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U.S. Regional Fishery Management Councils

August 26 - 28, 2024
Hosted by NEFMC
Boston, MA

SCS 8

Applying Acceptable Biological Catch (ABC) Control Rules in a Changing Environment

Eighth National Meeting of the Scientific Coordination Subcommittee of the Council Coordination Committee

Boston Fish Pier, located near the SCS8 meeting venue.

The eighth national Scientific Coordination Subcommittee meeting (SCS8) was led by SCS Chair Lisa Kerr and coordinated by Rachel Feeney of the New England Fishery Management Council (NEFMC) staff with input from the SCS8 Steering Committee, particularly SCS Vice-Chair Conor McManus. The meeting was facilitated and this report compiled by the Urban Harbors Institute (UHI) at the University of Massachusetts Boston including Kim Starbuck, Kristin Uiterwyk, Allison Novelly, and Shannon Hogan and was edited by Lisa Kerr, Conor McManus, Rachel Feeney and several members of the Scientific Coordination Subcommittee.

The report design is modeled after the final report of the seventh national SCS meeting, created by the North Pacific Fishery Management Council staff. Front cover photo of the Boston Fish Pier by Kristin Uiterwyk. Other images by UHI or NEFMC staff, except for page 3 (Gulf of Maine Research Institute), page 6 and 20 (NOAA Fisheries), page 15 (Debra Lambert), or as noted.

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1. Executive Summary

The eighth National Scientific Coordination Subcommittee Workshop (SCS8) was held in Boston, Massachusetts on August 26-28, 2024. SCS8 focused on the theme: *Applying Acceptable Biological Catch (ABC) Control Rules in a Changing Environment.* The workshop aimed to provide actionable guidance on how to best support Regional Fishery Management Councils (Councils) in the management of fisheries, particularly on the use of ABC control rules, given the changing environment. Participants included Scientific and Statistical Committee (SSC) members and staff from the eight Councils, as well as invited National Oceanic and Atmospheric Administration (NOAA) staff and topical experts.

Presentations and discussions focused on three sub-themes:

- Advances in ecosystem science and assessment to inform ABC control rules in a dynamic environment,
- Application of social science to achieve management goals under dynamic conditions, and
- Adaptation of reference points, control rules, and rebuilding plans to a changing environment.

The workshop provided an opportunity for Council delegates to learn from each other as they work to address a range of shared challenges such as data gaps, limits of existing models and processes, and managing under the rapid nature and degree of environmental change. Based on the productive discussions, SCS8 resulted in specific action items for Council SSCs to consider and advance in their own regions following the workshop.

> ***Acceptable Biological Catch:***
>
> ABC is a level of a stock or stock complex's annual catch, which is based on an ABC control rule that accounts for the scientific uncertainty in the estimate of OFL, any other scientific uncertainty, and the Council's risk policy.

In reviewing the state of assessment and ecosystem science across Council regions, delegates reflected on the new data products, emerging modeling platforms, and other advances, such as NOAA's Climate, Ecosystem, and Fisheries Initiative (CEFI) that aims to build capacity for adapting to changing ocean conditions. However, many notable regional differences exist in available data, models, products, and capacity. The integration of climate information into fisheries management is thus varied across federally managed species and Council regions. Delegates recommended greater commitment to making resources available more consistently across the nation, planning to address limitations, and identifying more opportunities for on-ramping ecosystem information.

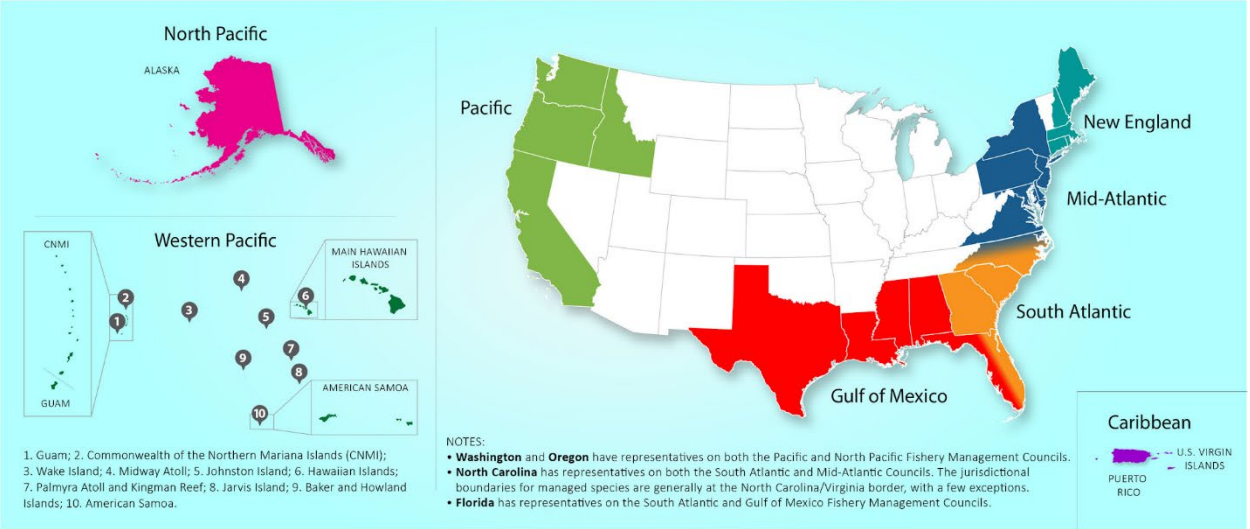
Although Councils value social science, and the potential for human dimensions information to contribute to climate-informed fisheries management, delegates acknowledged that social and economic data and expertise are limited, and the roles of SSCs in using this type of data are unclear or restrictive. Delegates recommended strategic planning and partnerships to better align staff capacity with information needs, scales of data, and the timing of producing science relative to decision timeframes.

A few examples were identified where reference points, rebuilding plans, and ABC control rules have been adapted to respond to climatic change, but it was noted that climate impacts have not been uniform, and there are ongoing limits to determining causal links between climate drivers and fishery outcomes. Delegates recommended identifying where constraints are limiting the ability to respond to a changing system, whether in generating science, in communicating across disciplines and organizations, or in regulatory constructs.

Despite the limitations in data, capacity, and understanding of ecosystem change and related fish and fishery impacts, delegates left SCS8 energized to make tangible progress, applying the recommendations and ideas for regional action to progress towards more climate-resilient fisheries and fisheries management.

Key Recommendations:

- Examine regional differences in available data and the resources to identify and respond to changing conditions; strategically plan how to meet needs more consistently.
- Identify how available ecosystem information can be more effectively integrated into management processes.
- Examine processes for defining and revising reference points and control rules to identify how to build more flexibility into the management system to respond to changing conditions.



The eight Council regions (source: https://www.fisherycouncils.org/about-the-councils).

2. Forword

Dr. Lisa Kerr, SCS8 Chair, NEFMC SSC Chair

A core function of our Fishery Management Councils' SSCs is to provide recommendations on tactical decision-making related to acceptable biological catch (ABC) for managed stocks and to support strategic decision-making on ABC control rules that align with Council management objectives. The focus of our SCS8 meeting on *Applying Acceptable Biological Catch (ABC) Control Rules in a Changing Environment* was a direct response to the challenges experienced by SSCs across the nation in effectively applying these rules. SSCs play a critical role at the intersection of science and management, often facing the constraints and breakdowns in processes that can limit their ability, and that of the broader management system, to adapt to change. Our goal at this meeting was to build upon the work of previous SCS meetings, particularly the SCS7 meeting focused on *Adapting Fisheries Management to a Changing Ecosystem* where the SCS recommended that Councils develop adaptations to status quo fisheries management approaches that will support sustainable fisheries in a changing environment.

During SCS8, it was encouraging to hear about the growing availability of climate and fisheries information products that have the potential to better inform our decision-making. Additionally, we are seeing an increasing number of examples nationwide where climate information is being integrated into stock assessments and considered in the definition of reference points that inform management. Across SSCs, there is a desire to more formally consider social science data in the design of ABC control rules and clarify its usage in catch advice setting. Despite the many challenges we face—such as data limitations, scientific uncertainty, and capacity constraints—there was a shared sense that we must find ways to make the most of the resources available to us now.

SCS8 brought together representatives from the SSCs across our Councils to share knowledge, collaborate, and address this urgent scientific challenge of national importance. These meetings are instrumental in accelerating learning and facilitating the sharing of approaches across regions, something that is more urgent than ever given the rapid pace of change in many of our systems. As a group, we made recommendations aimed at improving the incorporation of ecosystem and climate science into ABC control rules and catch advice setting. These recommendations focused on enhancing the availability and integration of data, refining and applying tools that account for climate impacts on stocks, and addressing current gaps to better manage fishery stocks in the context of climate change and ecosystem dynamics. These recommendations highlight the need for comprehensive evaluation of ABC control rule performance and building flexible approaches to control rules. By addressing these recommendations, the application of ABC control rules can be better adapted to the evolving challenges posed by climate and ecosystem change, improving sustainability and management efficacy.

I am confident that participants left with actionable steps to implement in their respective regions, and I look forward to seeing how these actions take shape across the Council regions.

Participants of SCS8
Boston, Massachusetts

Table 1. Date, host and theme of SCS meetings

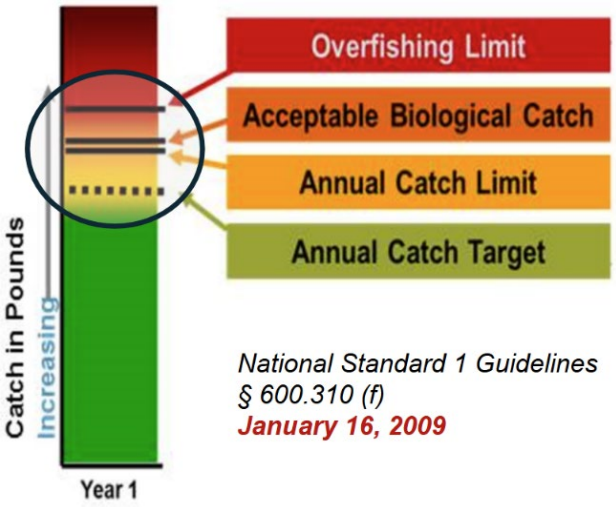
SCS	Year	Host	Theme
1	2008	WPFMC	Developing Best Practices for SSCs
2	2009	CFMC	Establishing a Scientific Basis for Annual Catch Limits
3	2010	SAFMC	ABC Control Rule Implementation and Peer Review Procedures
4	2011	MAFMC	Ecosystem and Social Science Considerations in U.S. Federal Fishery Management
5	2015	WPFMC	Providing Scientific Advice in the Face of Uncertainty: from Data to Climate and Ecosystems
6	2018	PFMC	The Use of MSE to Inform Decisions Made by the Regional Fishery Management Councils
7	2022	NPFMC	Adapting Fisheries Management to a Changing Ecosystem
8	2024	NEFMC	Applying ABC Control Rules in a Changing Environment

3. Introduction

The Scientific Coordination Subcommittee convened its eighth national meeting, hosted by the New England Fishery Management Council at the Seaport Hotel in the Seaport District of Boston, Massachusetts on August 26-28, 2024. The overarching theme of SCS8 was "Applying ABC Control Rules in a Changing Environment." The SCS reached consensus on this theme after seeking input from the Scientific and Statistical Committees (SSCs) of each Regional Fishery Management Council and approval of the Council Coordination Committee (CCC).

> ***SCS8 Goal:***
>
> Provide actionable guidance on how to best support Councils in the management of fisheries, specifically the application of ABC control rules, in a changing environment.

The goal of SCS8 was to provide actionable guidance on how to best support Councils in the management of fisheries, specifically the application of ABC control rules, in a changing environment. The core function of an SSC is to provide recommendations for setting ABC consistent with the Magnuson-Stevens Act and the ABC control rules established in fishery management plans. However, applying ABC control rules in a manner that reliably achieves management goals such as preventing overfishing or rebuilding stocks has proven difficult with the degree and increasing rate of environmental change and scientific uncertainty that Council regions are experiencing. Each Council region is challenged at varying degrees with managing catch under data limitations and scientific uncertainty. During the SCS8 workshop, strategies were explored for how to adapt aspects of ABC control rules given the impacts of climate change on the dynamics and distribution of our managed fish stocks. For example, participants discussed approaches to redefining reference points that inform stock status determination and rebuilding plans to account for changes in stock productivity. Participants also explored how SSCs can better consider social and economic information in the development and application of ABC control rules and how this information can provide critical insight regarding the effectiveness of control rules in achieving management goals.



After opening SCS8 with an overview of the current ABC control rules applied across Councils and challenges in their application, there were contributed talks and discussions under three sub-themes: 1) Advances in ecosystem science and assessment to inform ABC control rules in a dynamic environment, 2) Application of social science to achieve management goals under dynamic conditions, and 3) Adaptation of reference points, control rules, and rebuilding plans to a changing environment.

Developing recommendations within small group discussions that included delegates from across Councils fostered cross-communication and learning from different regions. Guiding questions helped focus the discussions, and key findings were

then presented and discussed in plenary. This report summarizes the SCS8 presentations, discussions and recommendations, and provides actionable guidance for SSCs, Councils, and the CCC. The plenary sessions of SCS8 were broadcast to the public via webinar. This report, speaker abstracts, presentation slides, recordings, and other SCS8 materials are archived on the CCC's website: https://www.fisherycouncils.org/ssc-workshops/scs-8.

4. Welcome and Opening Remarks

Welcome: Rick Bellavance, Chair of NEFMC

Rick Bellavance, Chair of the NEFMC, welcomed everyone and shared his excitement in hosting the SCS in New England. He noted the importance of the SCS8 theme both nationally and to the region as the New England Council works through revising the ABC control rule for groundfish and modifying its risk policy applicable to all stocks. He reflected that, as a charter boat captain from southern Rhode Island, he has seen many changes on the water including cod disappearing and black sea bass inundating southern New England waters. Mr. Bellavance noted that clients recently caught, tagged and released four sandbar sharks for the first time in 30 years. He shared that these changes require his industry to adapt from a business perspective and emphasized the importance of fishery management decisions made for New England's stocks to the fishing industry.

Opening Keynote: Janet Coit, NOAA Fisheries

Janet Coit, Assistant Administrator for NOAA Fisheries, also welcomed the delegates, encouraged their participation, and provided an update on recent NOAA initiatives to improve fisheries science and management. Since her appointment in June 2021, Ms. Coit has been leading the agency to ensure the sustainability of fisheries in a changing environment, including by modernizing fishery surveys and assessment capacity and overseeing the national implementation of programs to support climate-informed management. She is focused on how to use science-based management to effectively address the rapid changes in the marine environment occurring largely from

climate change. She strives to foster close coordination between scientists, managers, stakeholders, industry, and others in this work.

Acknowledging that everyone in fisheries management is grappling with the dramatic changes from climate change, Ms. Coit noted that the SCS8 workshop comes at a critical juncture when the science has developed, people have been seeing and hearing about changes in the water from fishermen for quite some time, and there is need to act with alacrity. To do this, those involved in the management process will need to be mobilized and make changes to effectively manage sustainable fisheries in light of climate change.

Ms. Coit recognized the critical role the SSCs play in fisheries management, their extensive knowledge of the ecosystems, and the talented, dedicated, experienced, and passionate group represented at this meeting. The SSCs work diligently for the Regional Fishery Management Councils and carry a heavy load, but she emphasized that this work is essential to the success of what she thinks are the best managed fisheries in the world and to the implementation of the Magnuson-Stevens Act.

Ms. Coit encouraged the delegates to persevere and help create a bridge between scientists, managers, and stakeholders, so that people have a better understanding of what is happening in the environment and how management choices can provide sustainable, responsible fisheries management. She noted that what the SCS8 workshop is trying in-part to advance is to make sure that people are aware of the available science and challenges, and that managers and scientists have key information for constructing control rules and management plans that effectively account for future conditions.

Ms. Coit noted that a map perfectly suitable for one purpose may not be at all suitable for another purpose. You can have the perfect map or model, but if you do not understand the territory of the actual world as it exists, it can lead to poor results. As applied to fisheries management, it is important to consider fishing effort, fishing sectors, social and economic factors, population dynamics, management requirements, and more to make sure science is useful for broader management goals.

She highlighted how incorporating social science can help to make fisheries management more useful and applicable. Social science is an increasing area of focus for NOAA Fisheries in all regions. Considering the social and economic aspects of communities and diversifying representation on the Councils will improve the management of fisheries and protected species for a broader set of partners. Effectively using the social sciences requires continued and expanded partner engagement as well as overcoming personal biases.

