# Supporting climate-resilient fisheries through understanding climate change impacts and adaptation responses

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DRAFT Climate Change Task Force work plan

of the Bering Sea Fishery Ecosystem Plan

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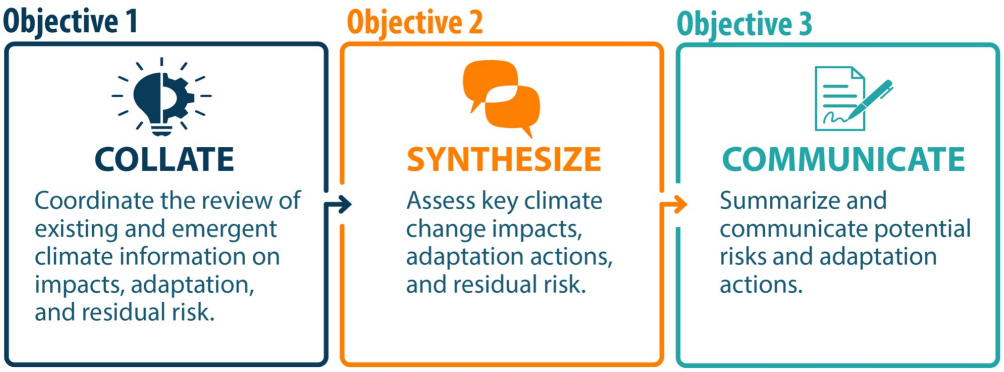
# Overview

The North Pacific Fishery Management Council (NPFMC; the Council) initiated a Climate Change Action Module as part of the Bering Sea Fishery Ecosystem Plan (BSFEP). This draft work plan reflects the proposed scope of work based on the efforts of the NPFMC's BSFEP Climate Change Taskforce (CCTF).

As defined by the CCTF and approved by the Council, the goal of this Climate Change Module is to facilitate the Council's work toward climate-ready fisheries management that helps ensure both short-term and long-term resilience for the interconnected ecological and human communities of the Bering Sea. This work plan is intended to further work toward that goal through three objectives:




**Objective 1. Collate:** Coordinate the review of existing and emergent climate information on impacts, adaptation, and residual risk.

> *Evaluate the ways in which climate change information is currently included in the fishery management process, identify gaps, and help create opportunities to increase the inclusion of available information*

**Objective 2. Synthesize:** Assess key climate change impacts, adaptation actions, and residual risk.

> *Synthesize information about long-term climate change impacts and scenarios and help create pathways for inclusion of that information in the fishery management process.*

**Objective 3. Communicate:** Summarize and communicate potential risks and adaptation actions.

> *Identify potential management tools and actions for consideration by the Council that could help increase resilience and adaptation to climate change impacts*

Very generally, the CCTF is taking a stepwise approach that will begin with a gap analysis to identify processes in which climate change is and is not incorporated into management advice. The second objective, focused on synthesizing and providing information about long-term climate change information is a need that has already been identified. Finally, the CCTF will provide a database of potential management tools and actions that could be adopted by the Council. The activities associated with each objective are detailed in this work plan.

Throughout each objective, the CCTF will seek to work with Council and agency staff to avoid duplication and ensure that CCTF products and processes complement existing, ongoing efforts. This coordination includes working with the LKTK Module Task Force, FEP Plan Team, and others.

Finally, this work will be undertaken by the CCTF acknowledging the team's five-year (2021-2025) time horizon. Over those five years, the CCTF will work with Council and agency staff to identify the manner in which this effort will continue.The CCTF will seek to provide information that is additive and suggest adjustments or expansions of current processes that would allow the work to continue.

# Introduction

Climate change is posing ongoing and new challenges to fisheries management in Alaska that require fisheries managers to be able to adapt and respond appropriately. In particular, the Bering Sea ecosystem supports a broad array of fisheries that are collectively considered by many to be well-managed and sustainable, but continued sustainability will likely depend to some extent on building further consideration of climate-related impacts into fisheries management. The Bering Sea is characterized by a strong connection between the marine system, coastal communities and regional fisheries that support the region's cultures, food security and well-being. Subsistence and commercial capture fisheries in the Bering Sea support economic vitality, social prosperity and food security both within and outside of Alaska and will be an essential contributor to sustainable and affordable nutrition for the future global population of 9 billion people (2050 UN estimate; Dumas, 1984; Fall et al., 2013; Haynie and Huntington, 2016; Raymond-Yakoubian et al., 2017; Meredith et al., 2019). Coastal communities in the Bering Sea are inextricably connected to their marine ecosystems, and subsistence fisheries and harvests have been critical for the collective well-being and stability of Alaskan communities since time immemorial. For decades, Bering Sea fisheries have sustainably supported the largest and most valuable US fisheries, and are important for national and global nutrition and food security. One out of every two fish captured annually in the US comes from Alaska, and regional fisheries support a >$5 billion USD fishing industry (2018), nearly half of which is Bering Sea groundfish harvest. Groundfish fisheries in the Bering Sea have a 30+ year history of proactive, science-based adaptive management that is able to adjust to highly-productive yet variable ecosystem dynamics.

However, Bering Sea marine systems are driven by ecological processes and climate conditions that are increasingly extreme and difficult to anticipate (e.g., 2016 and 2018 marine heatwaves and associated negative impacts to seabirds, marine mammals, coastal communities and commercially important groundfish fisheries). The frequency and intensity of marine heatwaves and extreme events in the Bering Sea are projected to increase in coming decades, and conditions are expected to shift markedly over the next 20-50 years (Figure 1; Frölicher et al. 2018, Cheung and Frölicher 2020, Laufkötter et al. 2020, Oliver et al. 2018). Specifically, marine heatwaves may become more commonplace and severe, winter and summer water temperatures are anticipated to increase, and the duration and frequency of productive "cold" multi-year stanzas are projected to decline (Oliver et al., 2019, Laufkötter et al. 2020).

