.00	$1,680.00	$2,800.00
Creating an interactive scorecard dashboard or tab on Wild Oceans Website	Implementation	40	80	$47.37	$1,894.80	$3,789.60
Determining scorecard analysis processes	Implementation	40	60	$28.00	$1,120.00	$1,680.00
Scoring the scorecard with partner organizations, members of the community, scientists, and management experts across all Councils	Implementation	40	60	$28.00	$1,120.00	$1,680.00
Determining final scores	Implementation	10	20	$28.00	$280.00	$560.00
	Implementation Total	**260**	**440**			
Summarizing findings in a comprehensive report	Communication	10	20	$28.00	$280.00	$560.00
Preparing presentations and policy briefs for Regional Fishery Management Councils	Communication	10	20	$28.00	$280.00	$560.00
Publishing results on Wild Oceans Website	Communication	10	20	$47.37	$473.70	$947.40
	Communication Total	**30**	**60**			
	Total Year 1 Hours	**465**	**780**	**Total Salary Year 1**	**$12,868.50**	**$21,957.00**
	Repeated Hours	80	140	Total Repeated Salary Costs	$2,433.70	$4,307.40
	Total Hours	**545**	**920**	Present Value of Repeated Salary Costs for 1 Additional Years	$2,363.14	$4,182.51
				Total Salary Costs for 5 Years	**$15,231.64**	**$26,139.51**

APPENDIX 6: NEW RESEARCH ADMINISTRATIVE BURDEN AND COSTS

New Research Study						
	Administrative Burden			Overhead and Salary Costs		
Item	**Category**	**Hours Low Estimate**	**Hours High Estimate**	**Salary Rate**	**Hours Low Estimate Cost**	**Hours High Estimate Cost**
Identification of general research topic (predator-prey relationships, forage fish recruitment)	Administrative	10	20	$56.40	$564.00	$1,128.00
Discussion meetings with Board members	Administrative	20	30	$56.40	$1,128.00	$1,692.00
Fundraising or grant applications	Administrative	20	40	$56.40	$1,128.00	$2,256.00
Hiring fishery scientist	Administrative	100	150	$56.40	$5,640.00	$8,460.00
	Administrative Total	**150**	**240**	**Total Overhead**	**$8,460.00**	**$13,536.00**
Clarifying research questions and hypothesis	Scoping and Development	40	80	$36.41	$1,456.40	$2,912.80
Literature review, including investigating prior studies' findings, methodologies, challenges, and identified research gaps	Scoping and Development	100	200	$36.41	$3,641.00	$7,282.00
Determine methodology, including sampling technique, sample size, number of repetitions, lab and field protocals, and analysis techniques	Scoping and Development	200	250	$36.41	$7,282.00	$9,102.50
	Scoping and Development Total	**340**	**530**			
Identify any co-authors	Collaboration with Partners	10	20	$36.41	$364.10	$728.20
Identify any organizations willing to aid in study funding	Collaboration with Partners	10	20	$56.40	$564.00	$1,128.00
	Collaboration with Partners Total	**20**	**40**			
Apply for necessary local, state, and federal research permits	Implementation	20	40	$36.41	$728.20	$1,456.40
Organize equipment	Implementation	20	40	$36.41	$728.20	$1,456.40
Organize vessel logistics	Implementation	20	40	$36.41	$728.20	$1,456.40
Organize lab logistics	Implementation	80	120	$36.41	$2,912.80	$4,369.20
Conduct multiple field trips to deploy and collect sampling equipment, record site conditions, and preserve, label, and transport samples for analysis	Implementation	250	440	$36.41	$9,102.50	$16,020.40
Sample processesing, such as species identification and morphological measurments	Implementation	500	600	$36.41	$18,205.00	$21,846.00
Conduct lab tests	Implementation	400	500	$36.41	$14,564.00	$18,205.00
Handle machiene calibration, quality control, and troubleshooting	Implementation	40	60	$36.41	$1,456.40	$2,184.60
Organize raw data, verify consistency, and handle errors	Implementation	150	200	$36.41	$5,461.50	$7,282.00
Run statistical models	Implementation	100	150	$36.41	$3,641.00	$5,461.50
Extract key patterns, findings, and ecological significance	Implementation	200	250	$36.41	$7,282.00	$9,102.50
Compare findings to historical or control sites	Implementation	40	80	$36.41	$1,456.40	$2,912.80
Contigency time for bad weather, equipment failes, or other sampling challenges	Implementation	20	40	$36.41	$728.20	$1,456.40
	Implementation Total	**1840**	**2560**			
Draft manuscript including introduction, methods, results, and disucssion	Communication	120	160	$36.41	$4,369.20	$5,825.60
Create necessary figures, tables, and appendices	Communication	80	100	$36.41	$2,912.80	$3,641.00
Cite references and format per journal guidelines	Communication	20	40	$36.41	$728.20	$1,456.40
Incorporate feedback from co-authors, mentors, or collaborators	Communication	40	80	$36.41	$1,456.40	$2,912.80
Prepare presentations for conferences, fisheries managers, or policy makers	Communication	40	80	$36.41	$1,456.40	$2,912.80
Attend and provide advice at any necessary fishery management organization follow-up meetings	Communication	20	40	$36.41	$728.20	$1,456.40
Sending updates to Wild Oceans	Communication	20	40	$36.41	$728.20	$1,456.40
	Communication Total	**340**	**540**			
	Total Year 1 Hours	**2640**	**3910**	**Total Year 1 Salary Costs**	**$92,681.30**	**$134,024.50**
	Total Repeated Hours	**5920**	**8160**	Total Repeated Salary Costs	$53,886.80	$74,276.40
	Total Hours for 5 Years	**8560**	**12070**	Present Value of Repeated Salary Costs for 4 Additional Years	$200,369.61	$276,185.14
				Total Salary Costs for 5 Years	**$293,050.91**	**$410,209.64**