Ms. Coit noted that the environment is changing, and the observed non-stationarity means that traditional approaches may be inadequate. Climate change is making fisheries management and science more unpredictable and difficult and is increasingly stressing the environment, systems, and people in the United States and around the world. The changing environment is affecting people on the ground, the decisions they make, and the anxiety they have about their futures. She highlighted that more work is needed to expand scientific endeavors, modernize management systems, and develop new methods to address existing and emerging issues. This includes considering the process of providing advice to the Councils and improving scientific advice to allow management structures to be more adaptable, predictive, and flexible to change.

Notable recent efforts by NOAA Fisheries include:

- Creating the Climate Governance Policy (Procedural Directive on 304(f)) that sets forth triggers and a specific process for identifying the geographic scope of fisheries and determining which Council or Councils will be responsible for managing those fisheries when they have moved beyond the geographical area of one Council.
- Participating in climate scenario planning initiated by the Councils (e.g., East Coast planning).
- Issuing an Advance Notice of Proposed Rulemaking to update and revise the guidelines for National Standards 4 (Allocation), 8 (Communities), and 9 (Bycatch) to incorporate climate change, access, and equity issues.
- Using Inflation Reduction Act (IRA) funding to create a new grant program for the Councils to help them support their expanding work around climate change. IRA funding also is being used to fund the Climate, Ecosystem, and Fisheries Initiative, as well as investments in data modernization, grants, and cooperative institutes.

In closing, Ms. Coit recognized SCS8 as an amazing opportunity to help address these issues, pick up the pace, and to focus very practically on what can be done to better inform management decisions. She encouraged everyone to get out of their comfort zones, flex their scientific muscles, and share ideas, because their voices are critical to addressing these challenges.

Opening keynote by Janet Coit.

5. Context Setting: Current Approaches to Defining ABC Control Rules and Challenges in their Applications

Round Robin Presentations

SSC delegates provided an overview of what stocks are managed by their Council, what types of ABC control rules are used, and what are the challenges each region has experienced with performance of ABC control rules in a changing environment. Participants were also informed by work of the SCS8 Steering Committee prior to the workshop in updating a database of all federally managed stocks that includes control rules and reference point definitions.

Mid-Atlantic

The Mid-Atlantic region is relatively data rich with a model-estimated OFL and ABC set using a P* approach for ten of 14 species managed by the MAFMC within six fishery management plans. For those stocks with an OFL, the ABC control rule and Council risk policy are applied similarly across FMPs and stocks with a greater buffer between the OFL and ABC as uncertainty increases and as stock biomass declines. For those stocks without an OFL, the SSC uses a variety of empirical or data limited methods to derive the ABC. The Mid-Atlantic has been successful at rebuilding most stocks to or above target biomass levels and there is no chronic overfishing. In addition, new state-space stock assessments have included explicit environmental effects.

While the Council has been successful at rebuilding stocks with infrequent overfishing, they face several challenges such as the noticeable degradation and more frequent interruption of survey data streams leading to poorer performing stock assessments and increased uncertainty. Other challenges pertain to determining when and how to change reference points and understanding the biological impacts of environmental drivers. There is a need to better detect changes in productivity (especially recruitment) and effects of changing environmental factors on fishing patterns, distribution of open populations, and growth rates that can change our understanding of reference point estimation. The MAFMC emphasized that there is a need to practice today what we need to do tomorrow, which includes timely and frequent assessments, engaging with fishermen, and streamlining Council actions.

Western Pacific

The WPFMC manages stocks through Fishery Ecosystem Plans (FEP) for the Mariana Archipelago, American Samoa Archipelago, Hawaii Archipelago, Pacific Remote Island Areas, and Pacific Pelagics. There are currently 44 management unit species (MUS) across the five FEP regions with 16 of those species having annual catch limits (ACL). An omnibus FEP amendment redesignated 539 species that were previously MUS to ecosystem component species (ECS) because they were primarily harvested in state/territorial waters. The Council uses tiered control rules, based on data quality and whether there is

an OFL/MSY, for setting catch levels for 44 species in its five Fishery Ecosystem Plans. A 'P-star' (P*) approach is used for stocks with more quantitative assessments (Tiers 1-3).

The Council's biggest challenges lie with basic data issues. Most of the region's fisheries are data limited and there are consequent issues of data quality, but stock status has a high impact on the livelihoods and sustenance of local communities, especially in territorial regions. American Samoa, Guam, and Northern Mariana Islands (CNMI) fisheries are primarily dependent on creel surveys for catch, effort, and size data used for stock assessments and fishery management, but there are concerns about the quality and variability of this survey.

In general, the data limitations in assessments make it difficult to identify the influence of climate change on stocks. For example, changes in stock status between assessments may be due more to changes in assessment methodology or data limitations rather than any climate related changes. Environmental and climate factors are not explicitly included in the assessment models. There is a need for better mechanistic understanding of the effects of climate change on stocks first before incorporating them into assessments. Additional challenges include species within complexes that often have varying life history characteristics with different temporal responses to climate.

The Council uses a Social Economic Ecological Management (SEEM) process to set ACLs that account for uncertainties, including those related to environmental and climate factors. In recent years, the SSC has discussed the topic of non-stationarity in assessments and the Council expects to soon review its specifications process, including the use of P* and SEEM, to provide revisions and updates. Additionally, and perhaps most critically, there is a strong need for flexibility in any federal management regulations related to climate impacts given the unique regional context of the Western Pacific considering regional data limitations.

Caribbean

The CFMC has three island-based fishery management plans for Puerto Rico, St. Thomas/St. John U.S. Virgin Islands (USVI), and St. Croix USVI, managing 275 species, including 89 stocks with catch limits. The FMPs use tiered ABC control rules based on data availability (Tier 1, 2, 3, 4a, and 4b), however, just one stock (Caribbean spiny lobster) is managed under Tier 3 (use of MSY_{proxy}) and the remaining 88 stocks are managed with Tier 4 (unquantified MSY_{proxy}). Six traditional assessments have been conducted in the region, which resulted in no management advice. Additionally, three data limited assessments were done with Tier 3 (moderate data) and Tier 4 (limited data), which resulted in management advice. Currently, a data limited assessment (for two species for three islands) is being conducted, and one assessment for spiny lobster (Tier 3) has been scheduled.

The region is highly diverse, relatively data limited, with major challenges including a high level of uncertainty associated with climate change, lack of fishery effort data, limited life history data (especially age), delays in available commercial catch data, and very limited to no recreational data. The challenges with performance of ABC control rules under climate change include: 1) lack of data to identify and address the impacts to fisheries, 2) difficulty to identify specific drivers of change (e.g., sea level rise, sea surface temperature, ocean acidification, 3) difficulty to understand the interactions between climate change drivers and local anthropogenic impacts (e.g., tourism, pollution, sedimentation), and 4) limited data to understand the effect of climate change to coral reefs (about 80% of the U.S. Caribbean fisheries is associated with coral reefs).

The Council leans on the expertise of industry members in the development of reference points and ABC control rules, especially from the District Advisory Panels. There have been recent efforts to: 1) improve understanding of life history, 2) increase social and economic data collection, 3) develop holistic conceptual models based on stakeholder perceptions to describe the U.S. Caribbean fishery system, 4) study specific stocks which have been traditionally hard to sample (e.g., deep water snappers and yellowtail snappers), 5) analyze available fisheries dependent and independent data to describe patterns of spatial and temporal changes of the assemblage, and 6) expand the options and applications of measuring stock health despite data limitations.

Gulf

The Gulf Council has six fishery management plans and sets catch limits for 40 species including coastal migratory pelagic species, reef fish, red drum, shrimp, spiny lobster, and coral. Tiered control rules are used to set catch based on assessment type, estimation of maximum sustainable yield (MSY), characterization of uncertainty, and availability of certain data and covariates. The tiers include 1, 2, 3a, and 3b, ranging from most data-rich to least, however, they are only applied to a fraction of managed species (10 species). Tier 1 is for stocks (just three currently) with a quantitative assessment with an MSY-informed estimate of OFL and estimation of scientific uncertainty. Tier 2 is for stocks with an assessment without the estimate of MSY, and OFL estimated with some alternative methodology. Tier 3 is for stocks with no assessment, but landings data exist and the probability exceeding the OFL is approximated from the variance about the mean of recent landings to produce a buffer between the OFL and ABC. Tier 3b is for stocks with no assessment available, but landings data exist, and recent landings data may be unsustainable or unreliable.

Recently, the Council has not been using its ABC control rule as prescribed for most species, because the buffers produced between the OFL and ABC are inappropriately narrow due to uncertainty being insufficiently characterized. Instead, they are using an approach akin to Restrepo et al. (1998), with the ABC set equivalent to 75% of the yield when fishing at F_{MSY} (or its proxy). The probability of exceeding the OFL is fixed at 50%. This forces a larger buffer than the current P* approach. The Council is currently reconsidering Tier 1 of its ABC control rule and expects modifications to lead to a more robust characterization of uncertainty.

Pacific

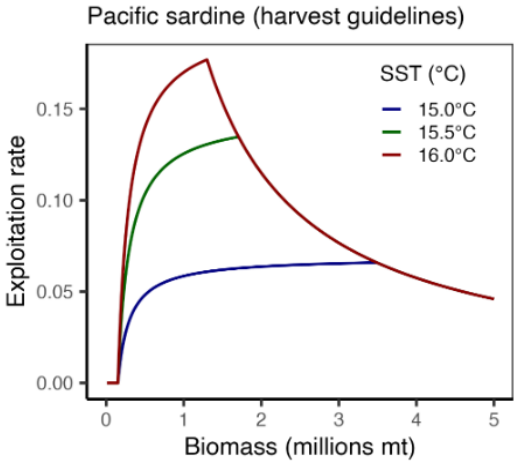
The PFMC manages over 100 stocks within five FMPs with threshold or kinked ABC control rules based on the assessment category, fishing mortality and biomass. Thus, there is heterogeneity in the functional form of the model-based harvest control rules used to manage data-rich stocks both within and across FMPs.

For groundfish species, threshold-based rules provide inherent climate resilience where thresholds and limits are based on productivity. Groundfish are managed using a threshold-based rule that reduces fishing mortality (F) below a threshold biomass level and halts fishing below a limit biomass level. These reference points are selected based on the productivity of the taxonomic group (10-40% of B_0 for groundfish, 25-50% of B_0 for flatfish). These rules provide climate resilience by hastening rebuilding after climate-driven declines in abundance.

The majority of salmon stocks are managed with a constant F rule but Klamath-River Fall Chinook salmon are managed using a highly kinked threshold-based rule and Puget Sound Coho salmon are managed using a stepped threshold-based rule. The catch advice from highly kinked control rules is highly sensitive to climate-driven fluctuations in biomass.

For coastal pelagic species, chub mackerel uses a constant F control rule, and Pacific sardine is the only stock in the Nation managed with a climate-linked control rule. It allows higher exploitation rates in years of warmer sea surface temperature and lower exploitation rates in cool years and critically depends on predictable relationships between the environment and productivity.

A key challenge to adapting harvest specifications to climate change is the declining capacity to conduct a growing number of assessments. Key successes include ongoing efforts to use risk tables to: 1) inform stock assessment prioritization, and 2) increase or decrease catch limits. The use of a "staleness" penalty to increase scientific uncertainty when using aging assessments to project future catch limits builds in some protection against uncertainty arising from climate change.



Pacific sardine is managed with a climate-linked ABC control rule.

South Atlantic

The SAFMC manages about 70 species under eight FMPs: coastal migratory pelagics, coral, dolphin-wahoo, golden crab, sargassum, shrimp, snapper-grouper, and spiny lobster. At least one stock assessment has been conducted for 22 of the 70 managed species under the jurisdiction of the Council. For most assessed stocks, ABC estimates were derived using an ABC control rule with a P* approach, though in some instances the SSC recommended a deviation from the model-based projections when substantial uncertainty in several model parameters was evident and used a 75% F_{MSY} approach for the ABC. For unassessed stocks without an overfishing limit, the SSC has used a variety of empirical or data-limited methods to derive an ABC.

The Council, with the help of their SSC, revised their ABC control rule in early 2024 for the Snapper-Grouper, Dolphin-Wahoo, and Golden Crab FMPs, but it has not been applied to any stocks yet. The stocks falling under the other FMPs still use the old ABC control rule. The new ABC control rule categorizes stocks into four tiers based on available data, if the stock is assessed, and appropriate characterization of scientific uncertainty. Current stock biomass is indicated from stock assessment output while the stock risk ratings are derived through input from the SSC, Social and Economic Panel (SEP), and Advisory Panels related to biological, social and economic, and environmental risk factors. The risk rating and relative stock biomass are then used to set an accepted probability of overfishing (P*), following the Council's risk tolerance policy.

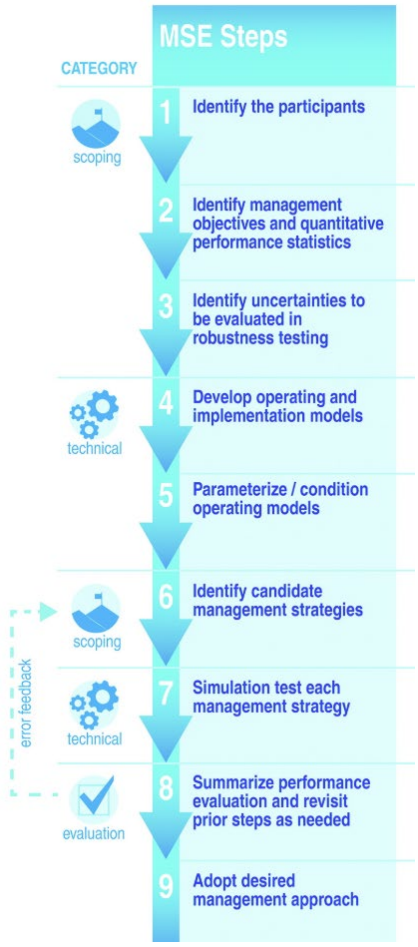
The goals with the revised control rule are to increase flexibility and adaptability in accounting for uncertainty through both the scientific and management process, to allow phase-in and carry-over provisions, and to provide a mechanism for categorizing uncertainty in data-limited and unassessed

stocks. Challenges with the new ABC control rule include whether to implement it for all stocks or only after future assessments, the SSC's review of productivity and vulnerability ratings for stocks, phase-in and carry-over elements, possible complications with climate/ecosystem change, data limitations, and other challenges, especially those related to data poor and unassessed stocks.

North Pacific

The NPFMC manages four large marine ecosystems and seven FMPs. The Council quantifies OFL and ABC for 39 stocks with model-based control rules (based on biomass and fishing mortality) and about 16 stocks with empirical approaches (e.g., biomass index, catch based). Current approaches are generally successful at avoiding overfishing, but recent marine heatwaves highlight increased risks. A major challenge is understanding how to adjust for non-stationarity in the system, including prevailing assumptions about stock dynamics and highly variable recruitment, as well as how to factor transient events like marine heat waves into models.

The Council has emphasized that annual ecosystem surveys are essential and require modernization to better track changing distributions, species composition, and environmental conditions. There is also an assumption about stationarity versus non stationarity which can strongly impact perception of stock status and rebuilding timelines. The next generation stock assessments should include vulnerabilities to overfishing, ecological pressures, and climate change.



Typical MSE stages, though MSEs are often iterative (Goethel et al. 2019).

The Council recommends that ecosystem and environmentally linked Harvest Control Rules (HCRs) have benefits and risks and should consider implications through simulation analysis (e.g., management strategy evaluation (MSE)) and explore across both life histories and variation in species-specific data quality. Ecosystem status and trends and species-specific considerations (ESPs) are used by the Council to inform risk tables, which help to articulate justification for setting the ABC lower than the maximum permissible (maxABC) in the uncommon situation where there is uncertainty not directly captured in the assessment, tier system, or harvest control rules. There is no prescribed buffer to maintain flexibility and tactical tools are needed for more timely communication of risks.

New England

The NEFMC manages 26 species as 39 stocks under seven FMPs and has established ABC control rules that are unique to each FMP. There are analytical (model-based) assessments and control rules (based on probability, tiered, or ramped) for about 44% of the stocks, but most stocks are assessed and managed with empirical approaches (based on catch, exploitation rate, or survey index) or have

unknown stock status. Climate impacts on stocks are broadly recognized in the region, but very few stocks are assessed with models that have integrated time-varying environmental covariates, resulting in uncertainty about stock biomass and fishing mortality rates. Further, performance of ABC control rules is not simulation-tested (e.g., MSE) with respect to their robustness to climate or ecosystem change.