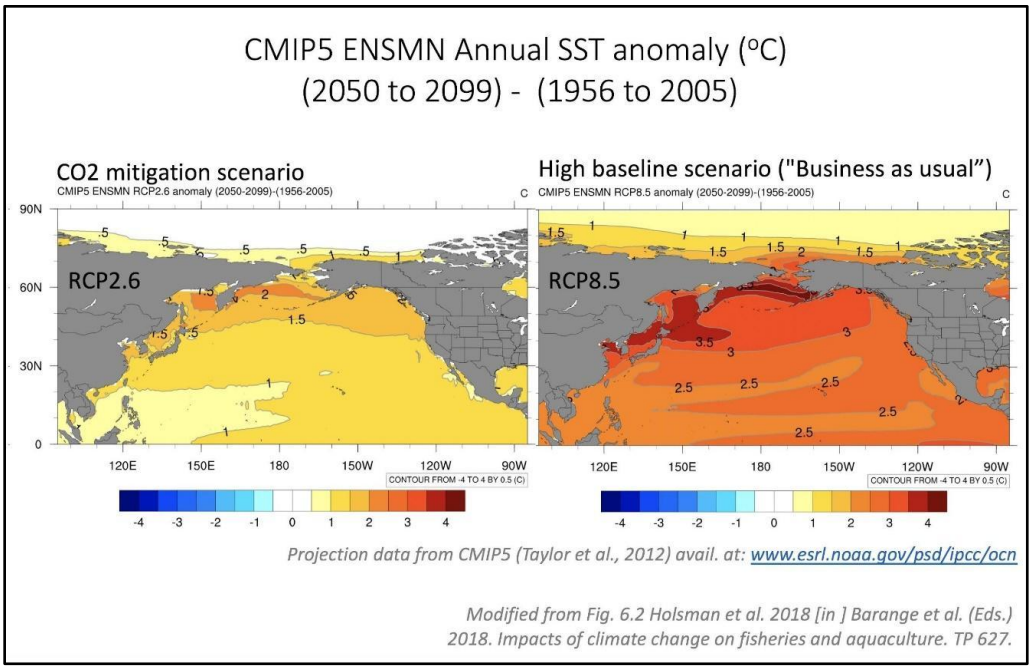



*Figure 1. Projected end of century changes in sea surface temperature (SST) anomalies relative to historical SST under global carbon mitigation (left) and unmitigated (right) future scenarios. Based on Coupled Model Intercomparison Project (CMIP) 5 ensemble scenarios.*

Climate change is very likely to continue to cause changes in fish distribution, survival, growth, timing, behavior, catchability and strength of species interactions (Polozinsca et al. 2013, Meredith 2019, Smale et al. 2019). Some of these changes may occur gradually, whereas other species may exhibit sudden threshold-like changes in response to changing climate conditions (i.e., as conditions cross ecological "tipping-points"; Lenton et al. 2019). Recent examples include the rapid redistribution northward from the EBS to the NBS of most of the Pacific cod stock (Stevenson et al. 2019, Spies et al. 2020), multitrophic shifts (i.e., phytoplankton through forage fish) in response to low sea ice in 2016-2017 (Duffy-Anderson et al. 2019), size structure and distribution range contraction of northern Bering Sea snow crab (Fedewa et al. 2020), and synchronous mortality events of seabirds, whales, and sea ice seals across the NBS from 2016-2018 (Piatt et al. 2020, Siddon and Zador, 2019).

A productive future for Bering Sea fisheries and harvests will require efficient and sustainable approaches and implementation of cutting edge, "climate-ready" fisheries management tools and policies. Some of these tools exist in the context of ecosystem-based management tools as well as Indigenous management and stewardship practices and should be supported and maintained going forward (Gadamus and Raymond-Yakoubian 2015, Raymond-Yakoubian and Daniel 2018, Holsman et al. 2019, Karp et al. 2019). In addition, long-term and fixed Ecosystem-based fisheries management (EBFM) measures, like the 2 MT cap on groundfish harvest and the minimal biomass threshold for Steller sea lions, may be of even greater importance as climate change affects the Bering Sea system; recent studies indicate such measures can stabilize fisheries and forestall climate driven collapse (Holsman et al. 2020). Similarly, other EBFM measures like protected areas, minimal biomass thresholds, by-catch limits, are by design intended to provide stability and remain stationary even when conditions are variable and may be vital as conditions become increasingly anomalous (Holsman et al. 2019). Periodic evaluation of such measures may be needed to ensure they continue to support ecosystem productivity as species distributions and phenology shifts give rise to new interactions, altered habitats, and novel management challenges (Holsman et al. 2019, Karp et al. 2019). To improve and ready fisheries management in the face of climate change and uncertainty, a robust portfolio management approach should be developed. CCTF activities are intended to provide clarity and efficiently build available and new information through the Council process into management through the development of climate-related options.

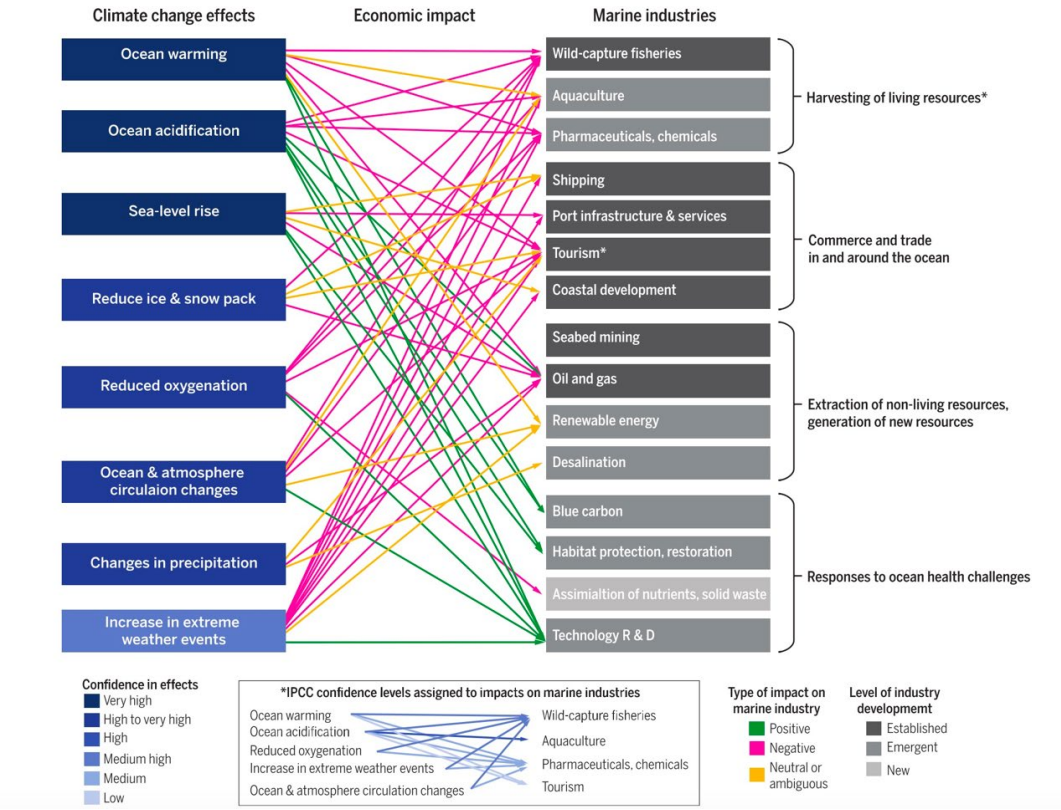



*Figure 2. Climate change impacts on marine systems. From Alisson and Bassett 2015.*