New Research Study				
Capital Costs				
Item	**Cost Per Unit**	**Number of Units**	**Monthly Cost (If Applicable)**	**Yearly Cost**
Lab Space	$1.14	125	$142.50	$1,710.00
Research Vessel	$90.00	6		$540.00
Plankton Net	$799.00	2		$319.60
Formalin	$40.00	5		$200.00
Ethanol	$24.99	5		$124.95
Sodium Borate	$46.98	5		$234.90
Research Permit	$40.00	3		$24.00
			Total Yearly Costs	**$3,153.45**
			Present Value Calculation For 5 Years	**$14,447.65**

New Research Study	
Travel Costs	
Item	Cost
Hotel	$2,392.00
Flight	$472.97
Rental Car	$1,000.00
Total Yearly Costs	**$3,864.97**
Present Value Calculation For 5 Years	**$17,707.51**

APPENDIX 7: UPDATING RESEARCH ADMINISTRATIVE BURDEN AND COSTS

Updating Research Study						
	Administrative Burden			Overhead and Salary Costs		
Item	**Category**	**Hours Low Estimate**	**Hours High Estimate**	**Salary Rate**	**Hours Low Estimate Cost**	**Hours High Estimate Cost**
Identification of general research topic (predator-prey relationships, forage fish recruitment)	Administrative	10	20	$56.40	$564.00	$1,128.00
Discussion meetings with Board members	Administrative	20	30	$56.40	$1,128.00	$1,692.00
Fundraising or grant applications	Administrative	20	40	$56.40	$1,128.00	$2,256.00
Hiring fishery scientist	Administrative	100	150	$56.40	$5,640.00	$8,460.00
	Administrative Total	**150**	**240**	**Total Overhead**	**$8,460.00**	**$13,536.00**
Clarifying research questions and hypothesis	Scoping and Development	40	80	$36.41	$1,456.40	$2,912.80
Literature review, including investigating prior studies' findings, methodologies, challenges, and identified research gaps	Scoping and Development	100	150	$36.41	$3,641.00	$5,461.50
Determine outdated study to replicate and/or improve based on outdated methods, questionable/outlire results, lacking modern theory/understandings, or other AND a study which is still of central important today for forage fish management	Scoping and Development	200	250	$36.41	$7,282.00	$9,102.50
	Scoping and Development Total	**340**	**480**			
Identify any co-authors	Collaboration with Partners	10	20	$36.41	$364.10	$728.20
Identify any organizations willing to aid in study funding	Collaboration with Partners	10	20	$56.40	$564.00	$1,128.00
	Collaboration with Partners Total	**20**	**40**			
Obtainment of data sets, either paper or digital	Implementation	80	100	$36.41	$2,912.80	$3,641.00
Data cleaning and manipulation into usable format	Implementation	200	300	$36.41	$7,282.00	$10,923.00
Run statistical or ecological models	Implementation	100	150	$36.41	$3,641.00	$5,461.50
Extract key patterns, findings, and ecological significance	Implementation	200	250	$36.41	$7,282.00	$9,102.50
Compare findings to historical studies	Implementation	40	80	$36.41	$1,456.40	$2,912.80
	Implementation Total	**340**	**480**			
Draft manuscript including introduction, methods, results, and disucssion	Communication	120	160	$36.41	$4,369.20	$5,825.60
Create necessary figures, tables, and appendices	Communication	80	100	$36.41	$2,912.80	$3,641.00
Cite references and format per journal guidelines	Communication	20	40	$36.41	$728.20	$1,456.40
Incorporate feedback from co-authors, mentors, or collaborators	Communication	40	80	$36.41	$1,456.40	$2,912.80
Prepare presentations for conferences, fisheries managers, or policy makers	Communication	40	80	$36.41	$1,456.40	$2,912.80
Attend and provide advice at any necessary fishery management organization follow-up meetings	Communication	20	40	$36.41	$728.20	$1,456.40
Sending updates to Wild Oceans	Communication	20	40	$36.41	$728.20	$1,456.40
	Communication Total	**340**	**540**			
	Total Year 1 Hours	**1140**	**1780**	**Total Salary Costs**	**$48,261.10**	**$71,035.20**