While appropriate definitions of biological reference points are integral to the performance of stock-specific ABC control rules, just 39% of NEFMC stocks use analytical approaches in the calculation of reference points, though there are a few recent examples of revisions to recruitment assumptions. There are varied definitions of reference time periods for NEFMC stocks that apply an empirical approach, including: 1) historical period where stock was responsive to management, 2) historical period of high sustained productivity that may approximate MSY conditions, and 3) contemporary periods representative of current conditions. The use of historical reference periods assumes conditions for the stock have remained relatively static and lacks contemporary measures of stock productivity. Contemporary reference periods incorporate recent measures of stock productivity which may be appropriate but can lead to changes in stock status and increase catch advice without observable changes in indicators of stock health. Static characterizations of a stock's productivity can lead to unrealistic expectations of future productivity and thoughtful revision of recruitment assumptions is paramount. The NEFMC has highlighted the need to outline criteria for defining reference periods for analytical and empirical reference points in a dynamic environment. It has also been difficult to determine catch advice when stock status is unknown.

SCS8 Chair Lisa Kerr leads a plenary session.

Keynote: Debra Lambert, NOAA Fisheries - Guidance and Flexibility in Specifying ABC Control Rules

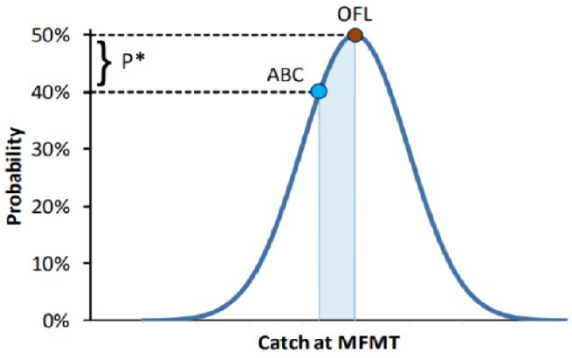
Deb Lambert, from the NOAA Fisheries Office of Sustainable Fisheries, described the National Standard 1 Guidelines for specifying ABC control rules and opportunities for flexibility. National Standard 1 (NS1) of the Magnuson-Stevens Act (MSA) requires that conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the United States fishing industry. The NS1 Guidelines provide guidance on, among other things, the specification of reference points (e.g., MSY, OY, OFL, ABC) and ABC control rules. The NS1 Guidelines require that each Fishery Management Council specify within their fishery management plans (FMP) an ABC control rule that accounts for scientific uncertainty in the OFL and for the Council's risk policy. The ABC cannot exceed the OFL. The ABC control rule should consider reducing fishing mortality as stock size declines below B_{MSY} and as scientific uncertainty increases.

Beyond these requirements, the NS1 Guidelines provide flexibility in how ABC control rules can be specified. These flexibilities include:

- A Council's risk policy could be based on an acceptable probability (at least 50%) that catch equal to the stock's ABC will not result in overfishing, but other appropriate methods can be used.
- When determining the risk policy, Councils could consider the economic, social, and ecological trade-offs between being more or less risk averse.
- The control rule may be used in a tiered approach to address different levels of scientific uncertainty.
- An SSC may recommend an ABC that differs from the result of the ABC control rule calculation, based on factors such as data uncertainty, recruitment variability, declining trends in population variables, and other factors, but must provide an explanation for the deviation.

Given the flexibilities in the NS1 Guidelines, Councils have developed a variety of ABC control rules and have used different approaches to account for uncertainty, risk, and social, economic, and ecological factors. Ms. Lambert noted that often, a Council's level of risk tolerance is based on the status of the stock or other biological factors. Even if not explicitly quantified or discussed, implicit in the level of risk tolerance are social and economic factors (e.g., a risk tolerant approach may enable increased economic return to the fishing industry).

Several Councils have developed a tiered approach to their control rules. In many cases, the most data rich tier of a control rule specifies that ABC is based on the scientific uncertainty around the OFL estimate and an acceptable probability of overfishing (P*). Deciding on the P* level is a choice made by a Council. A low P* is more risk averse than a high P*. In some cases, P* is based on a function of B/B_{MSY} (e.g., P* increases as the B/B_{MSY} ratio increases). In other cases, a risk determination table or other qualitative method is used to choose P* based on a consideration of stock status, level of information in the assessment, characterization of uncertainty in the assessment, stock productivity and susceptibility, or other factors.

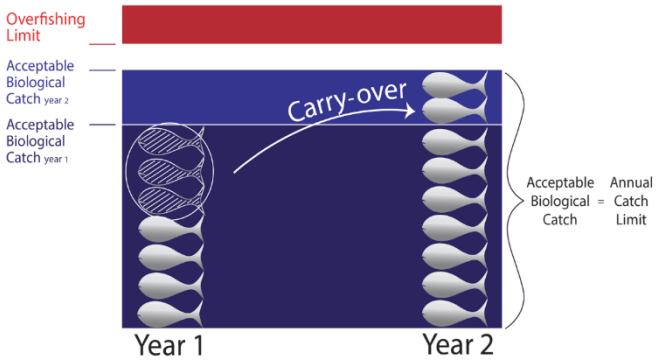


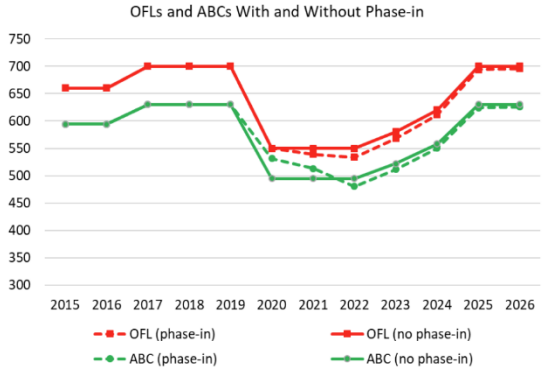
The P approach to setting ABC, where ABC is based on an acceptable probability of exceeding the OFL, i.e., of overfishing (Image courtesy of NOAA Fisheries).*

In addition to the P* method, other types of ABC control rules include: constant catch (e.g., ABC based on recent average catch), catch based method (e.g., ABC = 75% of the OFL), constant F (e.g., F_{ABC} = $75\%F_{MSY}$), or ramped F control rule (e.g., F declines as biomass declines). Regardless of which method is used to set a buffer between OFL and ABC, it includes an element of risk tolerance.

Ms. Lambert noted that the NS1 Guidelines also provide that Councils can develop ABC control rules that allow for changes in catch limits to be phased-in over time or to account for the carry-over of some of the unused portion of the ACL from one year to the next. The Council must articulate within its FMP when the phase-in and/or carry-over provisions of the control rule can and cannot be used and how each provision prevents overfishing.

Phasing in changes to catch limits can help support more stable fisheries catch advice, while carry-over provisions can help to relieve the pressure to harvest during poor fishery or market conditions. To date, phase-in and carry-over provisions have been added to the ABC controls rules for Atlantic sharks within the Atlantic Highly Migratory Species FMP, and the South Atlantic Council's Snapper-Grouper, Golden Crab, and Dolphin and Wahoo FMPs.





Hypothetical examples of how carry-over (left) and phase-in (right) provisions could be approached (Image courtesy of NOAA Fisheries).

Social and economic factors can also be considered in the specification of ACLs or total allowable catches (TAC). For example, ACL or TAC could be set lower than ABC to account for management uncertainty, needs of forage fish, market conditions or other reasons. For a specific example, Ms. Lambert noted that the NPFMC's Bering Sea/Aleutian Islands Groundfish FMP specifies an aggregate OY range for targeted stocks and stock complexes of 1.4-2.0 million mt (see 50 CFR 679(a)(1)(i)(A)). Catch limits are set as follows: the SSC recommends individual ABCs for targeted stocks and stock complexes; ACLs equal ABCs. The Council then recommends individual TACs for targeted stocks and stock complexes. The sum of the TACs may not exceed the OY cap of 2.0 million mt. Therefore, individual TACs may need to be adjusted downward to prevent exceeding the OY cap. The annual determination of TACs for each target stock and stock complex is based on a review of the biological condition of groundfish stocks and socioeconomic considerations (50 CFR 679.20(a)(2) and (3)).

In summary, Ms. Lambert highlighted that the NS1 Guidelines provide flexibility in developing ABC control rules, and provide flexibility in how uncertainty, risk, and social, economic, and ecological factors can be considered in specifications. ABC control rules account for scientific uncertainty and a Council's level of risk tolerance. Even if not explicitly quantified or discussed, implicit in the level of risk tolerance are social and economic factors. Phase-in and carry-over provisions can be developed in part to address social and economic factors. Lastly, social and economic factors can also be considered in the setting of ACLs or TACs.

Delegates build connections at lunch.

Discussions: Successes and Challenges

Workshop participants were encouraged to identify the degree to which control rule performance is evaluated and the successes and challenges SSCs face when applying ABC control rules in the context of ecosystem change. First, individuals were asked to answer the following questions, in writing, at different stations around the meeting room:

- Are your Council's control rules evaluated? If yes, briefly explain how.
- In the context of ecosystem change, what are the successes and challenges when applying ABC control rules?

In describing successes and challenges, participants were encouraged to note how: 1) information (e.g., data gaps, model limits, other tools), 2) form/type of ABC control rules (general types of control rules - threshold type rules), 3) process (e.g., Council, regulatory, planning), or 4) other aspects influenced these outcomes. Each region was assigned a specific color sticky note paper for the writing exercise, allowing for visual comparison across regions.

After time to review what others had written, participants met as region-specific delegations to address the following questions:

- What challenges are distinct to your region?
- Which challenges are exacerbated by or specific to climate/ecosystem change?
- Which challenges are the most urgent to address and how would you address them?

Following the regional discussions, participants came together in plenary to share their answers. Key points are described here.

Control Rule Evaluation

In response to if and how control rules are evaluated, only one region (CFMC) indicated that evaluation does not happen at all, and that was due to a lack of data. The other regions indicated that some level of evaluation happens, but it is occasional or ad hoc, not comprehensive, and not specifically evaluating robustness of control rules to climate change. Evaluation strategies included engaging fishermen with local knowledge, using management strategy evaluations/simulations, and retrospective analyses of management performance.

CFMC delegates discuss region-specific successes and challenges.

Successes

Regarding successfully applying ABC control rules in the context of ecosystem change, responses generally fell into the following categories:

- *Increased flexibility* – Some regions have increased flexibility and incorporated broader considerations into the process, such as moving to an ecosystem-based model and using risk-appropriate approaches (e.g., thresholds, risk tables).

- *Data enhancements* – Some regions identified the use of new data products as a success, citing ecosystem and socioeconomic profiles, ecosystem status reports, new assessment tools, and more frequent monitoring and assessments.
- *Greater coordination* – A few comments highlighted successes related to coordination and increased communication. For example, PFMC delegates noted improved coordination on U.S./Canada treaties for Pacific salmon and the Pacific whiting agreement; CFMC delegates noted the importance of work in the region to gather industry input through a structured process.
- *Improved process* – A few regions have new pathways to enable the acquisition and inclusion of new data and the use of new models. There has been increased communication and transparency, such as the presentation of *State of the Ecosystem* reports by the Northeast Fisheries Science Center (NEFSC) to the NEFMC and MAFMC, and recent inclusion of ecosystem and socioeconomic profiles (ESPs) in NEFSC research-track assessments.

Challenges

Delegates identified more challenges than successes with applying ABC control rules in the context of ecosystem change. Some focused on logistical hurdles such as lack of data and capacity while other comments suggested a need to reconsider regional and national processes for decision-making. Major categories of challenges included:

- *Pace and nature of change* – The rate of climate and ecosystem change is outpacing existing tools to measure, understand, and adapt to these changes.
- *Human resources/capacity* – More than half the regions noted that the needs for collecting data and conducting assessments are outpacing staff capacity.
- *Assessments and analyses* – Where assessments are infrequent or have substantial scientific uncertainty, Councils are forced to use lower-tiered control rules. New or improved assessment models are needed that account for changing stock dynamics. There could be more clarity of process and criteria on when climate change should be incorporated into assessment models and projections or addressed in ABC control rules. NEFMC delegates also noted a need to better coordinate with Canada on surveys, assessments, and management in the context of stocks with shifting distributions.
- *Defining reference points* – Comments on reference points centered on how to define them in the context of climate change. For example, how to characterize aspects of stock dynamics, such as recruitment, when calculating reference points (e.g., based on recent or long-term conditions) and what to do when timelines for meeting existing benchmarks are unachievable. Delegates discussed potential flexibility and constraints for developing non-stationary reference points.
- *Role of social sciences and data limitations* – Several regions flagged concerns about social, economic, and/or community data, noting a lack of data and challenges incorporating existing data. Data limitations were raised by every region, with several noting a lack of data and/or poor data quality as concerns. Other challenges included the scale of the data, uncertainty regarding interpreting the data (e.g., are data reflecting climate change impacts or something else?), the need to coordinate on transboundary issues, delays in acquisition and evaluation of data, and the role of stakeholders in gathering data.

- *Multispecies management* – Delegates from the New England and Caribbean regions identified challenges with multispecies management. The Caribbean raised issues with applying ABCs to one stock at a time when dealing with a multispecies fishery. New England's comments were focused on how to deal with choke/limiting species in a multispecies fishery and how ABC for one stock can have a rippling effect on other stocks in the fishery.

- *Management outcomes* – One commenter noted that while ACLs are intended to prevent overfishing, rapid ecosystem change can result in an overfishing determination, even when ACLs are underharvested. Other input on this topic centered around the idea of stability. One comment noted that there are different considerations in thinking through catch stability v. ABC stability. Other comments noted that volatility in ABC can lead to management and economic challenges.

Delegates find common ground across regions.

Sticky notes identifying successes (left) and challenges (right), color coded by region. Note that challenges outnumbered successes, and most regions experience both.

6. Sub-theme 1: Advances in Ecosystem Science and Assessment to Inform ABC Control Rules in a Dynamic Environment

Keynote: Dr. Jon Hare, NOAA Fisheries - Climate, Ecosystems, and Fisheries Initiative: Introduction to CEFI

Dr. Jon Hare, Science and Research Director of the Northeast Fisheries Science Center, outlined the Climate, Ecosystems, and Fisheries Initiative, a cross-NOAA effort to build a nationwide, operational ocean modeling and decision support system needed to reduce impacts, increase resilience, and help adapt to changing ocean conditions. The Initiative will provide decision-makers with the actionable information and capacity they need to prepare for and respond to changing conditions today, next year, and for decades to come. It is a timely, efficient, and effective way to address NOAA's requirements for climate-informed management of marine and Great Lakes resources.

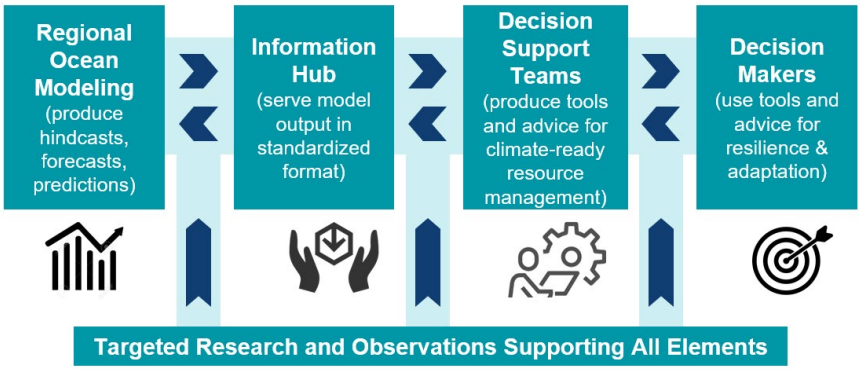
Four core requirements for climate-ready decision-making for marine resources that the Initiative aims to address are:

1. Reliable delivery of forecasts and projections of ocean and Great Lakes conditions for use in developing climate-informed advice.
2. Operational capability to assess risks, evaluate options, and provide robust advice on adapting to changing conditions.
3. Decision-maker capability to use climate-informed advice to reduce risks and increase the resilience of resources and the people that depend on them.
4. Continuous validation and innovation through observations and research.

Dr. Hare explained that the Initiative is building off the 2015 NOAA Fisheries Climate Science Strategy, which focused on building the infrastructure to measure and track change, understanding mechanisms and projecting future conditions, and informing management. Working across the NOAA line offices of the National Marine Fisheries Service (NOAA Fisheries; e.g., fisheries science and management), the National Office of Oceanic and Atmospheric Research (OAR; e.g., climate modeling capacity), and the National Ocean Service (e.g., ocean and coastal modeling, place-based management), the Initiative is leveraging existing capacity in research, modeling, and decision-making to produce an end-to-end decision-support system. Regional ocean grids are being developed by OAR, and each NOAA Fisheries

Science Center has a Regional Decision Support Team with staff across divisions to help integrate modeling products and the science support for management through existing advice pathways.