# Action Module Goal

The BSFEP summarizes the purpose for this "climate project" as "evaluat[ing] the vulnerability of key species and fisheries to climate change, to strengthen resilience in regional fisheries management" (NPFMC 2019, p.45). It states further that the module "is specifically responsive to Process Objective 13, to establish a process for addressing change under novel or intensified stressors, as well as the implementation strategy of the Council's ecosystem policy vision statement," and that it is intended to help the Council meet its objectives related to synthesis and incorporation of climate change information and evaluation and development of climate-resilient management tools.

To help guide its work and ensure that it is meeting the objectives set by the Council, the CCTF crafted the following goal statement based on the direction in the BSFEP:

> **The goal of the Climate Change Module is to facilitate the Council's work towards climate-ready fisheries management that helps ensure both short- and long-term resilience for the Bering Sea.**

The CCTF aims to operationalize the delivery of climate change information to the Council including climate change information, tools, and recommendations that can help the Council further its ecosystem vision statement through equitable climate change adaptation pathways, transparent communication, utilization of diverse knowledge sources, and broad engagement. This module will support the Council's capacity to:

1. More effectively incorporate climate change information from diverse knowledge holders into the fishery management process through transparent, effective and dynamic communication and engagement with

communities, fishers, managers, scientists and other Council stakeholders with the Council and Council staff; and,

2. Evaluate and implement management measures that can: help preserve livelihoods, economies, health and well-being across fisheries and dependent coastal communities; support near- and long-term adaptation to climate change; and ensure the continued productivity and sustainability of the coupled social-ecological Bering Sea system.

This module addresses the need to incorporate climate change knowledge, science and information about the Bering Sea system (see geographic description in the FEP) throughout the Council process. Current information is focused on annual advice and near-term forecasts while a wealth of information is available to inform longer-term strategic planning for the Bering Sea.

# Evaluating Adaptation and Resilience

The CCTF aims for an inclusive process in developing recommendations and when assessing risks, impacts, and tradeoffs. The latter relies on understanding and considering biological trajectories of change as well as the social, cultural, and economic implications and scope of adaptation in the intricately coupled social-ecological Bering Sea system. Therefore the CCTF will develop and update (as needed) definitions of "adaptation" and "resilience" in terms of climate change and Bering Sea fisheries (Appendix 1, 2), as well as attendant metrics and indicators of progress (or limitations) towards implementation and performance. The United Nations Intergovernmental Panel on Climate Change (IPCC) definitions for "adaptation" and "resilience" and the CCTF preliminary definitions of each are provided below and included here as starting points for discussion. The focus on these definitions is intended to provide clarity for the success of the work plan. They will be updated with input from and collaborative engagement with stakeholders, and the CCTF will maintain evolving documents describing Adaptation and Resilience in the Appendices to the work plan that provide more detailed definition and descriptions.