APPENDIX 8: GEAR RESTRICTIONS ADMINISTRATIVE BURDEN AND COSTS

Gear Restrictions						
	Administrative Burden			Overhead and Salary Costs		
Item	**Category**	**Hours Low Estimate**	**Hours High Estimate**	**Salary Rate**	**Hours Low Estimate Cost**	**Hours High Estimate Cost**
Discussion meetings with Board memebers	Administrative	10	20	$56.40	$564.00	$1,128.00
	Administrative Total	**10**	**20**	**Total Overhead**	**$564.00**	**$1,128.00**
Researching forage fish indexes to determine the level of desired buffer to advoacte for, based on already estbalished forage fish indexes in bluefish research tracks	Scoping and Development	10	40	$28.00	$280.00	$1,120.00
	Scoping and Development Total	**10**	**40**			
Identifying potential partners	Collaboration with Partners	5	10	$28.00	$140.00	$280.00
Outreach to potential partners, especially friendly New England Regional Fishery Management Council members	Collaboration with Partners	10	15	$28.00	$280.00	$420.00
Meetings and follow up with partners	Collaboration with Partners	10	20	$28.00	$280.00	$560.00
	Collaboration with Partners Total	**15**	**30**			
Reviewing Differcence-in-Difference analysis included in this report for accuracy	Implementation	5	10	$28.00	$140.00	$280.00
Discussing with fishery scientists and managers analysis results and integrating feedback	Implementation	5	10	$28.00	$140.00	$280.00
Drafting findings report of analysis, building upon past literature	Implementation	40	80	$28.00	$1,120.00	$2,240.00
Drafting, editing and finalizing a written public comment	Implementation	20	40	$28.00	$560.00	$1,120.00
Meeting with Council members and staff for questions and advocacy	Implementation	20	60	$28.00	$560.00	$1,680.00
	Implementation Total	**50**	**120**			
Seek publication, including drafting manuscript, creating figures, identifying and following jounral guidelines, and peer-review process	Communication	260	380	$28.00	$7,280.00	$10,640.00
Publishing public comment on Wild Ocean's Website	Communication	1	5	$47.37	$47.37	$236.85
	Communication Total	**261**	**385**			
	Total Hours Year 1	**346**	**595**	**Total Salary Year 1**	**$10,827.37**	**$18,856.85**

APPENDIX 9: GEAR RESTRICTIONS EXAMPLE PROGRAM EVALUATION (DID)

Evaluating the Impact of the 2007 Gear Restriction Policy on River Herring Populations in Herring Management Area 1A and Southern New England

Key Findings:

- Rivers within the protected area experienced statistically and economically significant differences in River herring populations, peaking in 2018 with over 380,000 more fish compared to unprotected rivers.

- These differences indicate a strong positive impact of the 2007 gear restriction policy on River herring populations in the Gulf of Maine.