Dr. Hare explained that by working with many partners, including Council SSCs, the Initiative will provide decision makers with the information and capacity they need to help safeguard resources and resource-dependent communities in a rapidly changing world. More information may be found at: https://www.fisheries.noaa.gov/topic/climate-change/climate,-ecosystems,-and-fisheries.



The CEFI decision support system (image courtesy of NOAA).

Case Studies

Three attendees gave case study presentations under Sub-theme 1 (abstracts in Appendix C).

Case Study 1: *Sarah Gaichas* - Operationalizing the use of ecosystem information in Mid-Atlantic science and management decisions

Case Study 2: *Lisa Kerr* - Integration of climate information into stock assessment and management; Northeast Climate Integrated Modeling Initiative (NCLIM)

Case Study 3: *Jie Cao* - Spatiotemporal dynamics of reef fishes in the Atlantic Ocean of Southeastern U.S. coast

Attendees discuss case studies.

Discussions: Advancements and Tools

Attendees met in four small groups that included representatives from all the Council regions. The discussions focused on: 1) identifying advances in ecosystem science and assessments to inform ABC control rules and time varying stock dynamics; 2) which tools and reports are being used in the design of control rules and setting of catch advice; and 3) what currently unavailable products and information would be the most useful and actionable. Following the breakout discussions, the participants reconvened for a plenary discussion; the highlights are described here.

Advances in assessments, ecosystem reports, and other tools that can incorporate climate information and time varying stock dynamics

Participants noted many examples of advances in ecosystem reports, ecosystem and stock assessments, and other tools that are incorporating climate information and time varying stock dynamics, though many are only available in select regions.

Ecosystem reports

The NEFSC has produced annual *State of the Ecosystem* (SOE) reports for the New England and Mid-Atlantic regions since 2017, and the Southwest Fisheries Science Center (SWFSC) has produced *California Current Ecosystem Status* reports annually since 2016. Both are presented to SSCs and Councils regularly and feedback drives subsequent improvements. However, other Science Centers do not produce such reports regularly and/or have regular outreach to Councils (e.g., SEFSC). The SOE reports, with their continued collaborative and iterative development which elevate discussions around climate impacts and availability of data, have allowed some Councils to understand and account for extreme climate events. The CFMC delegates were hopeful to see their first ecosystem report soon.

The NPFMC benefits from ecosystems status reports (ESRs) for each major ecosystem, but the Alaska Fisheries Science Center (AFSC) has pioneered Ecosystem Socioeconomic Profiles (ESPs) at the species level to inform assessments for six key species. Other regions (e.g., NEFSC) are beginning to use ESPs as well. Some ESRs and ESPs include specific climate information to ensure the information is shared with the Council.

Assessments

The Southeast Fisheries Science Center (SEFSC) has developed EcoPATH and EcoSIM models to help evaluate trophic interactions in the Gulf. Recent NEFSC stock assessments have used ecosystem profiles, local ecological knowledge (LEK) on stock and fleet behavior, and climate – stock variable relationships to identify time-varying processes and key environmental covariates that account for variation in aspects of stock dynamics. Several other examples were shared, and efforts to standardize approaches are making it easier to incorporate data into assessments.

Other tools or information

Delegates noted growing use of LEK, management strategy evaluation, fisheries-independent monitoring, additional focus on integration of ecosystem and climate influences on stocks into stock assessment and fishery evaluation (SAFE) reports, improving risk tables, and development of fisheries ecosystem plans.

Climate-informed tools and reports available and used in the design of control rules and setting catch advice

While climate information is gradually being included in stock assessments and decision-making products, participants noted only a few instances where it has been incorporated explicitly into ABC control rules or implicitly informed their design, such as: 1) the use of temperature as a variable in the ABC control rule for Pacific sardine, developed through a MSE in 2014; and 2) an ongoing MSE of Atlantic cobia and black sea bass is examining the performance of control rules over a range of recruitment scenarios (Damiano et al. 2024). Where tools or reports are not sufficiently advanced, at minimum, discussions are occurring around these topics.

Currently unavailable products and information that would be most useful and actionable

Participants felt that having more ecosystem and climate information products consistently available across the nation is very important. One example was how SOE reports need to be developed for some regions. The CFMC delegates noted that having this sort of information would be helpful for their data-poor region where stock assessments of individual species are largely impossible. Participants noted that few assessments integrate climate impacts on stocks and there is a need to better determine and manage for these risks (e.g., improve upon risk tables).

Several priorities were identified for using climate and ecosystem science to inform control rules. The groups identified many gaps in the data available, especially social and economic data; and there is a need to operationalize data for use in decision-making.

Breakout session discussion.

Some regions have more data than others, but many are missing baseline ecosystem data. Additionally, uncertainty stemming from: 1) the lack of information on how climate change impacts different species, and 2) varying perspectives on climate impacts, creates challenges when developing control rules.

Participants identified a need for more guidance on how to incorporate climate and ecosystem data into decision-making. Several suggested a need to improve forecasts including of biomass and abundance. There is also a need to identify sources of information and expand research on the role of environmental covariates as mechanistic drivers of stock dynamics (e.g., synthesizing current work, funding experiments, hypothesis-driven monitoring with stakeholder engagement). To avoid double-counting of climate risk, SSCs need guidance from Councils to determine appropriate levels of scientific uncertainty to prevent overfishing.

Participants noted the importance of defining opportunities for on-ramping information into the scientific and management process, and how to incorporate data and information into ABC in advance (e.g., risk tolerance). Also, evaluating the effectiveness of control rules should include simulation testing and hindcasting.

7. Sub-theme 2: Application of Social Science to Achieve Management Goals under Dynamic Conditions

Round Robin Presentations

SSC delegates provided an overview of how their Council may or may not be using social and economic data to inform ABC setting and/or other aspects of management. Specifically, delegates addressed how the SSCs are using their expertise in social sciences, how the SSCs are using social and economic information, and the challenges with using social science data.

Pacific

The PFMC SSC incorporates economics and social science expertise through its Economics Subcommittee. The Subcommittee members – three economists and three biologists -- participate in the full SSC and in the other Subcommittees of the SSC. The Subcommittee meets on an ad hoc basis and is asked to review documents related to economics and meets jointly with other SSC subcommittees. In recent years, reviews have covered topics such as: 1) economic consequences of harvest specifications and alternative rebuilding trajectories, 2) 5-year reviews of the catch-share program, and 3) social/economic indicators used in the Integrated Ecosystem Assessment (IEA) report.

There is no standardized or required process for integrating economics into the SSC decision-making process, but it is done so on an ad hoc basis when information is available. The Subcommittee has reviewed economic models for expected changes in impacts to income at the port and state levels, models to compare performance under different rebuilding trajectories, the catch share five-year program review, and topics related to gear switching in the trawl fishery and how the strategy affects trawl attainment of ABC. The SSC is interested in expanding its expertise on environmental equity and justice, perhaps by recruiting a new member with such expertise, and incorporating more diverse perspectives into its reviews. A key challenge in incorporating social and economic information into the SSC process has been the difficulty of providing technical review of social science topics without getting into policy considerations that are outside the purview of the SSC.

South Atlantic

The SAFMC has a Social and Economic Sub-Panel (SEP) of the SSC, made up of nine economists and three anthropologists, with three members also serving on the SSC. The SEP meets two times annually to review social and economic information and provide recommendations to the SSC and the Council. Certain members of SEP also serve on the SSC to assist with the exchange of information.

The South Atlantic SSC is incorporating social and economic information into pre- and post-stock assessment reviews for the determination of stock risk ratings that help inform the accepted probability

of overfishing (P*). Human dimension categories in the risk rating tool include the ability to regulate the fishery, potential for discard losses, recreational desirability, NOAA Fisheries' social indicators, and annual commercial value. They use an Allocation Decision Tool, Fishery Performance reports, and Stakeholder Engagement Meeting as resources for social and economic information.

Use of this expertise could be improved, as the need for social and economic data and analyses is not well understood or communicated, leading to under-investment. Lack of critical social and economic data is a major challenge faced by the SSCs, including: demographic information about fleets and fisheries, qualitative data on the sociocultural importance of fishery resources, data to measure the distribution of monetary benefits, timely quantitative information on how fisheries are valued, information on business dynamics and the seafood supply chain, and information to characterize the private recreational sector. Additional challenges include a lack of fisheries-focused social scientists in the region, Paperwork Reduction Act (PRA) restrictions, the need for additional funding and personnel, and a lack of trust between managers and stakeholders. The SEP and SSC are interested in including other social science disciplines to expand the type of social and economic expertise available to the SSC and Council.

Caribbean

The CMFC SSC has two members with social science expertise, and the Council's Ecosystem Based Fishery Management (EBFM) Technical Advisory Panel (TAP) emphasizes the importance of social science integration into the decision-making process, working closely with the SSC. Social and economic information is sometimes used in the SSC process, but it is not systematically analyzed. The SSC is currently working in collaboration with the EBFM TAP to develop a Fishery Ecosystem Plan and Risk Assessment strategy that incorporates social science data and information. They are also working to set research priorities for the Council that consider social and economic studies and data needs, and/or gaps.

The SSC is facing challenges such as a lack of systematically collected social science data streams. There are also PRA constraints for gathering new data, as well as an inadequacy of planning and data integration at the management level. However, there are also growing opportunities to improve the use of social and economic information, such as the current EBFM efforts in the region, high engagement with the industry and their willingness to collaborate with the Council, and ongoing Strategic Planning efforts to guide improvement of data collection and management in the U.S. Caribbean. The SSC believes that to enhance their ability to use social and economic information, additional funding and personnel capacity is required, along with support to create necessary social and economic data streams, institutional transformation to integrate social and economic data into the decision-making process, and improved communication and collaboration amongst all parties.

North Pacific

There are members of the NPFMC SSC with social science, economic, and cultural anthropology expertise, and sometimes the SSC will use subgroups. There is a Social Science Planning Team comprised of Council and NMFS staff and other experts that meets a few times a year to strategize on meeting information needs. Including social science data in ESPs, SAFEs, and ACEPOs helps inform annual ACL determinations. Social science data is also in National Environmental Policy Act and Regulatory Impact

Review analyses, reviews of limited access privilege programs and allocations, Annual Economic SAFE reports for crab, groundfish, and scallops, and Annual Community Engagement and Participation Overviews (ACEPOs). Social science data are also used to identify social and economic vulnerabilities, such as distributional effects of management actions, drivers of stock dynamics, and data collection needs to support future ESPs and stock assessments. Other applications include use in risk tables.

The SSC experiences many challenges including a lack of staff time to develop predictive models, funding to support research and development, information on directly related fisheries-dependent services and industries, and key crew information beyond that reported in Economic Data Reports. NOAA's confidentiality policy and its application to cooperatives also pose a challenge as it makes the largest producers and most vulnerable communities invisible. Specific data gaps the SSC has identified are the lack of cost information about vessels and fisheries limiting the type of analyses possible, and real-time price data, which are challenging to obtain. The Council also experiences barriers to instituting durable identifiers for crew and limited NOAA Fisheries and NPFMC staff capacity to conduct ethnographic research.

New England

The NEFMC SSC has four social scientists among its members. There is no formal subcommittee, but these members meet informally prior to the SSC meetings to exchange notes on the agenda items from social science points of view. However, social science is not well used or incorporated into the discussions and decision-making processes. An example need for more data is for helping explain fishing behavior and drivers of catch levels. The Greater Atlantic region has a lot of human dimensions data available that are rarely used in assessments or scientific advisory processes (Chan et al. 2022).

SSC social scientists hosted a May 2024 workshop inviting SSC members and staff of the Council, the NEFSC/Social Science Branch, and Greater Atlantic Regional Fisheries Office to discuss the obstacles impeding the use of available data and information in the management policy-making process. Preliminary findings from the workshop were that social scientists need to get involved at the front end of the process so that appropriate data (e.g., scale, resolution, format) can be prepared and analyses completed before the decisions need to be made. Stemming from the workshop, there have been discussions about creating a formal group of social scientists from SSC, NOAA Fisheries, and Council staff as a forum for continued collaboration on improving use of social science in the Council process.

Western Pacific

The WPFMC SSC social science capacity derives from sitting members that bring expertise in anthropology, sociology, and economics. Additionally, multiple SSC members bring indigenous knowledge to SSC deliberations. This capacity is amplified through social science experts that participate in other Council advisory bodies, such as the WPFMC Social Science Planning Committee and Fishery Ecosystem Plan teams. The Planning Committee meets once or twice a year and provides advice and information on all aspects of social sciences that are relevant to Council needs, including social science planning, research, and policy development for Western Pacific fisheries. Members include Pacific Islands Fisheries Science Center (PIFSC) social scientists as well as non-NOAA social scientists, with two members overlapping with the SSC (Council staff are not members but staff the committee).

The WPFMC SSC reviews regional social science products including research from NOAA and academia and annual SAFE reports and provides critical input into the WPFMC social science research priorities. In recent years, WPFMC SSC social scientists have participated in numerous SSC working groups evaluating the science supporting regional biological opinions, bycatch mitigation strategies, and sociocultural components related to area-based management across the Pacific Islands Region. The WPFMC's use of social science research is challenged by timelines between research and management and the need to respond quickly to emerging issues. Additionally, the Pacific Islands Region consists of diverse underserved communities using a wide range of fishing practices, fishing motivations, language, and culture. It is difficult, at times, to inform management decisions with relevant aspects of culture and traditions. This high fishing community diversity, coupled with constraints associated with data collection and the high costs of travel generally results in a data limited environment for considering social science in fishery management decisions.

Gulf

There are social scientists on the Gulf Council's SSC including anthropologists, economists, and sociologists. The SSC social scientists routinely confer with each other, and other members of the SSC, on actions that involve human dimensions of fisheries. SSC members have been introduced to approaches that place fish and habitats into social, economic and biological contexts. An SSC anthropologist and economist were primarily responsible for writing the socioeconomic report of the main Southeast Data Assessment and Review (SEDAR) 87 meeting. Additionally, several SSC social scientists participated in SEDAR 87, the Gulf White, Pink and Brown Shrimp Stock Assessment, reporting on social and cultural dimensions of shrimping that could influence landings (e.g., fuel costs, rising shrimp imports, labor issues, ethnic composition of the fleet, shrimper protests). Social scientists on the Council staff routinely evaluate the impacts of programs like the Gulf Individual Fishing Quota (Red Snapper and Grouper-Tilefish) presenting the findings to the SSC. At times, the Council's social scientists act as liaisons between the SSC and the commercial fishing community to reinforce the community's perspective of stock status based on local and traditional ecological knowledge.

One barrier to using social science is the time-consuming and expensive effort required for collecting valuable social science data. Additionally, social science expertise of the SSC is underused in discussions of stock status, and in setting ABC, OFL, or other catch limits. Furthermore, fisheries management continues to prioritize biological information over social science.

Mid-Atlantic

The MAFMC SSC has four economists, who along with the rest of the SSC focus mainly on the ABC setting process. There is also an ad-hoc Economic Working Group of the SSC comprised of economists and biologists from the full SSC that focuses on economic issues and considerations. Each year, the Council's advisory panels develop Fishery Performance Reports providing the Council and SSC with a description of factors influencing fishing effort and catch within the region, and summarizing fishermen's perspectives. Ecosystem-scale fishery management objectives in the region include social and cultural aspects with reported indicators of community engagement, environmental justice status, and economic information. Collecting and incorporating social and economic data into the fishery management decision process and stabilizing yields is also part of the Council's 5-year research

priorities. The SSC has also been asked to review economic models and analyses developed explicitly to support fishery management actions.

Economists on the SSC have developed social and economic ecosystem indicators relating to fleet and community resilience, recreational angler trips, and commercial fishery resilience from diversity of revenue and abundance of shoreside support. This information has been useful in supporting the Council's ecosystem approach to fisheries management (EAFM) initiatives, developing a modeling framework and providing input on recreational management issues, and in providing economic considerations and implications on the Council's Research Set-Aside program.

Additionally, they have helped to develop priority questions to address within the Summer Flounder fishery and studied the economic trade-offs of alternative ABC Control Rules for Summer Flounder. The Economic Working Group provided guidance and input regarding economic considerations and trade-offs associated with a revised RSA program.

The primary challenge in the Mid-Atlantic is the lack of resources needed to develop the projects that would showcase the added value of these endeavors within the management process. This is primarily due to the Council's focus on tactical as opposed to strategic decision-making. However, there is increasing interest in this type of interdisciplinary work both regionally and nationally, including through ecosystem reporting, recent workshops around the social and economic aspects in stock assessments, and assessing the impact on fisheries from offshore wind development.