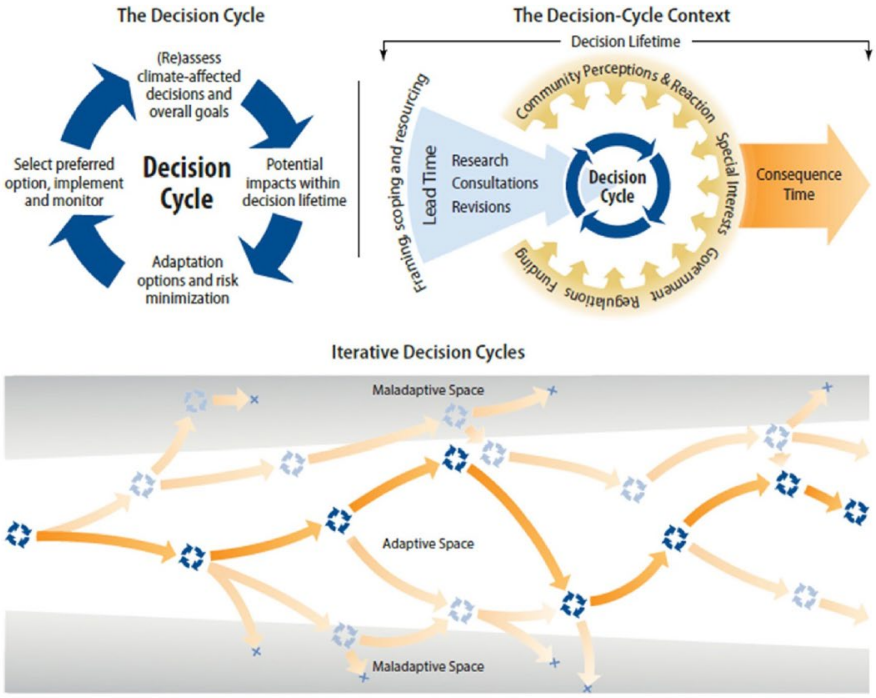



*Figure 3. Climate adaptation pathways. From Wise et al. 2014.*

## Adaptation

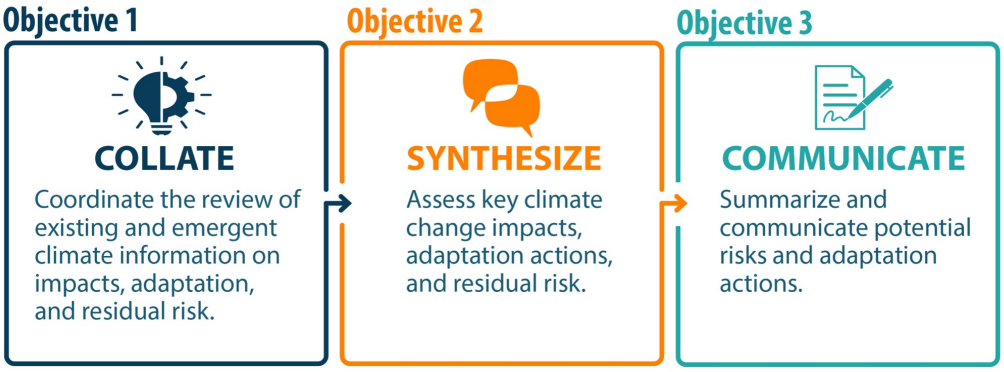
The IPCC defines adaptation as "the process of adjustment to actual or expected climate change and its effects" (IPCC 2014, p. 5). In the context of Bering Sea fisheries, adaptation to support climate resilient social-ecological systems includes ecosystem-based management policies that embrace uncertainty, adjust at a rate that is consistent with observed changes (e.g., allows communities and fisheries to adapt in a proactive rather than a solely reactive manner), are inclusive of diverse knowledge sources and information that may change and evolve over time, and consider both direct and indirect impacts and interactions with other species, sectors, and stakeholders and the environment. The latter relies on understanding and considering biological trajectories of change as well as the social, cultural and economic implications and scope of adaptation in the intricately coupled social-ecological Bering Sea ecosystem. Co-production of knowledge is essential for understanding changes as well as identifying, understanding and promoting pathways of adaptation in both fisheries and fishing communities. Some social and ecological changes could help promote adaptation, but others might intensify negative impacts of climate-driven change. Adaptation can include reactive responses as well as proactive, anticipatory planning and prevention. Adaptation is separate from, but can be synergistic with (i.e., have co-benefits for), "carbon mitigation" measures, which are actions at global or regional scales that aim to reduce or recapture atmospheric $CO_2$. Climate adaptation planning is a multi-step and iterative process that includes evaluation of key risks and needs, assessment of available potential tools and approaches, understanding of institutional capacity and feasibility for adaptation planning and implementation (and evolving limits and constraints to adaptation), and interactive inclusive discussions regarding realized costs, trade offs, and benefits of adaptation measures (Meredith et al. 2019). This evolving definition will serve as the basis for ongoing climate-biological-social-economic evaluations of management actions that address climate-driven impacts, utilize novel opportunities, and identify and promote equitable adaptive pathways.

## Resilience

Community resilience has numerous interconnected aspects, including the epistemic (e.g. access to information, rich involvement in scientific-management-policy activities, etc.), the individual (e.g. mental and physical health), and the sociocultural (e.g. social cohesion, self-determination, integration of community with natural resources, thriving intergenerational relationships, community sustainability and vibrancy, food security, economic diversity, adaptability to change, etc.). The biological resilience of marine resources likewise spans a wide array of considerations including genetic diversity, healthy habitats and populations, adequate resources, sustained recruitment, and a balanced trophic structure. Finally, resilience must be considered at the nexus of these two domains, i.e. coupled social-ecological systems. This includes, for example: sustained strong connections between harvest species and humans and communities that rely on them; management that is capable of being adaptive and flexible while also sustaining ecosystems and livelihoods; strengthened resource management through co-management, community engagement, and co-production of knowledge; alignment of knowledge, management, and policy to challenges of variability and unpredictability; and strong information-based decision making that includes diverse knowledge sources and perspectives in order to ensure inclusive and just assessment of risks, impacts and tradeoffs.

# CCTF Iterative process of information review and synthesis

The CCTF will summarize existing information for the Council regarding climate change impacts and responses in the Bering Sea. The CCTF will also implement a process to regularly synthesize emergent information for the Council including IK and TK observations of change and adaptation responses, local knowledge regarding on the ground impacts and adaptation measures, and emergent scientific research from integrated modeling, physiological studies, and environmental observations. Specifically this module will be used to collate, synthesize, and communicate climate change information.




**Objective 1. Collate:** Coordinate the review of existing and emergent climate information on impacts, adaptation, and residual risk.

> *Evaluate the mechanisms and processes through which climate change information is currently included in the fishery management process, identify gaps, and help create opportunities to increase the inclusion of available information*

**Objective 2. Synthesize:** Assess key climate change impacts, adaptation actions, and residual risk.

> *Synthesize information about long-term climate change impacts and scenarios and help create pathways for inclusion of that information in the fishery management process.*

**Objective 3. Communicate:** Summarize and communicate potential risks and adaptation actions.

> *Identify potential management tools and actions for consideration by the Council that could help increase resilience and adaptation to climate change impacts*

## How Action Module will interface with existing work

We aim to complement existing delivery of ecosystem-based management to the Council process by organizing and synthesizing the breadth of climate information, a subset of which is currently communicated through various channels to the Council (Fig. 6). This module will also standardize the method of communicating actionable climate information to the Council. This includes 1) systematic review of existing climate information in Council reports as well as new and emergent climate change information, both immediate and long-term in scope (most long-term information is currently not included in Council reports), 2) synthesis and evaluation of key issues, emergent trends, and potential red flags relevant to the Council, 3) communication and iterative review with the LK/TK/Subsistence Task Force and FEP Team to support the diversity of perspectives and knowledge sources needed for evaluations of risk, and tradeoffs, and the variety of sources of climate information, and 4) identification of climate-resilient management actions to enable adaptation to climate-driven change (this particular point would be in the form of recommendations that can be considered by the Council through the Council process). The proposed approach is outlined in Fig. 6. As much as possible we will work with existing teams and products to minimize the amount of reporting and review and avoid duplication of existing efforts.

## Approach

We propose the following annual cycle to summarize and deliver actionable climate-information and advice relevant to fisheries management in the Bering Sea. First, there will be two information gathering meetings (Bering Sea Fisheries Climate Adaptation meetings), that will include Indigenous, Traditional, and Local Knowledge regarding climate change and fisheries from communities in Alaska as well as academic and agency research findings. Speakers will be asked to provide information according to a “Climate Briefing” template (Appendix 3) in order to

standardize information for the *EBS Climate Change and Fisheries Report.* This will aid in synthesis and summary of findings, which will be included as a short report and executive summary .

Finally, the CCTF will coordinate a draft synthesis of anticipated short to long-term climate change impacts on the Bering Sea ecosystem, including fish, protected species, fisheries, and coastal communities, and an evaluation of and recommendations for management actions. Initial studies suggest that the outcome of potential climate change impacts on fish and fisheries in the Bering Sea largely depends on harvest strategies in the region (Punt et al. 2016, Seung et al. 2018, Hollowed et al. 2020, Reum et al. 2020, Holsman et al. 2020). Climate change creates additional sources of uncertainty in the system that need to be accounted for in trade-off analyses and future policies. Fortunately, Traditional Knowledge regarding impacts and adaptation responses, completed and ongoing regional research studies (e.g., ACLIM), and national and international strategic assessments (e.g., US National Climate Assessments, IPCC reports) continue to advance understanding of climate change impacts to fish and fisheries and the range of potential adaptation measures that may be utilized to minimize impacts and promote long-term resilience.