- Scientific literature and genetic studies confirm that bycatch disproportionately impacts the most depleted River herring stocks, particularly in Southern New England and Long Island Sound—regions not currently protected by gear restrictions.

Policy Implications:

- Gear restrictions like the 2007 policy are an effective tool for reducing bycatch.

- Expanding similar seasonal gear restrictions to additional Herring Management Areas—particularly those covering Southern New England and Long Island Sound—would help address regional River herring disparities and better protect critical habitats.

- Ensuring equitable ecological and cultural benefits across all New England communities depends on managing fisheries with a focus on habitat-specific vulnerabilities and bycatch risks.

Recommendation: Policymakers should consider extending the successful 2007 gear restriction model to other high-risk areas to support the recovery of River herring populations, protect broader marine food webs, and sustain cultural and recreational uses tied to these fish.

Executive Summary

River herring are a vital species in New England's marine ecosystems, yet populations remain critically low in many southern rivers despite decades of restoration efforts. A 2007 policy restricted midwater trawling in nearshore waters of the Gulf of Maine (Herring Management Area 1A) to protect forage fish. This impact evaluation, using River herring run count data from 1995 to 2022, found that rivers within the protected area saw significant population levels—up to 380,000 more fish—compared to unprotected rivers in Southern New England. Past studies have indicated that bycatch could be a culprit for this status quo, and that the Southern New England and Long Island Sound waters could be critical for rebounding already-depleted populations. The findings of this impact evaluation support expanding seasonal gear restrictions to additional areas as an effective and equitable policy tool to reduce bycatch, support species recovery, and ensure all New England communities benefit from healthier river and marine ecosystems.

Introduction

Too few River herring have returned to Connecticut, Rhode Island, and some parts of Massachusetts rivers despite large-scale efforts to restore River herring ecosystems through dam removals, fish ladders, fishing moratoriums, and other clean-up efforts. Most New England runs are at or near historic low levels, with populations so low that listing the species as endangered has been considered and total stock collapse has been a concern since as early as 2000. River herring represent an important part of the ecosystem as a middle-trophic level fish providing forage for a variety of predators, including species such as striped bass that are targeted by recreational fishermen, and are integral to cultural traditions and native practices by rivershed communities and coastal tribes.

Beginning in 2007, the New England Fishery Management Council and National Marine Fisheries Service prohibited midwater trawling in Herring Management Area 1A from June 1 to September 30. This time/area/gear closure, known as the "Purse Seine/Fixed Gear Only Area," only allows the use of purse seines and fixed gear in the near-shore areas of the Gulf of Maine to protect near shore forage species off the coast of Maine, New Hampshire, and part of Massachusetts.

The return to healthy River herring populations in rivers connected to Herring Management Area 1A has been largely attributed to the river restoration efforts, with bycatch from Herring commercial vessels considered as an ambiguous factor.

According to Reid et al. (2023), who authored the study *Spatial and temporal genetic stock composition of river herring bycatch in southern New England Atlantic herring and mackerel fisheries*:

> "Various approaches have been utilized to characterize the composition of river herring caught as bycatch, and to determine the rivers and/or stocks most impacted. Bethoney et al. (2014) used length-frequency distributions and life-history patterns to determine that bycatch from 2011 and 2012 was having the greatest impacts on populations from the SNE [Southern New England] and the New Jersey-Long Island (NJLI) regions. Hasselman et al. (2016) used a genetics approach, assessing the stock composition of both alewife and blueback herring bycatch in 2012 and 2013. They found that the highest proportion of bycatch originated from the most depressed genetic stocks (which included their defined SNE RG for alewife and Mid-Atlantic (MAT) RG for blueback herring). Palkovacs et al. (2014) suggested that bycatch was having the greatest negative influence on populations from the Long Island Sound region."

Reid et al.'s (2023) investigation aimed to provide additional geographic resolution on the origins of bycatch, assess the frequency of bycatch events, and assess stock-specific mortality for River herring in a 3569 km2 area off Southern New England, including Rhode Island and Block Island Sounds. They found that "bycatch took about 4.6 million alewife and 1.2 million blueback herring [during the 4-year study period], highlighting the need to reduce bycatch mortality for the most depleted river herring stocks".