Case Studies

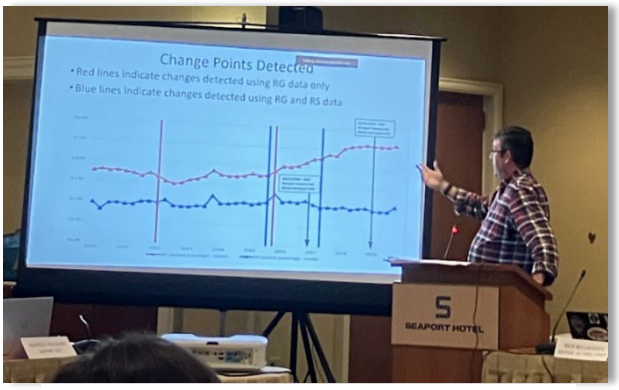
Four case studies were presented which focused on the theme of social science to achieve management goals under dynamic conditions (abstracts in Appendix C).

Case Study 4: *Justin Hospital and Craig Severance* - WPFMC's SEEM Indicators, collecting fishermen's observations

Case Study 5: *Andrew Ropicki* - Using catch shares market information to inform fisheries management

Case Study 6: *Dan Goethel* - Spasming sablefish: Unraveling the quandary of a climate boon and socioeconomic swoon

Case Study 7: *J.J. Cruz Motta and Tarsila Seara* - Using LEK to advance ecosystem approaches for fisheries management in the U.S. Caribbean



Andrew Ropicki providing a case study.

Discussions: Social Science

Attendees met in four small groups that included representatives from all Council regions to discuss how SSCs and Councils are balancing tradeoffs between resilience, precaution, and human dimension objectives in: 1) revisions to or implementation of their risk policy, 2) informing ABC control rules and catch advice, and 3) input on management other than catch setting. They also identified actionable approaches for using social science for climate-informed management where information is available. The groups identified information gaps and discussed how management might proceed without the information. Following the breakout discussions, the participants reconvened for a plenary discussion. Discussion highlights are described here.

Balancing Tradeoffs; Actionable Approaches

There is variation in the degree to which SSCs use social and economic information in recommending ABCs. For the NPFMC, only scientific uncertainty (biological) is used to define the buffer between OFL and ABC, and delegates noted constraints on considering social and economic impacts when adjusting application of ABC control rules. The Gulf Council is revising its control rules to introduce social and economic information.

Risk policies vary by Council, ranging from formulaic to qualitative with some separate from the Council's ABC control rules whereas others are integrated. The NPFMC risk policy only includes biological risk to the stock. In some regions, human dimensions and ecosystem considerations are explicitly included in risk policies. The NEFMC is currently revising its risk policy to have a more quantitative approach and to include human dimensions and ecosystem considerations .

For the NPFMC, only scientific uncertainty (biological) is used to define the buffer between OFL and ABC, and delegates noted constraints on considering social and economic impacts when adjusting application of ABC control rules. The Gulf Council is revising its control rules to introduce social and economic information.

Fundamental to the discussion in some groups was the question: to what degree does National Standard 1 (*prevent overfishing, achieve optimum yield*) take precedent over National Standard 8 (*importance of fishery resources to fishing communities, sustained participation of such communities*)? As was noted by Ms. Lambert in her keynote address, there is flexibility within NS1 Guidelines to use catch setting approaches that consider human dimensions (e.g., phase-in approaches) so long as overfishing is prevented.

Climate change, social, and economic factors can be integrated into different parts of the decision-making process. For example, in the WPFMC, social and economic considerations take place at the Council level when they discuss the importance of fisheries through their SEEM process.

Scenario planning was identified as a tool to help integrate social and economic data and consider tradeoffs as resources and management change.

When data are available, participants noted that they are not always used. There is a need to form pathways to onboard social and economic data and expertise into the decision-making process, such as through sub-committees/panels and working groups. Data confidentiality issues can limit sharing of raw data across potential partners for collaborative work. Also, decision-making processes can be slow and challenging to modify.

Information Gaps

Many data gaps were identified, and they varied by region. Examples included recreational data, profitability data, discard data, the impacts of management decisions on fishing communities, and an understanding of the full range of climate impacts on a fishery (e.g., causes of resource or fishery range expansion). Participants also noted the issue of confidentiality in smaller fisheries and challenges with using qualitative data. Some discussions focused on the need for a community index (e.g., a way to characterize the health of a fishing community and identify social and economic tipping points). One challenge with this concept, however, is that fishing communities are often dynamic for numerous reasons, making it difficult to select meaningful indicators.

Strategies to Proceed where there are Data Gaps

Participants identified ways to fill data gaps, with a focus on cooperative research, citizen science, and efforts to capture local ecological knowledge. As data are gathered, additional engagement may be needed to provide context to inform the analysis process. When these collaborations are fostered, it was suggested that people be appropriately compensated for their contributions. This effort to work together to gather and analyze data may help build community/industry trust and understanding in the fisheries management process, as well as elevate under-represented voices. Until data are available, people noted that they look to the industry and community to provide comments and testimonies through existing processes.

Left to right: Cate O'Keefe, NEFMC Executive Director; Rachel Feeney, NEFMC SCS8 Coordinator; Rick Bellavance, NEFMC Chair; Lisa Kerr, SCS8 Chair; Conor McManus, SCS8 Vice-Chair; Janet Coit, Assistant Administrator for NOAA Fisheries

8. Sub-theme 3: Adaptation of Reference Points, Control Rules, and Rebuilding Plans to a Changing Environment

Keynote: Dr. Jeremy Collie, URI - Harvest Strategies for Climate-Resilient Fisheries:

Jeremy Collie, a Professor at the University of Rhode Island and member of the NEFMC SSC, gave a presentation about harvest strategies for climate-resilient fisheries, reporting on testing the ability of harvest control rules to track and respond to climate-induced changes in the productivity of marine fish stocks. The research team focused on changes in recruitment productivity, the per-capita recruitment rate at low stock size. Recruitment rate was modeled with time-invariant and time-varying Ricker models. The time-varying recruitment model was significant for 49 of 84 stocks examined across five regions of the U.S. The incidence of time-varying recruitment rate was higher for stocks on the east coast than those on the west coast and Alaska. For stocks with time-varying productivity, the dynamic stock-recruitment model can improve recruitment forecasts for up to three years because estimates are based on the current, instead of long-term average conditions. Some stocks have significant climate covariates, which can also improve recruitment forecasts.

Dr. Collie noted that for most stocks, the mechanisms by which climate affects productivity are not yet known. Biological reference points depend on the life-history parameters of a given stock and are most sensitive to changes in the recruitment rate. He suggested that dynamic reference points could lead to time-varying harvest control rules that reflect changes in recruitment productivity. The study used stochastic dynamic programing to determine the optimal harvest policy for fish stocks with dynamic productivity and the loss in performance of applying suboptimal harvest strategies. This knowledge was then used to investigate the performance of time-varying versions of the actual harvest-control rules that are used to manage U.S. fisheries. Age-structured simulations were run to investigate the performance of time-invariant and time-varying versions of fishing morality rate and state-dependent control rules.

These simulations illustrate the classic trade-off between maximizing catch and maintaining spawning stock biomass (SSB) above target levels. Dr. Collie concluded that time-invariant harvest policies can produce roughly the same average catch as their time-varying equivalents but were unable to maintain SSB at the target level during periods of low productivity. By contrast, the time-varying policies maintained SSB near the target level by gradually adjusting fishing pressure in response to climate-driven changes in productivity.

Case Studies

The following five case studies were presented during this session which focused on the theme of adapting reference points, control rules, and rebuilding plans to a changing environment (abstracts in Appendix C).

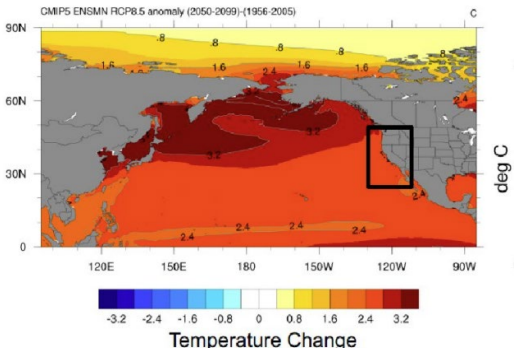
Case Study 8: *Paul Spencer* - Temperature-dependent recruitment and dynamic harvest-control rules for Bering Sea walleye pollock

Case Study 9: *Conor McManus* - Southern New England/Mid-Atlantic winter flounder reference point revisions and ABC outcomes

Case Study 10: *Desiree Tommasi* - Sardine harvest control rules under climate change (Future Seas)

Case Study 11: *Matt Damiano* - Non-stationarity in recruitment: Stock assessments in the South Atlantic Region

Case Study 12: *Cassidy Peterson* - The role of Management Strategy Evaluation (MSE) in turning climate science into climate informed management advice.



Yearly mean difference between future projection (2070-2099 average) and historical period (1976-2005 average). Source: NOAA Climate Change Portal

Discussions: Adaptations

In four diverse groups, delegates sought to: 1) identify if and how Councils have adapted reference points, control rules, and rebuilding plans to a changing environment, 2) if not, identify reasons and barriers why not, and 3) identify how Councils can improve adaptation of control rules to climate change. Participants then reconvened for a plenary discussion. Discussion highlights are described here.

If and how Councils have adapted reference points, control rules, and rebuilding plans to a changing environment

Many examples were identified, though participants cited more adaptations of reference points and rebuilding plans than to ABC control rules, including:

- Adaptations when productivity has changed over time. For example, the MAFMC shortened the time series of recruitment of Atlantic mackerel that informed assumptions of productivity in the calculation of reference points to align with prevailing conditions. Reference points that used the full time series of recruitment were no longer considered realistic, and the stock failed to meet rebuilding expectations. These same types of adjustments were made for Southern New England yellowtail flounder and winter flounder (NEMFC stocks), and for Sacramento River Fall Chinook salmon (a PFMC stock).
- Delegates from NPFMC and PFMC noted that while adaptations to reference and control rules have been limited, risk tables are

incorporating more ecosystem information. With these updates, the SSC is making recommendations that account for changing conditions.

- Adaptations when ecosystem impacts are better understood. For example, gag grouper is vulnerable to red tide events, and a 2022 assessment incorporated the impacts of four recent red tide events. In part, this triggered the Gulf Council to make the reference points more conservative through an FMP amendment.
- Adaptations by taking a multispecies approach that considers predator/prey interactions and other factors, such as information on predation informing assumptions of natural mortality in the stock assessment for Walleye pollock (NPFMC stock).

Challenges and barriers to adaptation

It can be challenging to determine causality of changes in fish population dynamics, such as whether recruitment rates are driven by an environmental factor, fishing mortality, population density or some other factor. It is also difficult to know if there is a long-term regime shift and what the implications are for the ecosystem and fishery resources. This uncertainty has limited the ability to adapt with confidence, though some regions are using models and scenario planning to consider a range of plausible outcomes to help address this challenge.

Inertia within the science and management processes can also limit change. Limited human capacity and budgets can constrain data collection, assessments, and management responses. Changes must be justified, which requires data and staff resources. There also needs to be a willingness to change. Delegates noted that making changes can result in significant social and economic impacts (e.g., impacts associated with establishing a choke species for a fishery) that should be considered.

Strategies to improve adaptation

Suggestions were made to include more opportunities for inter-regional knowledge sharing (e.g., across SSCs) regarding adaptation strategies. In addition, the group highlighted approaches such as simulation methods that would be useful for testing performance of adaptation strategies.

Establishing criteria for prioritizing adaptation responses for stocks, including identification of indicators of broad-scale ecosystem change, as well as performance indicators for single species stock assessment that reflect a need to integrate climate impacts, could help management adapt. Councils could be more forward-thinking, ensuring that flexibility is written into FMPs so that they can be nimble and responsive to change, as well as working more broadly to transition to a more flexible management process.

Breakout session discussion.

9. Actionable Outcomes

To fulfill the SCS8 objective of providing actionable guidance on how to best support Councils in the management of fisheries, the final day of the workshop was designed to synthesize takeaways and identify actionable steps that each region could take going forward.

Closing Keynote: Dr. Cate O'Keefe, NEFMC - Applying ABC Control Rules in a Changing Environment: Rules of Change

Dr. Cate O'Keefe, Executive Director of the New England Fisheries Management Council and former NEFMC SSC member, has taken a lead role in transitioning fisheries management in New England from reactionary to proactive approaches that are necessary for climate resilient fisheries.

Dr. O'Keefe gave a call to action to motivate SCS8 participants to pull together the discussions and ideas from the workshop to begin action planning, and to bring the plans developed back to their regions for continued progress towards implementing solutions.

Her presentation focused on transitioning ideas into actions, how to understand and overcome inertia by considering rules of change, and recognizing that change is challenging, but the requirement to do it is very real.

Transitioning Ideas into Action

Following the SCS7 Workshop in 2022, the Council Coordination Committee (CCC) urged the SCS to consider how outcomes from future SCS workshops could be shared with the CCC and the Councils in a manner that affects change. Dr. O'Keefe encouraged SCS8 participants to consider best practices for moving from just talking about science, a changing climate, and how to adapt, to actually adapting. She posed the questions of how can Councils pick up the recommendations that SSCs are making, and how can there be more collaborative dialogue between Councils and SSCs?

Dr. O'Keefe reiterated that the objective for this workshop was to provide actionable guidance on how to best support Councils in the management of fisheries, particularly on the use of ABC control rules, given the changing environment. She recognized that this workshop has explored both the need to adapt to environmental change and mechanisms to implement changes to management.

Dr. O'Keefe noted that adapting to change is critical for success and survival, but implementing change is challenging and is often met with resistance. In complex systems that often undergo change, such as

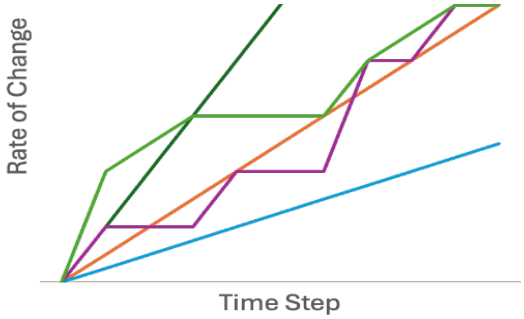
fisheries science and management, participants in the system need to be working in the same direction, even if it is not done in identical ways. The Councils all want to move in the same direction to adjust ABC control rules to adapt to climate change, but there will be regional specificity in how best to achieve that.

Rules of Change

To facilitate this directional change, a shared set of simple rules is needed to overcome inertia and inform the decisions and actions (Ropnack 2024). Dr. O'Keefe suggested that these rules of change include: setting clear goals and objectives, balancing perspectives, defining implementation strategies, maintaining momentum, and continued communications.

***Setting clear goals and objectives: Define the scope and scale*.** It is important to think about goals at multiple tiers in the management process. Dr. O'Keefe suggested that it is most effective not to think too broadly or too narrowly, understand the scope of the problem to address, and set goals and objectives to meet that.

***Balancing perspectives: Consider the range of impacts and build confidence in dynamic approaches*.** Most ABC control rules are developed assuming static conditions without consideration of disproportionate impacts across metrics or perspectives including sustainable fisheries, economic viability, scientific advancements, and legal mandates. Dr. O'Keefe recommended that balancing perspectives for desired outcomes could promote flexibility to adapt to a dynamic environment.



Recognizing change incentives and organizational capacity can help predict timing and likelihood of successful outcomes.

***Defining implementation strategies: Identify management on-ramps and revisit, revise, and reiterate*.** What is the best way to integrate scientific information into management actions? Dr. O'Keefe noted that the process of taking a technical scientific concept through all the steps in the management process can seem so daunting that trepidation hinders advancement. It is important to figure out how to integrate this information to identify management on-ramps upfront, align priorities to ensure useful products, and provide formal guidance for managers. Understanding timelines and processes are also critical for implementation.

It is impossible to meet all expectations and understand all implications of changing ABC control rules on the first attempt. She noted that it will be necessary to revisit, revise, and reiterate ideas and implementation strategies. Understanding that progress is not always linear can ensure that change continues in a positive direction while building trust and confidence in the process.

***Maintaining momentum: Need to see it all the way through*.** Maintaining momentum can be challenging. Science is always evolving, with a tendency for continuous incorporation of new developments. Management is slower-moving, with a tendency to react to past crises. Dr. O'Keefe noted that there may be learning plateaus during implementation, or other management priorities may

arise that require attention. Commitment to see the process from start to finish by minimizing deviations and avoiding distractions will help maintain momentum.