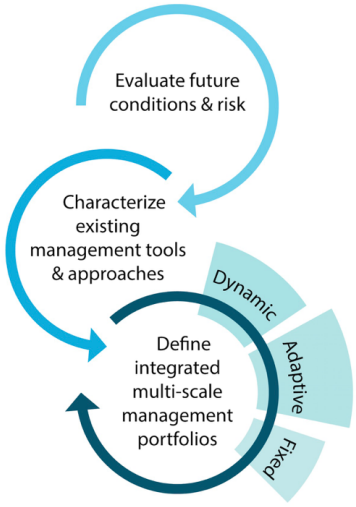



*Figure 4. Iterative climate-resilient fisheries management approach. Modified from Holsman et al. 2019.*

The CCTF will assemble information from recent ongoing and completed efforts, present synthesized results to the Council and other stakeholders for feedback, and work with the Council and stakeholders to develop a suite of potential climate resilient management tools and policies and a plan for their consideration, implementation, and evaluation. Specifically, the CCTF synthesis will draw from multiple knowledge sources (e.g., Indigenous Knowledge; Traditional Knowledge; Local Knowledge) through ongoing, proposed, and completed projects (e.g., ACLIM); co-production of knowledge projects, and expert knowledge from Alaska Native Tribes and Organizations, State and Federal government entities, academic institutions, non-governmental organizations, industry, communities and other stakeholders. The CCTF synthesis will use a three point approach to deliver the climate information to the Council via management "on-ramps" that will help inform short-, medium-, and long-term actions, processes, and evaluations that might be implemented by the Council (Fig. 6). The Council will likely be interested in particular to results of analyses regarding the performance of existing ecosystem-based management measures and aggregate total harvest limits (e.g., Holsman et al. 2020), area-based conservation measures, alternative time-space closures (e.g., Hazen et al. 2019), catch share programs, bycatch reduction incentives, sector/gear specific fishing areas, minimum biomass thresholds that address target and non-target species and upper/lower trophic levels, and information, pathways, and tools that can be used by the Council to ensure equitable climate resilience in the region's fishery management. The CCTF will work collaboratively with a diverse body of stakeholders in its efforts through the Council process, by utilizing best practices identified by existing Council bodies (e.g. the LK/TK/Subsistence Taskforce, Community Engagement Committee, etc.), and through the CCTF's Activities described herein. These efforts will provide a foundation for co-productive approaches to addressing climate issues in the Council process.

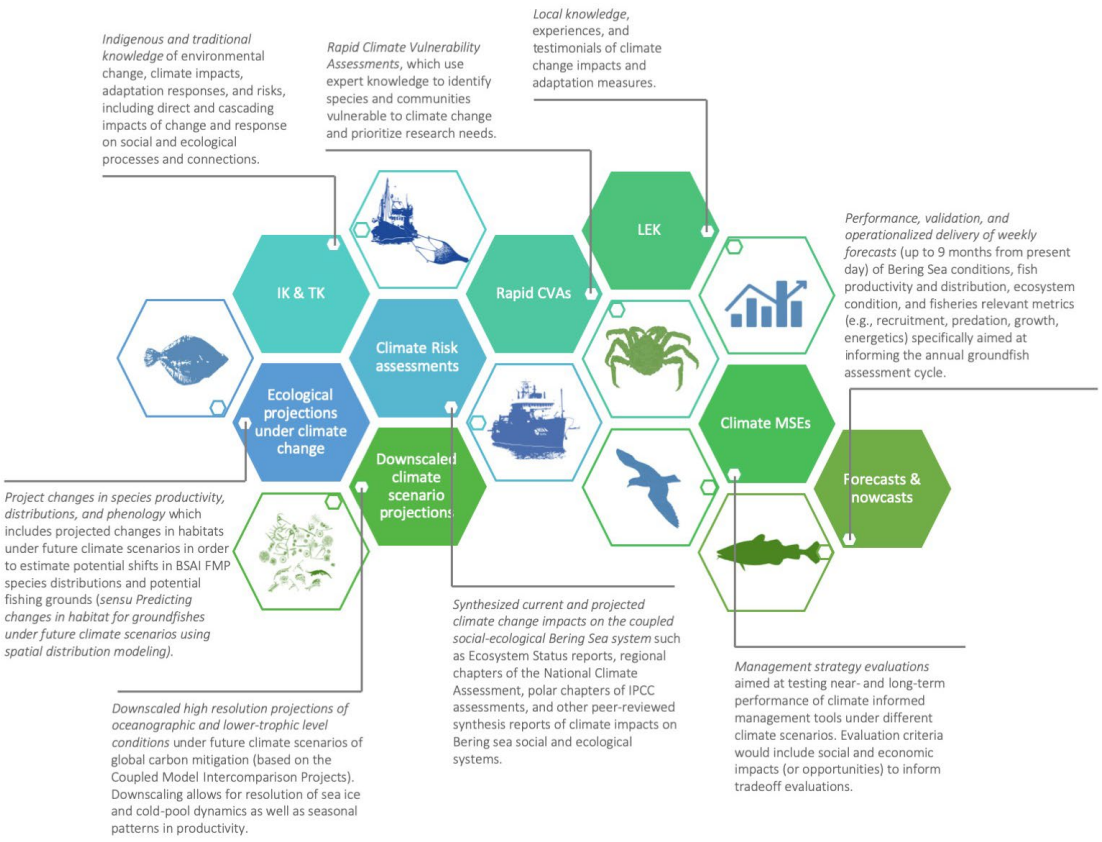



*Figure 5. Example of potential sources of information to be synthesized by the CCTF.*

The CCTF process will evolve iteratively over the course of the CCTF 2021-2025 implementation phase (and, ideally, beyond) to include information and perspectives gathered during and from other CCTF activities and products. The CCTF process will also help the Council track climate impacts on the Bering Sea ecosystem and ensure that fisheries managers in the region have the right tools to adapt to rapid shifts in species distributions or abundances under future conditions. If implemented, these new tools and pathways should help ensure that fisheries management best complies with the Magnuson-Stevens Act, including the National Standards, Fishery Management Plan objectives, and other statutory obligations, and that the Council has a more complete understanding of impacts to communities as conditions change.