These studies point to the importance of continuing to investigate bycatch as a critical factor affecting River herring populations, and the importance of Southern New England and the Long Island Sound as essential habitats for River herring populations. Furthermore, the Atlantic States Marine Fishery Commission Shad and River Herring Advisory Panel has demonstrated a desire to know more about the effects of the 2007 time/area/gear as it relates to River herring populations.

In this program evaluation, I used datasets produced by state departments of natural resources and citizen scientists for alewife and blueback herring run counts to evaluate the effects of the 2007 time/area/gear closure on River herring populations and bycatch in the Atlantic herring fisheries from 1995 to 2022. This policy timeline was chosen because midwater trawl vessels entered New England waters in 1994, and data was only sufficient until the year 2022. Furthermore, this distribution provides a relatively even distribution of years within the policy pre-period and the policy post-period.

I aimed to: (1) evaluate the effectiveness of the 2007 time/area/gear closures in relation to River herring populations and (2) determine if disparities exist across geographic regions as divided by Herring Management Areas. I deployed a difference-in-difference (DID) impact evaluation method to accomplish this, which at its most basic is a comparison of the average outcomes for two groups—one affected by the policy and one not—over time. By looking at how trends change before and after the policy for both groups, the policy's impact can be isolated while canceling out other factors they have in common.

Data and Methods

This evaluation utilizes a DID approach, where the change in conditions before and after the intervention are compared between control and treatment sites (Gurney et al., 2014). A DID is only accurate if the control and treatment sites had similar trends prior to the intervention (parallel trends assumption) and if there are no major changes in one group that another did not experience (Ferraro 2009; Smallhorn-West et al., 2020). The DID uses longitudinal data to assess long-term intervention impacts (Gurney et al., 2014). Past studies conducted by McDermott et al. (2018), Ovando et al. (2021), and Fox & Swearingen (2021) have demonstrated the application and usefulness of the DID method in fishery management impact evaluations.

River herring run counts were gathered for several New England states, including Connecticut, Rhode Island, Massachusetts, Maine, and New Hampshire. Data was collected by accessing publicly available data on state department of natural resources websites, contacting state department biologists for their River herring run counts, and by contacting citizen science organizations. Alewifes Annonomys provided the only citizen science data used for this study.