***Continued communications: Convey ideas and listen to feedback*.** Ensuring that there is a dialogue, maintaining consistent messaging, and understanding the audience are critical to success. Scientific information is complex and can be challenging to communicate to different audiences. Dr. O'Keefe emphasized that the best way to move new concepts forward is to ensure common understanding. It can be difficult to onboard new ideas in the management arena, but persistent communication after launching a change initiative maintains a sense of urgency and fosters a culture shift.

Change is challenging, but the requirement for this change is real.

Dr. O'Keefe noted that the challenges of using existing ABC Control Rules include: stationary assumptions in a changing environment, unknown or unrealistic rebuilding targets, inconsistency between reference points and projections, substantial reductions in fishing effort without progress towards rebuilding, creation of choke stocks, and analyzing potential social and economic impacts.

Dr. O'Keefe encouraged SCS8 participants to be active contributors during the action planning phase of the workshop: 1) identify actionable outcomes, 2) look for pathways for these actions to move forward, and 3) understand and set expectations for what will happen following the workshop. She concluded by emphasizing that there are no bad ideas, no idea is too small, and change is needed now.

Delegates networking at breaks.

Reflections and Recommendations

Workshop hosts synthesized the presentations and engaging conversations, identifying challenges and recommendations that emerged for each sub-theme.

Sub-theme 1: Advances in ecosystem science and assessment to inform ABC control rules in a dynamic environment

The conversations for this sub-theme centered on: 1) new information and emerging products relevant during different stages of the decision-making process, and 2) examples of operationalizing the use of ecosystem information in stock assessments and fisheries management decisions and how those examples might relate to each region.

Challenges

Challenges include that data and information products differ by region, even when there are common types of data that each region uses/needs. SSC members also noted that assessment model types differ by region and data availability, many regions have capacity limitations, and the use of data in decision-making processes is still ad hoc and evolving in some regions/circumstances. Some also questioned whether ABC control rules were the best tool for managing fisheries in a dynamic environment due to data gaps and the realities of complex, multispecies ecosystems.

Recommendations

Delegates recommended identifying partners to expand and improve data collection and quality. Recommendations were also made to integrate LEK into decision making processes and to improve forecasting abilities at fisheries and management-relevant scales. Discussions also focused on stock assessments and the need to revise reference points in a thoughtful manner, as well as the need for strategic guidance on revising risk policies and using phased-in approaches. Participants identified the importance of being able to evaluate the effectiveness of decisions and recommended looking beyond ABC control rules to other ways of managing fisheries. Working together, regions could address some capacity limitations and develop more uniform data, products, and processes.

Challenges	Recommendations
Data limitations	Basic research: funding and planning to address data limitations.
Regional differences	Consistent availability: identify differences in data and information available by region; commit to making resources available across the nation.
Stock assessment performance	Analytical advances: integrate climate impacts into stock assessments and in the definition of reference points.
Capacity limitations	Expand collaborations: Expand data collection and collaboration with partners, integrate local ecological knowledge.
Ad hoc uptake	Strategic guidance: Define opportunities and provide guidance for on-ramping ecosystem information into the decision-making process.

Sub-theme 2: Application of social science to achieve management goals under dynamic conditions

Challenges

Multiple challenges were highlighted associated with the application of social science expertise and information. Although many regions recognize the value of social science, they also acknowledge that data and expertise are limited and the roles of SSCs in using this type of data can be unclear. When data sets are available, they may be difficult to use for reasons such as a mismatch between the decision-making process and the scale or timing of the data.

Recommendations

Recommendations focused on formalizing the use of social science by SSCs, including but not limited to qualitative and quantitative information, LEK, cooperative research, public testimony, and citizen science. SSC members also recommended redirecting limited expert capacity to where it might be most impactful with specific recommendations on developing social and economic indicators to signal in situations where there is poor biological data or a delayed stock assessment. Delegates encouraged developing relationships and trust with those who may provide qualitative information for assessing fishery performance. SSC members also highlighted the need to reconsider the timing of science and management processes to better integrate social and economic information.

Challenges	Recommendations
Data Limitations	Address information gaps: identify and fill data gaps; address constraint of data confidentiality issues.
Regional differences	Engage and formalize use of social science: Respond to public testimony, foster relationships and trust; use LEK, cooperative research and industry input.
Capacity limitations	More coordination: Focus the available staff resources; define how SSCs can contribute; use cooperative research.
Ad hoc uptake	Strategic guidance: Define on-ramps for social science; consider alignment of scales of data, timing of science and decisions, and roles; adapt decision making process to incorporate social science.

Sub-theme 3: Adaptation of reference points, control rules, and rebuilding plans in a changing environment.

Challenges

Sub-theme three focused on examples of adapting reference points and control rules. Performance testing of control rules was identified as useful in some regions and lacking in others. Reference points are being adjusted but best practices and processes are still emerging in many regions. Some of the variation in regional adaptations may be driven by the fact that climate impacts are not uniform in all ecosystems and for all fisheries. Other limitations include data scarcity, incomplete understanding of when and how ecosystems change and how those changes impact stocks, uncertainty surrounding the role of SSCs in the decision-making process, and inflexible procedures that create barriers to making changes.

Recommendations

Like the previous two sections, the recommendations within this sub-theme focused on data and processes. First, regions need to understand what data are available or missing to assess changes in ecosystems and productivity. Second, regions need to identify the management constraints that limit their ability to respond to a changing system. Lastly, regions need to explore ways in which to be more flexible to increase the use of climate information. While some of these recommendations can be addressed by regions, there are opportunities to advance these recommendations at the federal level as well.

Challenges	Recommendations
Data limits	Consistent availability: funding and planning is needed to address data limitations and the need for more mechanistic studies.
Inertia in science and management process	Analytical advances: integrate climate impacts into assessment and biological reference points, adapt risk tables and policies to incorporate climate risk.
ABC control rule performance	Performance evaluation: simulation testing robustness in a changing environment with management strategy evaluation or retrospective analyses.
System rigidity	Proactive actions: need address challenges and barriers to adaptation; examine where regulatory actions are required to allow future flexibility (e.g., phase-in, carryover); build flexibility into FMPs.

Regional Action Planning

Given the very real limitations in data, capacity, understanding of ecosystem change and fish and fishery impacts, and funding, participants were challenged to consider:

- How can we do more with what we have right now?
- What action can we take in our specific regions to make progress?

Attendees worked in region-specific groups to plan how each Council delegation would bring SCS8 recommendations home to continue the dialogue and progress the recommendations. Each region identified one or more action items for addressing a key challenge specific to their regions and identified:

- Audience: Who is the audience for this action item?
- Scale: Is this at the national or regional level?
- Prioritization/timeline: What is the timeline for this, is it urgent (1-2 year), near-term (3-5 years), or strategic (5+ years)?
- Process: Does this require research, assessment improvements, management action?
- Partners: Who needs to be involved to make this happen?
- Resources needed: What is needed to implement the action item, such as funding or capacity?
- Next steps: What are the next steps your region will take?

During plenary, regions picked one action item to report on, noted here. Other ideas discussed by the small groups are also provided. This brainstorming exercise does not represent a commitment from a Council to move ahead ideas, though delegates were encouraged to bring ideas home for continued dialogue.

New England

The NEFMC delegates suggested convening a working group of managers and scientists to develop guidance for modifying reference points in response to changing climate conditions. For the NEFMC FMPs, some reference points are defined within FMPs and some can be changed through assessment updates, and the delegates noted this has created challenge due to process inconsistency. The working group could start with a focus on New England stocks and perhaps expand to coordinate with the Mid-Atlantic, as the two regions share the assessment capacity of the NEFSC. This action item would require staff to coordinate and funding to convene.

Pacific

While the PFMC delegates noted that the region benefits from quite a bit of data on stocks, assessments are infrequent (i.e., can become outdated) and mainly focused on research-track ("benchmark") assessment approaches. The SSC should help advocate for more frequent stock assessments, like the management track assessment process in the Greater Atlantic Region to increase the throughput of stock updates and be able to respond to system dynamics. This would ensure the availability of more timely data that could allow for dynamic management. There needs to be more dialogue about how stock assessment schedules are set and the capacity for scaling back some current efforts to allow more updates that require less capacity per stock.

Mid-Atlantic

The MAFMC delegates identified a need to build a conceptual model of the constraints (e.g., scientific/data, management systems, permitting, allocation, regulatory) to understand the limitations and find pathways to make changes to management in a rapid way in response to climate change. This initiative, which they identified as urgent, would require time and capacity to develop, but would not necessarily require any new data or research.

Western Pacific

The WPFMC delegates noted that setting catch limits in a manner that meets MSA requirements is a challenge for this data-poor region. This challenge could be overcome with the help of a cross-region, diverse work group to explore alternative management frameworks that may be possible within ACL requirements and existing data collection schedules/methods. There is an opportunity to collaborate with other data-poor regions to create new management actions and/or inform future MSA reauthorizations. This effort would require funding for convening and coordinating and for supporting research on potential alternate approaches.

Caribbean

The CFMC delegates support leveraging an existing SEFSC work group to consider how assessments in this data-poor region can improve with integration of social and economic data, fishery characteristics and LEK. The group could address a critical deficiency: the lack of fishery effort data and explore alternative management pathways in addition to ABC control rules. The group should partner with Western Pacific colleagues to address common issues with data deficiencies.

Gulf

The Gulf Council delegates identified expanding the application of the Council's Fishermen Feedback Tool used to gather social and economic data and information about the fisheries to be more real-time. This would involve the Gulf states resource management agencies, Gulf States Marine Fisheries Commission, academic partners, fishing clubs, and the public. Staff capacity and Paperwork Reduction Act issues may be limiting factors for implementation.

North Pacific

The NPFMC delegates identified expanding on the SSC's role of recommending best available science to the Council by identifying and implementing the appropriate vehicle to provide social, economic, and community information at the appropriate level, aggregation, and in an easily digestible way for the Council at time of TAC setting. Delegates recommend starting with identifying the universe of disparate products where this information is housed, then strategizing on how to more effectively deliver the information.

South Atlantic

The SAFMC delegates developed three action items to explore. First, investigate the use of dynamic harvest controls and dynamic reference points as they relate to rebuilding plans to increase flexibility, adaptability and inclusion of social economic factors. This would involve the SEFSC, SSC, Council, and possibly academic researchers. The process could include investigating potential resources and inviting presenters from other regions to provide examples.

Second, explore tradeoffs between timeliness and complexity in stock assessment models for providing management advice, especially in the face of climate/environmental changes creating additional complexity, which may result in longer periods between management advice. This would involve the SEFSC, SSC, Council, and SEDAR steering committee, and will involve revamping the SEDAR process and identifying key stocks along with exploring alternate analytical methods to provide more timely management advice, especially for data-limited and unassessed stocks.

Third, evaluate the climate-driven changes in species distributions in the South Atlantic as some centers of biomass for species have changed significantly over the last decade, and it is unclear whether this is due to spatial changes in productivity or actual shifts in distribution. This would involve academic researchers, the SEFSC, and SSC and would require funding for additional research projects, incorporation of existing initiatives (such as CEFI), and integration into future stock assessment projects.

Discussing next steps for the SAFMC region.

Other Ideas

In addition to the action items presented during plenary, the region-specific discussions identified other ideas to explore. Several are listed here, noting that some are underway already in certain regions:

Planning and Communication

- Identify stock-specific target frequencies for benchmark-type assessments and establish a process for incorporating them into planning.
- For adjacent regions managing the same species, improve coordination to enhance efficiency.
- Revise FMPs to enable future flexibility with ABC control rules (e.g., allow phase-in approaches).
- Increase collaboration and communication between the SSCs and Science Centers through a structured and facilitated approach.
- Explore how artificial intelligence can help increase the throughput of data analysis.
- Convene a work group of the SSC, the Social Sciences Branch at the NMFS Science Center and Council staff to focus on social science, including incorporating social science more explicitly into the management process, addressing opportunities and needs regarding new species, having social science inform climate-ready fisheries, and identifying how SSCs should use social science.

Projects and Products

- Conduct a management strategy evaluation (including goals, objectives, and a conceptual model) of a management system with time-varying reference points.
- Address data gaps including fishing effort, changes in spatial and temporal trends, local ecological knowledge, social and economic data, and data for recreational and subsistence fishing effort.
- Identify through analysis, where the assessment of fish assemblages may be more appropriate than single-species stock assessments.
- Complete the development risk tables and operationalize them.

Next Steps

For nearly all the action items, regions identified a need to broaden the conversation to include others such as Council staff, SSCs, Science Centers, and/or others. In some cases, the next steps were to build support and secure resources for specific actions, while in others, the actions require additional consideration to determine the appropriate direction. Many delegates were interested in staying engaged with workshop participants to continue learning from each other.

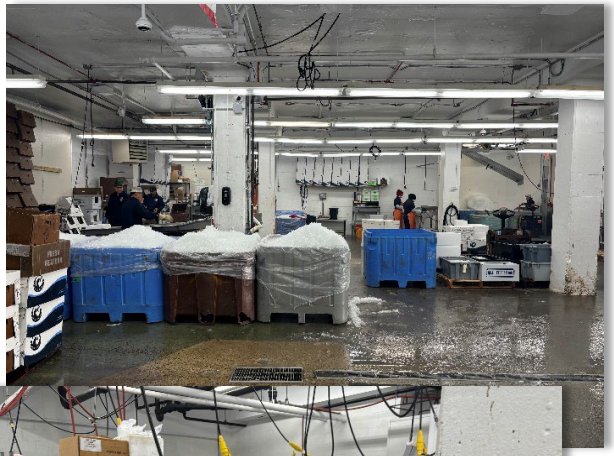
Staff coordinators of the Councils' SSCs.

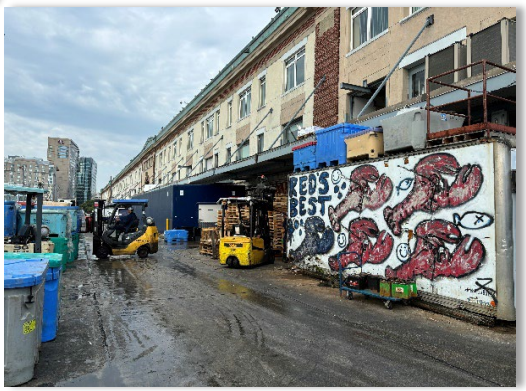
10. Field Trip: Red's Best

Workshop participants took a field trip to a local seafood dealer, Red's Best, located on the historic Boston Fish Pier a short walk from the SCS8 venue. Founded in 2008, Red's Best (www.redsbest.com) aggregates catch from small boats and uses innovative technology to track and market seafood. Their processes provide a way to maintain an unbroken chain of custody and connect consumers directly to those who harvested the seafood.

The founder, Jared Auerbach, gave a tour of the Boston facility, highlighting the staff, technologies, and processes behind the company's success. A fisherman himself, Jared shared some of the challenges he and the fishing community face, helping to contextualize many of the conversations taking place during the workshop.

The Boston Fish Pier was established in 1910 and remains the central site for the fishing industry in the city. In 2017, the Boston Fish Pier was added to the National Register of Historic Places.