## Objective 1: Coordinate the review of existing and emergent climate information on impacts, adaptation, and residual risk.

The CCTF supports development of co-production of knowledge approaches aiming to be inclusive of multiple perspectives and providing transparency in tradeoff analysis. In this spirit, collaborative efforts will be undertaken by the CCTF, including a synthesis of information from Bering Sea Fisheries Climate Adaptation meetings ("Climate Adaptation meetings"; Activity 1.1), targeted workshops (as needed Activity 1.2) in coordination with the FEP, Ecosystem committee, and the LK/TK/Subsistence Module taskforce, and regular climate impacts and adaptation summary Council reports (see deliverables and Activities 3.1-3.3).

### *CCTF Activity 1.1. Collate existing information and annually coordinate emergent information on climate impacts and adaptation actions*

The CCTF will elicit input from a diverse group of Bering Sea experts involved in ongoing and completed climate change projects, partnerships, experiences, knowledge, and research, including longer-term projections and forecasting. The CCTF will host two Climate Adaptation meetings (Objective 1). Prior to these meetings the CCTF will encourage interested participants to submit a "Climate Briefing" in which they will be asked to highlight crucial information and perspectives regarding climate change, the marine environment, and implications for resource management in the region. Information centralized through the workshops will be synthesized by the CCTF (Objective 2) and presented regularly to the Council (Objective 3). This process looks to establish an operational process to collate and convey climate science and knowledge to the Council process as well as broad public understanding about the nature and utility of such information for the Council. While this process is envisioned for the lifespan of the CCTF (2021-2025), it is designed as a framework that could extend into the future (with appropriate support and resources).

### *CCTF Activity 1.2 Support a co-production of knowledge approach to identify the key hazards, impacts and risks for the ecosystem as well as the relative efficacy of, limits to, and tradeoffs among various adaptation actions.*

In addition to annual Climate Adaptation meetings (Activity 1.1), as needed the CCTF will support workshops aimed at summarizing key climate hazards, impacts and risks for the Bering Sea social-ecological system. In particular, the CCTF will collaboratively synthesize shared knowledge, risk, and vulnerability assessments to identify species and communities that may be impacted by ongoing climate driven change and longer-term climate driven shifts to the system. Where possible, impacts will be mapped during workshops to potential adaptation and management actions that might reduce risk, and results will be included in synthesis Activities (2.1).

## Objective 2: Assess key climate change impacts, adaptation actions, and residual risk

### *CCTF Activity 2.1. Synthesize the relative efficacy of, limits to, and tradeoffs among various adaptation actions across a range of potential climate and management scenarios.*

The CCTF will support an inclusive and proactive climate change planning process by the Council through identification and strategic re-evaluation of emergent impacts, risks, management actions (recommendations only that would be considered through the Council process) and attendant residual climate risks (i.e., remaining risk after adaptation), limits to adaptation, and tradeoffs between adaptation measures. The CCTF will review existing adaptation evaluations including adaptation feasibility, efficacy, and residual risk in order to identify enabling conditions for, limits of, and barriers to adaptation. CCTF will also highlight gaps in understanding of climate response and areas where impacts and adaptation are unclear. The CCTF supports development of co-production of knowledge approaches to understanding impacts and adaptation options. To that end, the CCTF will facilitate discussions around tradeoffs and impacts across multiple stakeholders as part of the synthesis. This information will be collated in a table that will be regularly updated and made publicly accessible. (e.g., Table 1).

## Objective 3: Summarize and communicate potential risks and adaptation actions

The CCTF will work with the, FEP Team (and/or Council committees, Plan Teams, working groups, and other module task forces) to iteratively (e.g., annual basis) identify potential short-term, medium and long-term management actions for climate adaptation (i.e., derive alternative strategies for MSEs).

### *CCTF Activity 3.1 Support climate-informed stock assessment through rapid communication of "red flags" and emergent fishery specific climate issues to report and stock assessment authors (On-ramp 1)*

Annually the CCTF will identify emergent impacts that may influence stock assessments (e.g., rapid redistribution of Pacific cod to NBS in 2016, Spies et al. 2020, Thompson et al. 2020). Emergent issues and red flags will be

identified during the spring Climate Adaptation meetings, subsequent workshops (if applicable), and through review of new research findings, and national and international climate assessments (e.g, IPCC reports). Emergent issues that might impact stock assessment models will be rapidly communicated to assessment authors through the Ecosystem and Socioeconomic Profiles (ESP) process for development of indicators for use in Climate Enhanced stock assessments (CE-assessments). This streamlined approach will help reduce the lag time between emergent issues and uptake of information into the stock assessment process (e.g., Barbeaux et al. 2020).