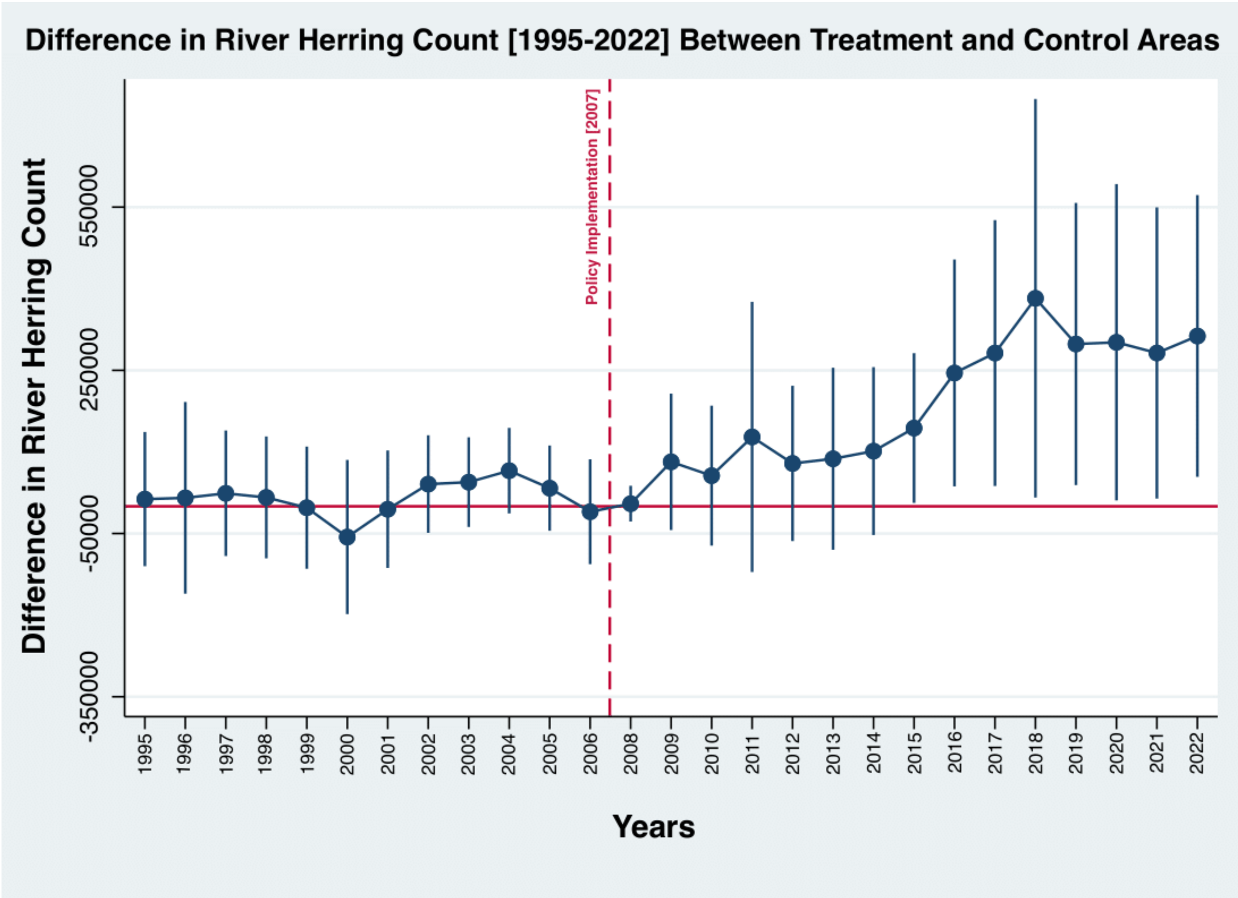
Rivers included in the dataset were determined based on the data made available through these sources. Rivers that flow into the Gulf of Maine within Area 1A were grouped together as the treatment area (rivers from Maine, New Hampshire, and some parts of Massachusetts). Rivers that flow outside of Area 1A were grouped together as the control area (some Massachusetts, Rhode Island, and Connecticut). Massachusetts rivers used for the study were classified as flowing or not flowing into area 1A by the Massachusetts Department of Natural Resources. To ensure that the rivers included are impacted by similar human management and environmental conditions, and therefore experience similar conditions before and after the policy intervention, rivers further south than Connecticut and further north than Maine were not included.

This study leverages 2007 as the policy intervention cutoff to compare River herring counts before and after policy intervention. The study incorporates year-fixed effects and state-fixed effects, and clusters data by river. Year-fixed effects account for confounding factors that might influence River herring populations in a given year, such as the removal of a dam or installation of a fish ladder. Meanwhile, state-fixed effects recognize differences between states, like access to funding for river restoration or River herring counting procedures. River clusters were used to obtain more accurate error estimates by accounting for similarities within each river over time, ensuring estimates are reported with the proper uncertainty.

Findings

The Event Study below demonstrates that the parallel trends assumption is met. Visually, two distinct, relatively flat cycles of differences in River herring populations can be observed. Furthermore, the confidence intervals touch the 0 line in all years prior to the policy intervention, indicating that there were no statistically significant differences between the River herring trends before the policy intervention.

After the policy intervention in 2007, the cycles seen from 1995-2006 were disrupted. Furthermore, the differences in River herring across the treatment and control groups became statistically significant in 2015, with a positive magnitude of 143,819.2 more fish in the rivers connected to Herring Management Area 1A. The differences peaked in 2018, with an estimated 382,361.7 more fish in the rivers connected to Herring Management Area 1A than in the river outside of this area.



Event study of the differences in River herring counts over time from 1995 to 2022 between rivers connected to Herring Management Area 1A and rivers outside of Herring Management 1A. Policy implementation in 2007, resulting in its exclusion from the graph, as this is the base year. The dotted red line marks 2007, dividing the policy pre-period and the policy-post period.

Conclusions

Based on the findings of this study, statistically and economically significant differences in River herring populations exist across the treatment and control areas surrounding the time/area/gear closure policy intervention in 2007. Given this finding, as well as the literature's identification of SNG and the Long Island Sound as critical habitats to aid in River herring population rebounds, it is recommended that similar time/area/gear closure be implemented in additional Herring Management Areas. Gear restrictions represent the best tool at managers' disposal which will limit bycatch and allow River herring populations to rebound, ensuring that communities across all New England rivers are able to partake in the benefits River herring provide to marine and river habitats equally.

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