Appendix A. Agenda

Sunday, August 25: *5:00 – 7:00 p.m. Meet and greet at the Seaport Hotel to pick up registration materials.*

Monday, August 26			
Time	**Title**	**Presenter**	
8:30 – 9:00	**Arrival and coffee**		
	Welcome	Lisa Kerr & Rick Bellavance	NEFMC
	Opening remarks	Janet Coit	NMFS/HQ
9:30 – 12:35: Context Setting: Current approaches to defining ABC control rules and challenges in their application			
	Round Robin: Overview of the Councils' current ABC control rules	SSC	All Councils
	Keynote: *Guidance and flexibility in specifying ABC control rules*	Debra Lambert	NMFS/HQ
	Facilitated discussion and plenary		
12:35 – 1:35	**Lunch**		
1:35 – 5:00: Sub-theme 1: Advances in ecosystem science and assessment to inform ABC control rules in a dynamic environment			
	Keynote: *Climate, Ecosystems, and Fisheries Initiative CEFI*	Jon Hare	NMFS/NEFSC
	Case Study 1: *Operationalizing the use of ecosystem information in Mid-Atlantic science and management decisions*	Sarah Gaichas	MAFMC SSC
	Case Study 2: *Integration of climate information into stock assessment and management; Northeast Climate Integrated Modeling Initiative (NCLIM)*	Lisa Kerr	NEFMC SSC
	Case Study 3: *Spatiotemporal dynamics of reef fishes in the Atlantic Ocean of Southeastern U.S. coast*	Jie Cao	SAFMC SSC
	Breakout group discussions and plenary		
5:30 - 7:00	**Networking at Legal Seafoods Harborside**		

Tuesday, August 27			
Time	**Title**	**Presenter**	
8:00 - 8:40	**Welcome**	Lisa Kerr	NEFMC & UHI
8:45 – 12:00: Sub-theme 2: Application of social science to achieve management goals under dynamic conditions			
	Round Robin: Review of how Councils are using social and economic data/indicators	SSC	All Councils

	Case Study 4: *WPFMC's SEEM Indicators, collecting fishermen's observations*	Justin Hospital & Craig Severance	WPFMC SSC
	Case Study 5: *Using catch shares market information to inform fisheries management*	Andrew Ropicki	Gulf region, on SAFMC SSC
	Case Study 6: *Spasming sablefish: Unraveling the quandary of a climate boon and socioeconomic swoon*	Dan Goethel	NMFS/AFSC
	Case Study 7: *Using LEK to advance ecosystem approaches for fisheries management in the U.S. Caribbean*	J.J. Cruz Motta & Tarsila Seara	CFMC SSC
	Breakout group discussion and plenary/report-out		
12:00 – 1:00	**Lunch**		
1:00 – 5:00: Sub-theme 3: Adaptation of reference points, control rules, and rebuilding plans to a changing environment			
	Keynote: *Harvest strategies for climate-resilient fisheries*	Jeremy Collie	NEFMC SSC
	Case Study 8: *Temperature-dependent recruitment and dynamic harvest-control rules for Bering Sea walleye pollock*	Paul Spencer	NMFS/AFSC
	Case Study 9: *Southern New England/Mid-Atlantic winter flounder reference point revisions and ABC outcomes*	Conor McManus	NEFMC SSC
	Case Study 10: *Sardine harvest control rules under climate change (Future Seas)*	Desiree Tommasi	NMFS/ SWFSC
	Case Study 11: *Non-stationarity in recruitment: Stock assessments in the South Atlantic region*	Matt Damiano	NMFS/ SEFSC
	Case Study 12: *The role of Management Strategy Evaluation (MSE) in turning climate science into climate informed management advice*	Cassidy Peterson	NMFS/ SEFSC
	Breakout group discussion and plenary/report-out		

Wednesday, August 28			
Time	**Title**	**Presenter**	
7:15 – 8:30	**Tour of Red's Best at Fish Pier**	Jared Auerbach	Red's Best
8:30 – 12:00	**Welcome and overview of Day 3**	Lisa Kerr	NEFMC SSC
	Closing Keynote: *Applying ABC control rules in a changing environment: rules of change*	Cate O'Keefe	NEFMC
	Synthesis and Actionable Outcomes: *Identifying actionable outcomes and next steps*		
	Wrap-up: *Expectations after the meeting and follow up work*		
12:00	**Close meeting**		

Appendix B. Bios of Hosts and Keynote Speakers

Hosts

Dr. Lisa Kerr is an Associate Professor of Fisheries Science at the University of Maine. She leads research that informs sustainable management of fisheries and ecosystems. Currently, her research involves integrating climate information into fishery stock assessment and management to support the climate resilience of fisheries and ecosystems. Lisa has expertise in structural analysis of fish hard parts, and the application of chemical methods to these structures, and she uses mathematical modeling to understand how biocomplexity within fish stocks impacts their response to natural climatic oscillations, climate change, fishing, and management measures.

Rick Bellavance has been a member of the New England Council since 2016, and Vice Chair since 2021. He currently serves as Council Chair and Chair of the Groundfish Committee. He is the owner/operator of Priority Charters, LLC, a charter fishing business located in Point Judith, and he also serves as President of the Rhode Island Party and Charter Boat Association. Rick has been involved in a variety of recreational and commercial fishing industries over the course of three decades. He has represented the recreational for-hire fishing industry on state, regional, and federal panels, committees, and commissions. He has helped to develop electronic reporting tools that can improve recreational catch estimates and has strongly supported improvements to the Marine Recreational Information Program. Rick represents the New England Council on the NOAA Fisheries Highly Migratory Species Advisory Panel, and the International Commission for the Conservation of Atlantic Tunas (ICCAT) Advisory Committee to the U.S. Section of ICCAT.

Keynote Speakers

Janet Coit is the Assistant Administrator for NOAA Fisheries. Since her appointment in June 2021, Janet has been leading the agency to ensure the sustainability of fisheries in a changing environment, partly by modernizing its survey and assessment capacities and overseeing the national implementation of programs to support climate-informed management. She has engaged with partners and stakeholders to address challenges related to predicting and preparing for the impacts of climate change from the Aleutian and Pacific Islands to New England, Puerto Rico, the Gulf, and beyond. Previously Janet directed the Rhode Island Department of Environmental Management for more than a decade. She also served as state director for the Nature Conservancy of Rhode Island, worked for three U.S. Senators from New England, and was counsel to the U.S. Senate Committee on the Environment and Public Works, where she advised on national and environmental policy. Janet is a magna cum laude graduate of Dartmouth College and holds a law degree from Standford Law School.

Debra Lambert is a Fishery Policy Analyst at NOAA Fisheries Office of Sustainable Fisheries, based at NOAA Headquarters, where she applies principles of fisheries science to develop policies that promote the conservation and management of U.S. marine fisheries. Deb has worked for NOAA Fisheries since 2006 and co-led the last two revisions of the National Standard 1 Guidelines. Deb earned an M.S. in Marine Science from William and Mary, and a B.S. in Biology from the University of New Hampshire.

Dr. Jon Hare is the Science and Research Director of the Northeast Fisheries Science Center in Woods Hole, Massachusetts and has been in that role since 2016. Jon is a fisheries oceanographer, and his research has focused on understanding the interactions between the ocean environment and fisheries populations. Specifically, he studies the effect of climate change on fish and invertebrate population dynamics. Jon has been a key leader at the Center in integrating ecosystem and fisheries science. Jon serves on the East Coast Climate Coordination Group, which coordinates leadership across NOAA Fisheries, the Councils, and the Atlantic States Marine Fisheries Commission. Nationally, Jon has been a key partner on projects such as the Climate, Ecosystem, and Fisheries Initiative. Previously Jon served as Oceanography Branch Chief in 2008, and Lab Director in 2012 at the NOAA Narragansett Laboratory. Jon earned his Ph.D. in Oceanography from SUNY Stony Brook and his B.A. in Biology from Wesleyan University.

Dr. Jeremy Collie is a Professor at the University of Rhode Island, Graduate School of Oceanography, and has been a member of the New England Council SSC since 2013. Jeremy is a quantitative marine ecologist focusing on population models to determine reference points for sustainable fisheries targets. He has developed adaptive management strategies for Pacific Salmon, where harvest policy is modified in response to climate-driven changes in productivity. He has also used the GSO Fish Trawl data to document long-term shifts in the fish community of Narragansett Bay. In addition to serving on the NEFMC SSC, Jeremy is also a member of the Rhode Island Ocean Special Area Management Plan, Habitat Advisory Board, and the ICES Working Group on Ecosystem Effects of Fishing Activities. He earned his Ph.D. in Biological Oceanography from the MIT/Woods Hole Oceanographic Institution Joint Program, and a B.S. in Biology from the University of York.

Dr. Cate O'Keefe has been the Executive Director of the New England Fishery Management Council since 2023, and she previously served on the SSC. Since becoming Executive Director, she has taken a lead role in transitioning fisheries management in our region from reactionary to proactive approaches that are necessary for climate-resilient fisheries. Cate is an experienced fisheries scientist, with a demonstrated history of working directly with the fishing industry and is skilled in policy development and fisheries management. Previously she worked as a marine science and policy analyst in the Massachusetts Division of Marine Fisheries. Cate earned her Ph.D. in Fisheries from UMass Dartmouth's School for Marine Science Technology, her master's degree in Fisheries from Boston University, and a bachelors degree in Biology and Fisheries from Hampshire College.

Appendix C. Case Study Abstracts

Case Study 1: Operationalizing the use of ecosystem information in Mid-Atlantic science and management decisions

SARAH GAICHAS, GERET DEPIPER, BRANDON MUFFLEY

Operational is defined as "in use or ready for use." The MAFMC uses ecosystem information operationally in stock assessments, acceptable biological catch specification, and its Ecosystem Approach to Fishery Management (EAFM) process. Ecosystem information has informed stock assessment model assumptions for multiple Mid-Atlantic stocks, and winter bottom temperature is used as a recruitment covariate in the operational Black Sea Bass assessment. Data quality, model performance, and ecosystem information is used in the SSC's determination of scientific uncertainty in the overfishing limit from all assessments, which is used to specify acceptable biological catch for every assessed stock. The MAFMC developed its EAFM process to integrate ecosystem information into its current management system. The full process has been used to evaluate risk from multiple sources using ecosystem indicators, then to integrate these risks into a management strategy evaluation for Summer Flounder, focused on addressing recreational discards. This process resulted in the operational use of a multispecies recreational demand model to set fishery specifications. After the initial cycle, the risk assessment was evaluated and updated to promote further operational use. Council and Advisory Panel members recommended new elements addressing human dimensions (recreational access equity), cross-sectoral impacts (ecological offshore wind development impacts as well as fishery access and scientific impacts), and transitions from static to time series ecosystem indicators (prey availability, predation pressure, and fishing community vulnerability). Targeted ecosystem research developed new indicators, and collaborative refinement of indicators and risk thresholds with MAFMC continues to bring new components of the risk assessment into operational use. Ecosystem reporting has evolved to directly address management objectives and risks. Collaborative development of risk assessment frameworks considering ecosystem information is happening in multiple U.S. regions, providing a broad set of options for current and future operational use.

Case Study 2: Integration of climate information into stock assessment and management; Northeast Climate Integrated Modeling Initiative (NCLIM)

LISA KERR, JAMIE BEHAN, ANNA BIRCHENBACH, JEEWANTHA BANDARA, STEVEN CADRIN, MATT CULTER, ENRIQUE CURCHITCHER, JON DEROBA, GAVIN FAY, AMANDA HART, ALEX HANSELL, JERELLE JESSE, JESSICA KITTEL, SCOTT LARGE, CHENGXUE LI, EMILY LILJESTRAND, MIN-YANG LEE, KATHY MILLS, TIM MILLER, VINCE SABA, ABBY TYRELL, JOHN WIEDENMANN

The Northeast U.S. shelf ecosystem is a complex and changing region that supports a wide array of living marine resources and resource-dependent human communities. Over the last 40 years, the waters of the northwest Atlantic have warmed at a rate over three times the

global average, and recent decadal warming is among the fastest in the world. This warming has led to geographic shifts in commercial species and declines in economically and culturally important stocks. Due to the rapid pace of change in the region, there is a critical need to develop and apply scientific knowledge and tools that can help integrate climate change impacts into the fisheries decision making. The work of the NCLIM team has focused on: 1) developing a community of practice in the region that integrates broad interdisciplinary and regional perspectives on climate-fisheries, 2) building a flexible integrated modeling framework for simulation testing climate informed fisheries decision making in the Northeast U.S., and 3) delivering candidate climate-informed assessment models to the research track stock assessment processes. We have made progress on developing a modeling framework that allows us to test the impact of changing climate and ocean conditions on fishery resources and the people, businesses, and communities that depend on them. We have also contributed to climate-integrated assessment modeling in the context of the research track stock assessment process. The project team has developed climate-integrated assessment models for species that have demonstrated shifts in distribution and changes in productivity, including American plaice, Atlantic cod, black sea bass, and yellowtail flounder. This work has improved stock assessment performance in the context of climate change and promoted management strategies that support climate resilience and adaptation of Northeast U.S. marine fisheries and fishing communities.

Case Study 3: *Spatiotemporal dynamics of reef fishes in the Atlantic Ocean of Southeastern U.S. coast*

Jie Cao, J. Kevin Craig, Matthew D. Damiano

Understanding the spatiotemporal dynamics of fish species is a central concern in fish ecology and crucial for guiding management and conservation efforts. We constructed a joint species distribution model (JSDM) to simultaneously estimate the spatiotemporal distributions and densities for 21 reef fish species in the southeastern United States. The model separately estimates encounter probability and positive density, and accounts for unobserved spatial and spatiotemporal variation using latent factors, where the correlations among species are induced. We applied the model to video data collected from a large-scale, fishery independent survey. A clustering method was applied to the results of the JSDM to group species based on spatial and spatiotemporal synchrony in encounter probability and positive density. We found strong spatial associations among most of the reef fish species. However, species did exhibit differences in occupied habitat that varied with latitude and/or depth. Within their area of occupied habitat, almost all the species share similar spatial pattern of average density. However, for some species annual distributions were less correlated with their expected average distributions perhaps due to differing responses to underlying spatiotemporal drivers. Some species show significant declines in abundance, e.g., black sea bass, red porgy, blueline tilefish, while a small number of species showed evidence of shifts in distribution, e.g., black sea bass. The findings suggest that spatiotemporal management strategies may be of limited use for reducing bycatch in these highly mixed reef fisheries due to high spatial correlations in occupied habitat

and spatial patterns in density. Species-specific responses to environmental change may also influence the spatiotemporal structure of reef assemblages. This work suggests management attention is needed for some of the lesser-known species as they are showing declining trends in abundance.

Case Study 4: *WPFMC's SEEM Indicators, collecting fishermen's observations*

Craig Severance

In 2019, representatives from the WPFMC SSC, WPFMC Social Science Planning Committee (SSPC), and Pacific Islands Regional Office developed a structure and process for considering social, economic, ecological, and management uncertainty information in setting of annual catch limits (SEEM*). SEEM* is proposed to be independent of P* as an additional consideration when setting the final ACL and offers guidance for when an Annual Catch Target (ACT) may be appropriate. In general, the social, economic, and ecological (S/E/E) dimensions determine if the ACL should be set below the ABC, while the management dimension (M*) determines if an ACT should be established below the ACL. SEEM* Working Groups include "expert" panels of experienced fishermen and social scientists (Council SSC and SSPC) to discuss and score dimensions.

Beginning in 2020, a WPFMC fisher observations process was initiated by the fishing community as a systematic collection of "on water" observations to promote ecosystem science and attempt to improve local and indigenous knowledge in management decisions. These observations are collected via quarterly Advisory Panel meetings and during an annual summit. Pacific Islands Fisheries Science Center (PIFSC) staff process these observations in a SEEM* framework, publish as PIFSC Data Reports, and develop narrative summaries that are included in annual SAFE Reports.

The WPFMC SEEM* demonstrates a precautionary approach to setting ACLs (and use of ACTs, where feasible) with buy-in from the fishing community. Given increasing uncertainties, the SEEM* process may need to become more rigorous and systematic, especially for the *Ecological* dimension which has often been the least considered due to lack of information and understanding. The WPFMC SSPC and SSC are scheduled to conduct a review of the SEEM* process during 2025 to explore opportunities for improvement.

Case Study 5: *Using catch shares market information to inform fisheries management*

Andrew Ropicki, Jordan Moor, Adams Ceballos

Fishing quota price information can provide fishery managers with information on the changing status of fish stocks more quickly than other forms of analysis. Assuming competitive equilibrium, the lease price of a quota unit in a catch shares managed fishery should equal the ex-vessel price of the fish less the marginal cost of catching the fish. By monitoring quota lease prices and ex-vessel prices, fishery managers can potentially detect changes in fish stocks using quota and fish market data. In this analysis, we examine trends in the relationship between quota lease prices and ex-vessel prices in the Gulf Grouper-Tilefish and Red Snapper IFQ Programs. We employ a change point detection technique to see if changes in price

relationships could have alerted fishery managers to red grouper stock issues in 2015 prior to a quota increase in 2016 that was reversed in 2019. The research evaluates the potential of using the quota lease price to ex-vessel price ratio as a stock health indicator for multispecies catch shares managed fisheries.