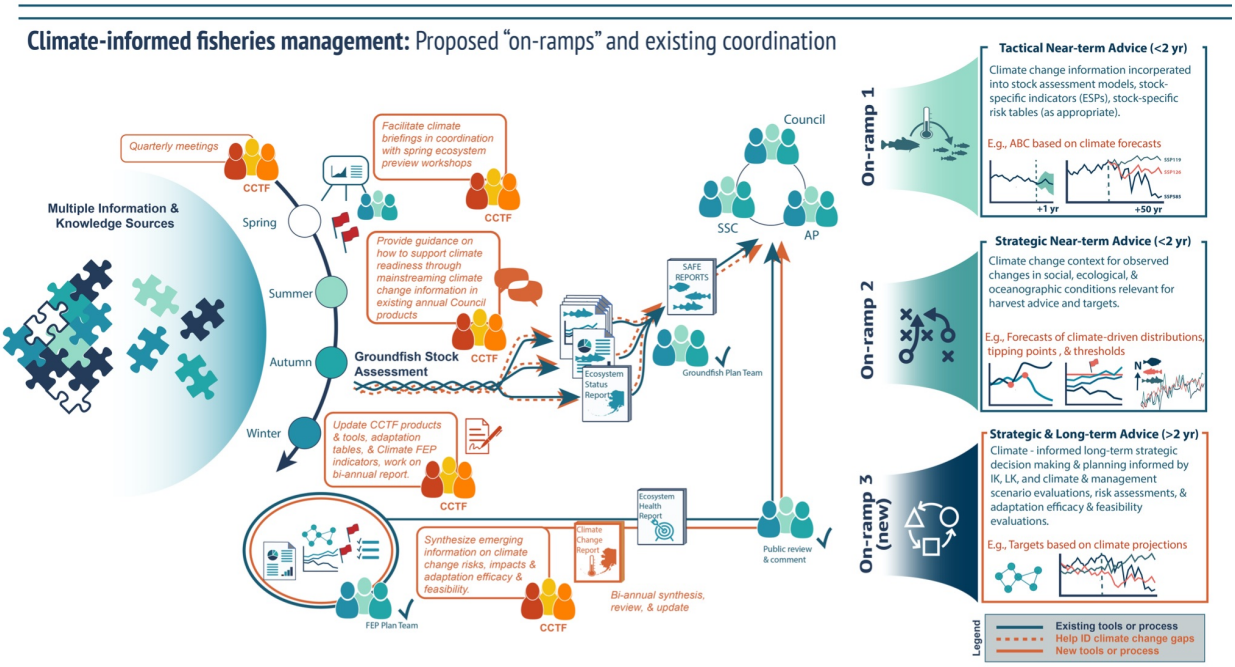



*Figure 6. Climate Change Task Force process for synthesis and review of information to the Council to support climate-informed management in the Bering Sea. Note the three identified "on-ramps" for climate change information. Orange boxes and lines represent CCTF activities and products; blue lines represent existing processes and products.*

### *CCTF Activity 3.2 Summarize relevant climate change information in previous year's reports and documents provided to the Council and identify new or additional climate change information relevant to short -term advice (on-ramps 1 & 2).*

The SAFE report annually provides biological and ecosystem information to the Council as strategic context and tactical advice for harvest recommendations and management decisions. The CCTF will review the previous year's reports for climate change information, synthesize key climate change findings, and provide a summary of advice for inclusion of climate change information to support climate ready near-term management decisions (e.g., information relevant for stock-assessments, ESPs, and Ecosystem Status reports, etc. For example, long-term projections of ecosystem conditions, species productivity, and species distributions provide context for strategic decision making as well as fixed measures (like boundaries of protected areas or the 2 million ton cap on groundfish harvest) and could provide additional perspective to the climate conditions and extreme events currently summarized in current SAFE reports and Council materials..

### *CCTF Activity 3.3 Synthesize climate impacts, adaptation responses and residual risk in a synthesis report (EBS Climate Change and Fisheries Report; On-ramp 3)*

Based on information from Objectives 1 and 2, and Activities 3.1 and 3.2 the CCTF will synthesize existing information into a biannual " *EBS Climate Change and Fisheries Report*" synthesis report (Figure 6). This report will be aligned with the FEP Ecosystem Health report and will summarize key risks, adaptation actions, and where possible residual risk (remaining risk after adaptation), limits to adaptation and enabling conditions for adaptation

and resilience. It will also include a conceptual model of how climate and other stressors impact the coupled social and ecological systems of the Bering Sea, and a summary of short-(1-3 years), medium-(5-10 years), and long-term (10+ years) management actions that the Council could consider to build climate resilience in regional fisheries and fisheries-dependent communities (Table 1). It will also identify knowledge gaps, information requirements, and technological needs that should be addressed in order to promote resilience and adaptation to climate-induced changes (Figure 3). This could include synthesis of long-term management scenario analyses to inform short-term climate-specific decisions during relevant management cycles (e.g., annual groundfish assessment cycle, updates to essential fish habitat designations, updates to marine mammal assessments and species biological opinions), reviews of emergent information regarding alternative policy options including in-season management tools, adaptive management experiments (e.g., to address temperature-dependent shifts in spatial distribution), and fixed management measures (e.g., long-term ecosystem biomass caps, closure areas, and/or minimal biomass threshold reference points).

# Recent EBS climate change assessments and other related FEP Task Force and additional efforts

The NPFMC BSFEP LK/TK/Subsistence Action Module Task Force is currently working on developing protocols for the integration of LK, TK, and subsistence information into the Council process, and the Council's Community Engagement Committee is developing ways to enhance two-way engagement between the Council and stakeholders (e.g. Tribal communities). These efforts will, among other things, help increase the quantity and robustness of climate change information coming into the Council process. Bering Sea Tribes and Tribal organizations are also actively engaged in work documenting and analyzing climate-related changes in the marine ecosystem.

The Alaska Integrated Ecosystem Assessment program, the Bering Sea Regional Action Plan teams, and multiple ongoing projects at AFSC and various academic and independent research efforts provide the logistical and analytical support to meet objectives 1 and 2 of the module, as well as providing the modeling platforms for objective 3. Under the Regional Action Plan, climate assessment teams from the IEA (Integrated Ecosystem Assessments), the Alaska Climate Integrated Modeling project (ACLIM), and potential NOAA Climate Fisheries Initiative (CFI) are working closely together with each other and with Pacific Marine Environment Lab and University of Washington CICOES researchers to expand the suite of downscaled climate projections coupled to climate-enhanced bioeconomic assessment, ecosystem and fish habitat models, as well as management strategy evaluation sub-modules for some of the ecosystem and assessment models. Thus, the expert teams, analytical capacity, and climate scenarios are already operationally available for some priority species. The rapid climate assessment conducted during 2016 also provides a framework for quickly and efficiently identifying additional species that may be impacted (Spencer et al. 2019). Similarly, the other projects maintain the operational readiness of AFSC to evaluate climate impacts on Bering Sea species and additional ecosystem models or species additions to existing models could be readily implemented for future evaluations.

# Deliverables and Progress Tracking

CCTF proposed deliverables are listed below and discussed in relation to the Objectives and/or Activities from which they will be developed. Progress towards meeting the CCTF goals is also noted. A detailed and regularly updated timeline of deliverables and progress can be found at this link.

## Products of the CCTF annual process:

*On-ramp 1: Climate-informed near-term tactical advice (<2yr)*

- **When**: Annually as part of the annual stock assessment cycle
- **Who**: CCTF will summarize existing climate information and identify additional information that may be useful for tactical decision making (e.g., ABC harvest recommendation, gear specification, size-based release, area/season closures; Gavaris 2009) based on review of contributions provided during the Climate Adaptation meetings, as well as synthetic analysis of diverse sources of climate information.

- **What**: List of potential issues, red flags, and stock-specific indicators and emergent issues for possible consideration in climate-enhanced stock assessments (e.g., OA indices, temperature indices, changes in habitat area). CCTF will review existing climate-information included in stock assessments and will help summarize additional climate knowledge from various sources to help increase the speed of uptake of climate information into tactical decision making (as is deemed appropriate).

*On-ramp 2: Climate-informed near-term strategic advice (<2yr)*

- **When**: Annually as part of the annual stock assessment cycle
- **Who**: CCTF will produce this summary based on contributions provided during the Climate Adaptation meetings (and shared with permission from knowledge holders and with clear attribution of authorship, following and consistent with the co-production of knowledge approach ), and synthetic analysis of diverse sources of climate information.
- **What**: An annual review of the previous year reports (including Stock assessments, Ecosystem Status Reports, and Socio-economic reports) in order to provide a long-term multidecadal context of climate conditions and changes in the Bering Sea to inform near-term strategic management decisions (e.g., climate-informed MSY proxies like 40% of B0, by-catch limits, ecological tipping points thresholds) .

*On-ramp 3: Long-term strategic advice based on synthesis of climate change impacts, risks, and adaptation*

- **When**: The report will be bi-annual and in coordination with the Ecosystem Health Report (FEP report)
- **Who**: CCTF will produce this report with input from contributing authors and review from the FEP team, stakeholders and the public and will provide it to the Council.
- **What**: EBS Climate Change and fisheries report
    - Synthesis of diverse knowledge about climate change effects, evaluation of the scope of impacts from such change, suggestions about tools to aid in decision-making, and on-ramps for climate information into the Council process) (Objective 1 and associated Activities)
    - Evaluation and summary of key risks and short-, medium-, and long-term adaptation measures across a range of climate scenarios (updates to Table 1) (Objective 2 and associated Activities)
    - Conceptual model of climate-social-ecological linkages (including direct and indirect connections)
    - Recommendations for short-, medium-, and long-term actions that could be considered and initiated through the Council process (Objective 3 and associated Activities)
    - Review of additional ways in which climate information can be on-ramped and operationalized within the Council process (especially in association with Objective 1 and its associated Activities, as well as through coordination with LK/TK/Subsistence Taskforce)

## CCTF additional products:

- These key products will be included by reference or appended to the above-noted Synthesis Report and Framework, and will be developed iteratively throughout the CCTF's work:
    - Adaptation Briefing Note (collaboratively and iteratively developed with stakeholders)
    - Resilience Briefing Note (collaboratively and iteratively developed with stakeholders)
    - Climate Briefing Form and Process (used for Adaptation and Climate Testimonial workshops)
    - Table of climate change drivers, impacts, potential policy/management responses, targets, and gaps/needs
    - Adaptation and Climate Testimonial workshop summaries
- Coordination with LK/TK/Subsistence Taskforce and the BS FEP Team to communicate issues/topics of joint relevance, minimize duplicative efforts/products, and coordinate related to pertinent Activities noted above to follow best practices (e.g. regarding use of LK/TK/Subsistence information).

- Periodic updates with SSC, Plan Teams, and Ecosystem Committee to provide interim synthetic climate information of value to ongoing work by those bodies e.g. assisting in the period update of recommendations for the Council's climate-specific research priorities.

# Glossary of Terms

A glossary of Terms from this work plan can be found at this link.

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Table 1. Draft of potential climate change impacts and adaptation responses toolbox.

Appendix 1: Adaptation draft document

Appendix 2: Resilience draft document

Appendix 3: Climate knowledge briefing form

Appendix 4. Action Module Scoping Summary from Core BSFEP

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| 1. Synopsis *including how it will be accomplished* | The goal of this climate project is to evaluate the vulnerability of key species, fisheries and communities to climate change and to strengthen resilience in regional fisheries management. Methods will leverage ongoing projects at AFSC and partner organizations. The Action Module will address the following objectives: (1) coordinate to synthesize results of various ongoing and completed climate change research projects; (2) evaluate the scope of impacts on priority species identified in initial studies; and (3) strategically reevaluate management strategies every ~5 years; (4) include synthesis to evaluate climate-resilient management tools. The climate change Action Module taskforce will work with the Council to iteratively identify and assess the performance of potential short-term, medium and long-term management actions for climate adaptation (i.e., derive alternative strategies for MSEs). |
| 2. Purpose *relationship to the BS FEP's strategic objectives* | This Action Module is specifically responsive to Process Objective 13, to establish a process for addressing change under novel or intensified stressors, as well as the implementation strategy of the Council's ecosystem policy vision statement. While the Action Module leverages ongoing AFSC research projects on climate change, including it in the BS FEP provides a direct link for the Council to be involved in prioritizing Action Module research that addresses questions most relevant to Council fishery management. This is in keeping with the BS FEP's purpose to facilitate dialogue between managers, co-managers, scientists, and diverse stakeholders. This Action Module will provide a five to seven-year climate context within which to interpret and respond to annual signals and will establish a more formal process for considering those variables. This is responsive to the BS FEP purpose to build resiliency into the Council's management strategies, and to enhance the capacity for adaptive EBFM approaches in the context of shifting climate conditions. |
| 3. How it will inform the Council process | Climate-ready fisheries management will help continue the legacy of sustainable fisheries management in the region, including management to promote a productive marine ecosystem and healthy vibrant marine fisheries. Results will inform short, medium, and long-term "climate ready" tactical and strategic management measures. |
| 4. How it will be integrated in the Council process | Short-term "climate-ready" management actions can be developed and implemented relatively quickly, thus climate change management strategy evaluations would be focused on testing their performance under the full scope of potential future conditions. In contrast, modification of medium- and long-term management measures require more specific characterization of risk and uncertainty around future trajectories, with thorough scientific evaluation as well as stakeholder and Council review and feedback. This information can provide a frame of reference for setting harvest recommendations and implementing other management actions. Alternatively, climate-specific biomass reference limits (e.g., temperature-specific $F_{ABC}$) are derived using projections of environmentally enhanced single- or multi-species assessment models and can be used to set harvest rates that account for future climate variability. If management strategy evaluations as part of objective (3) determine the performance of these reference points is acceptable or preferable, they could be used to set harvest recommendations (or alternatively, could be presented along with status-quo assessment values) and to inform conservation measures. |

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| 5. Estimate of time and staff resources | Multiple ongoing projects at AFSC are already providing the logistical and analytical support to meet the first two parts of the Action Module, as well as provide the modeling platforms for part 3. Interdisciplinary teams like those already assembled for ongoing projects will be needed to conduct the full 5- to 7-year MSE evaluations, but personnel needs will depend greatly on the number and complexity of MSE scenarios and the number of new species evaluations. |

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| 6. Plan for public involvement | For this Action Module, the Council may solicit public input, to identify priorities for MSE evaluations. The climate change module taskforce would ideally include broad expertise across diverse knowledge holders (e.g., traditional knowledge holders). Stakeholders will also be involved through the Council process and iterative dialogue with module taskforce members. |