Case Study 6: *Spasming sablefish: Unraveling the quandary of a climate boon and socioeconomic swoon*

Daniel Goethel, Chris Lunsford, Dana Hanselman, Kalei Shotwell, Sara Cleaver

Climate change has led to perturbations of the marine environment (e.g., more frequent marine heatwaves in Alaska) causing species redistribution and fluctuating demographics. Sablefish (*Anoplopoma fimbria*) are unique in Alaska because productivity has increased and historical population centers have been reestablished concomitant with rapid alterations to the marine ecosystem. Although sablefish are emerging as a climate 'winner', increasing biomass has led to inversely proportional responses in socioeconomics. Rapid increases in catch quotas have led to saturated markets, reductions in prices, and intensified price gradients among size classes, which has made abundant small fish nearly worthless. The recent development of ESPs has helped increase awareness of the issues facing the fishery. Similarly, the implementation of risk tables as a pathway to adjust ABCs to account for uncertainty helped to initially avoid rapid quota increases but does not allow for socioeconomic considerations. Therefore, to address stakeholder concerns regarding reduced product value, the NPFMC is analyzing the potential impacts of removing the full retention requirement for sablefish to allow discarding of low value, small fish. Furthermore, stakeholder engagement through the ongoing development of a management strategy evaluation research tool for sablefish has identified several potential refinements to harvest control rules that are also of interest to fishermen (e.g., catch stability constraints, inventory management strategies, and alternative calculations of spawning stock biomass to reduce the influence of young fish). We discuss how a changing climate has impacted sablefish fisheries and the types of alternate management options and harvest strategies that have and could be explored to help avoid market saturation, decrease interannual variability in quotas, and ensure age structure diversity for this long-lived species. Ensuring future sustainability of the sablefish resource and fishery will require increased collection of spatiotemporal data related to ecosystem and socioeconomic drivers.

Case Study 7: *Using LEK to advance ecosystem approaches for fisheries management in the U.S. Caribbean*

Tarsila Seara, JJ Cruz-Motta

Fisheries management agencies in the U.S. Caribbean are currently taking steps into transitioning from a single species approach to one that includes Ecosystem Based Fisheries Management (EBFM) considerations. These efforts have created opportunities to explore the use of local ecological knowledge to inform the decision-making process. This presentation shows select results of a study funded by the Lenfest Ocean Program (PIs Cruz-Motta, Williams, and Seara) that use qualitative and quantitative approaches to guide the

development of a Fishery Ecosystem Plan (FEP) for the U.S. Caribbean region. Here, we specifically present results of the development of stakeholder-driven conceptual models with different groups in Puerto Rico and the U.S. Virgin Islands, as well as preliminary results of quantitative analyses using fisheries dependent data that provides support for using LEK in the management process, especially under limited data conditions. Conceptual model data was collected during 29 separate workshops with seven different stakeholder groups involving 236 participants representing Commercial Fishers, Managers, Academics, Local Businesses, Environmental NGOs, and the CFMC District Advisory Panels (DAPs) and SSC. Data was analyzed using social network analyses methods. Landings data for the quantitative analyses was extracted from NMFS databases and analyzed using multivariate analyses that preserved the multispecific nature of the data. Findings of this study support the use of LEK to guide decision-making – as exemplified using conceptual model data in the development of the FEP, aid prioritization of data collection, and increase collaboration and cooperation among stakeholders in the context of fisheries management.

Case Study 8: *Temperature-dependent recruitment and dynamic harvest-control rules for Bering Sea walleye pollock*

PAUL D. SPENCER, JAMES N. IANELLI, ALBERT J. HERMANN, KIRSTIN K. HOLSMAN, JEREMY COLLIE, RICH BELL, COILIN MINTO, RACHEL MARSHALL

Anthropogenic changes in environmental conditions (i.e., warming) resulting from climate change have motivated climate-enhanced versions of population models that comprise, for example, an important component of the Alaska Climate Integrated Modeling Project (ACLIM) and other research efforts. For eastern Bering Sea walleye pollock (*Gadus chalcogrammus*), summer sea surface temperatures appear to reduce pre-recruit survival due to lower planktonic prey abundance. We model this with a climate-enhanced stock-recruitment function. Bayesian posterior distributions of key model parameters, and AIC model selection criteria, indicated support for the climate-enhanced stock recruitment relationship. The climate-enhanced recruitment does not strongly affect estimates of historical recruitment (due to the large amount of age and size composition data) but does affect estimation of fishing and biomass reference points, affecting the interpretation of the intended harvest control rules (HCRs). The current control rule would close directed fishing when the stock is at 50% of B_{MSY}. As temperatures rise, stock productivity and recommended fishing rates decrease. We used temperature projections from a dynamically downscaled climate model to evaluate options for both static and dynamic HCRs. The climate-enhanced HCRs maintained the stock at higher biomass and lower F rates but produced similar yields as the non-climate-enhanced HCRs. These also had lower annual variability in F_{abc} rates due to fewer fishery closures. While fishing rate reference points will naturally vary with new data (especially with time-varying parameters), declines in productivity driven by environmental changes may not be fully recognized without time-varying stock-recruitment estimation procedures. For walleye pollock, dynamic HCRs could help align management targets with productivity changes.

Case Study 9: Southern New England/Mid-Atlantic winter flounder reference point revisions and ABC outcomes

M. Conor McManus, Anthony Wood

The Southern New England/Mid-Atlantic (SNE/MA) winter flounder stock has historically supported significant commercial and recreational fisheries. However, the stock has declined substantially since the mid-1980s due to fishing mortality. Despite reducing harvest through management actions, changes in climate have prevented the stock from recovering to historic levels. Specifically, warmer winters have been hypothesized to impact early life survival through increased temporal overlap with predators, and thus reduce stock productivity. Population models with environmentally-explicit stock-recruit relationships suggest that rebuilding the stock to historic levels is unlikely. Based on this field of research, the most recent stock assessment used a contemporary stanza of recruitment for short term projections, and estimated SSB_{MSY} from long term projections. This change aimed to use more realistic recruitment levels under current environmental conditions for stock projections. Doing so led to revising reference points and projections, which determined that the stock is no longer overfished, overfishing is not occurring, and the stock is considered rebuilt. Under NEFMC Groundfish Control Rules, these status determination changes corresponded with setting the ABC as the catch associated with $75\%F_{MSY}$. Consequently, this catch advice equated to four times the current catch, despite our perspective of the stock's current condition compared to historical estimates unchanged. The NEFMC SSC struggled with providing catch advice in accordance with the control rules; the assessment science has improved to account for a changing climate and the stock's productivity, but subsequent catch advice per current control rules suggested fishing harder on a resource that is at or near all-time low levels. After thorough deliberations, the SSC recommended to the Council to deviate from the control rule, and recommend a constant ABC associated with $50\%F_{MSY}$. This case study highlights challenges that can be faced when operationalizing 'climate-ready' assessment techniques for setting catch advice.

Case Study 10: Sardine harvest control rules under climate change (Future Seas)

Desiree Tommasi, Robert Wildermuth

In the California Current Large Marine Ecosystem (CCLME), Pacific sardine (*Sardinops sagax*) is a key trophic link between the planktonic food web and a host of top and mid trophic-level predators. They also support commercially important fisheries. Their biomass dynamics are characterized by boom and bust cycles driven by environmental variability. Future Seas, a multidisciplinary project that aims to quantify climate impacts on CCLME species and fisheries, showed that future sardine productivity will be impacted by climate change. To be able to sustain their mandate of maintaining a resilient ecosystem and fishing economy under future climate change, fisheries managers require a climate-informed, decision-support tool to evaluate performance of current and alternative harvest control rules for sardine under these projected climate impacts. Here, we present results of a MSE conducted as part of the Future Seas Project to assess the robustness of current and alternative HCRs for the northern subpopulation of Pacific sardine under a variety of recruitment scenarios representing potential projections of future

climate conditions in the CCLME. The current environmentally informed sardine HCR modifies the harvest rate for the northern Pacific sardine subpopulation based on average sea surface temperatures. The MSE tested seven different HCRs in addition to the current rule, including those with dynamic biomass reference points and an empirical HCR based on a survey biomass estimate rather than assessment output. We found that the current HCR performs best in terms of catch but may increase variability in catch and closure frequency compared to alternative control rules. Climate-robust HCRs for Pacific sardine were responsive to changes in population status, had a higher biomass at which the harvest rate started to be reduced, and used a stock assessment model biomass estimate rather than solely a survey index.

Case Study 11: *Nonstationarity in recruitment: Stock assessments in the South Atlantic region*

MATT DAMIANO, KYLE SHERTZER, ERIK WILLIAMS

Stock assessments and fishery-independent trend analyses suggest that multiple stocks from the snapper-grouper management complex in the south Atlantic U.S. have demonstrated poor recruitment over the last 15 years. The prolonged period of poor recruitment may or may not be indicative of a regime shift, therefore, the SAFMC faces a difficult choice as to whether to base biological benchmarks on long-term average or recent recruitment conditions. Biological benchmarks, e.g., spawning stock biomass, are dynamic and difficult to estimate, and long-term projections of stock status from assessment models are not likely to produce realistic estimates of rebuilding times for overfished stocks. Under the non-stationary recruitment conditions in the south Atlantic US, it is unlikely that the true stock status is known. We propose relying on fishing mortality (F)-based benchmarks such as proxies for F_{msy}, e.g., $F_{40\%}$, which are robust to non-stationarity in mean recruitment, and should drive stock biomass toward the target level. We demonstrate the effect of this approach with a simulation study using south Atlantic scamp as a case study. We projected a simulated scamp population forward in time over 80 years at an alternate mean recruitment every 20 years while fishing at $F_{40\%}$. Corresponding values of spawning stock biomass were reduced to the target level relative to the magnitude of mean recruitment. Although more rigorous simulation work is underway to test this approach, we conclude that fisheries management should focus on short-term, F-based catch advice and benchmarks using recent recruitment over biomass benchmarks.

Case Study 12: *The role of management strategy evaluation (MSE) in turning climate science into climate-informed management advice*

CASSIDY PETERSON, JOHN WALTER, SARAH GAICHAS, KRISTIN MARSHALL, DESIREE TOMMASI, ROB AHRENS, JON DEROBA, BEN WILLIAMS

Scientific and Statistical Committees are challenged with distilling science into tangible management advice. Management strategy evaluation is the essential pathway to test, develop, and implement climate ready management procedures. MSEs can evaluate performance of these procedures across biological, economic, and social objectives,

allowing SSCs and Councils to assess risks, benefits, and tradeoffs of alternative strategies under increased uncertainty related to climate change. We present example MSE-tested procedures and solicit feedback on what MSE approaches and outputs SSCs need to develop actionable climate-informed advice.

SSCs are charged with the challenging task of distilling science into tangible fisheries management advice for Councils. Given the pace and scale of climate-related changes in marine ecosystems, the task now requires consideration of past, current and expected future conditions.

MSE is a powerful framework to assess how alternative management strategies may perform under likely future conditions across biological, economic, and social objectives, allowing SSCs and Councils to better assess risks, benefits, and tradeoffs of different strategies under rapidly changing climate and ocean conditions. MSE is an essential pathway towards identifying timely, robust, and well-performing management recommendations in the face of climate change. MSE is poised to serve as the actionable and transformative link between climate science and fisheries management.

Appendix D. SCS8 Attendees

SSC Delegates

NEFMC

Lisa Kerr*	University of Maine; SCS8 Chair
Conor McManus*	NOAA Fisheries, NEFSC; SCS8 Vice Chair
Jeremy Collie	University of Rhode Island
Hirotsugu Uchida	University of Rhode Island

PFMC

Cheryl Barnes	Oregon State University, Oregon Department of Fish and Wildlife
Chris Free	University of California, Santa Barbara
Jason Schaffler*	Muckleshoot Indian Tribe

Gulf Council

David Griffith	East Carolina University
Jim Nance*	Unaffiliated

WPFMC

Erik Franklin	University of Hawai'i
Jason Heyler	Hawai'i Division of Aquatic Resources
Justin Hospital	NOAA Fisheries, PIFSC
Craig Severance	University of Hawai'i, Hilo (retired)

SAFMC

Jie Cao	North Carolina State University
Kai Lorenzen	University of Florida
Marcel Reichert*	Unaffiliated
Andrew Ropicki	University of Florida, Florida Sea Grant

CFMC

J.J. Cruz Motta	University of Puerto Rico, Mayaguez
Walter Keithley	Louisiana State University (retired)
Tarsila Seara	NOAA Fisheries, NEFSC
Vance Vicente*	Unaffiliated

MAFMC

Geret DePiper	NOAA Fisheries, NEFSC
Sarah Gaichas	NOAA Fisheries, NEFSC
Paul Rago*	NOAA Fisheries (retired)
Mike Wilberg	UMCES, Chesapeake Biological Laboratory

NPFMC

Mike Downs*	Wislow Research

Sherri Dressel	Alaska Department of Fish and Game; *SCS8 Steering Committee*
Franz Meuter	University of Alaska, Fairbanks; *SCS8 Steering Committee*

Facilitators

Kimberly Starbuck	Urban Harbors Institute, UMass Boston; SCS8 Lead Facilitator
Allison Novelly	Urban Harbors Institute, UMass Boston
Kristin Uiterwyk	Urban Harbors Institute, UMass Boston

Staff Attendees

Rachel Feeney*	NEFMC staff, SCS8 Coordinator
Marlene A. Bellman*	PFMC staff
Max Birdsong	GMFC staff
Ryan Rindone*	Gulf Council staff
Asuka Ishizaki*	WPFMC staff
Judd Curtis*	SAFMC staff
Graciela Garcia-Moliner*	CFMC staff
Brandon Muffley*	MAFMC staff
Diana Stram*	NPFMC staff

Other NOAA Attendees

Janet Coit	NOAA Fisheries
Matt Damiano	NOAA Fisheries, SEFSC
Daniel Goethel	NOAA Fisheries, AFSC
Deb Lambert	NOAA Fisheries
Jon Hare	NOAA Fisheries, NEFSC
Melissa Karp*	NOAA Fisheries
Moira Kelly	NOAA Fisheries, GARFO
Rick Methot	NOAA Fisheries
Cassidy Peterson	NOAA Fisheries, SEFSC
Paul Spencer	NOAA Fisheries, AFSC
Desiree Tommasi	NOAA Fisheries, SWFSC; UC Santa Cruz

NEFMC Hosts

Rick Bellavance	NEFMC Chair
Cate O'Keefe	NEFMC Executive Director
Emily Bodell	NEFMC staff
Jamie Cournane	NEFMC staff
Jenny Couture	NEFMC staff

David McCarron	NEFMC staff
Angelia Millier	NEFMC staff

SCS8 Steering Committee members unable to attend

Cameron Speir	PFMC
Dan Holland	PFMC
Jim Lynch	WPFMC
Luiz Barberi	Gulf Council
Jeff Buckel	SAFMC
Richard Appeldoorn	CFMC
Jason Cope	CFMC
Cody Szuwalski	NOAA Fisheries, AFSC
Tim Miller	NOAA Fisheries, NEFSC
Shannon Cass-Calay	NOAA Fisheries, SEFC

Appendix E. Acronyms and References

ABC	Acceptable Biological Catch
ACEPO	Annual Community Engagement and Participation Overview
ACL	Annual Catch Limits
ACLIM	Alaska Climate Integrated Modeling Project
ACT	Annual Catch Target
CCC	Council Coordination Committee
CCLME	California Current Large Marine Ecosystem
CFMC	Caribbean Fishery Management Council
CNMI	Commonwealth of the Northern Mariana Islands
CR	Control Rule
DAP	District Advisory Panel
EAFM	Ecosystem Approach to Fishery Management
EBFM	Ecosystem Based Fisheries Management
ECS	Ecosystem Component Species
ESP	Ecosystem and Socioeconomic Profiles
ESR	Ecosystem Status Reports
FEP	Fishery Ecosystem Plan
FIM	Fisheries-Independent Monitoring
FMP	Fishery Management Plan
HCR	Harvest Control Rules
ICCAT	International Commission for the Conservation of Atlantic Tunas
IEA	Integrated Ecosystem Assessment
IFQ	Individual Fishing Quota
JSDM	Joint Species Distribution Model
LEK	Local Ecological Knowledge
MAFMC	Mid-Atlantic Fishery Management Council
MSA	Magnuson-Stevens Act
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
NCLIM	Northeast Climate Integrated Modeling Initiative
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NS1	National Standard 1
OAR	Oceanic and Atmospheric Research
OFL	Overfishing Limit
P*	Probability of Overfishing
PFMC	Pacific Fishery Management Council
PIFSC	Pacific Islands Fisheries Science Center

PRA	Paperwork Reduction Act
RSA	Research Set-Aside
SAFMC	South Atlantic Fishery Management Council
SCS	Scientific Coordination Subcommittee
SEASAW	Socioeconomic Aspects in Stock Assessments Workshop
SEDAR	Southeast Data Assessment and Review
SEEM	Social Economic Ecological Management
SEFSC	Southeast Fisheries Science Center
SEP	Social and Economic Sub-Panel
SOE	State of the Ecosystem
SSB	Spawning Stock Biomass
SSC	Scientific and Statistical Committee
SSPC	Social Science Planning Committee
TAC	Total Allowable Catch
TAP	Technical Advisory Panel
USGS	United States Geological Survey
WPFMC	Western Pacific Fishery Management Council

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