



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

December 2020

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 an Action Module for Climate Change within 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). 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 coupled social-ecological system of the Bering Sea.

The work plan provides three overarching objectives:

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

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

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

Activities associated with each objective are detailed in this work plan. Additionally we propose an annual cycle to summarize and deliver actionable climate information and advice relevant to fisheries management in the Eastern Bering Sea (EBS). The CCTF will conduct Adaptation and Climate Testimonial Workshops, centered around Climate Briefings, which will aid in this endeavor. These Briefings will include Indigenous, Traditional, and Local Knowledge (IK, TK, and LK) (see Kawerak 2018) inputs regarding climate change from communities in Alaska, as well as academic and agency research inputs regarding climate change and fisheries. The Taskforce 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. The Taskforce 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.

In summary, over the 5-year timeframe of the CCTF effort, this module will seek to provide the Council with recommendations for pathways to identify and implement management measures that provide for fisheries adaptation to future climate conditions and to ensure that diverse perspectives and knowledge sources are considered when developing these recommendations and when assessing risks, impacts and tradeoffs.

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

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 particularly important 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.

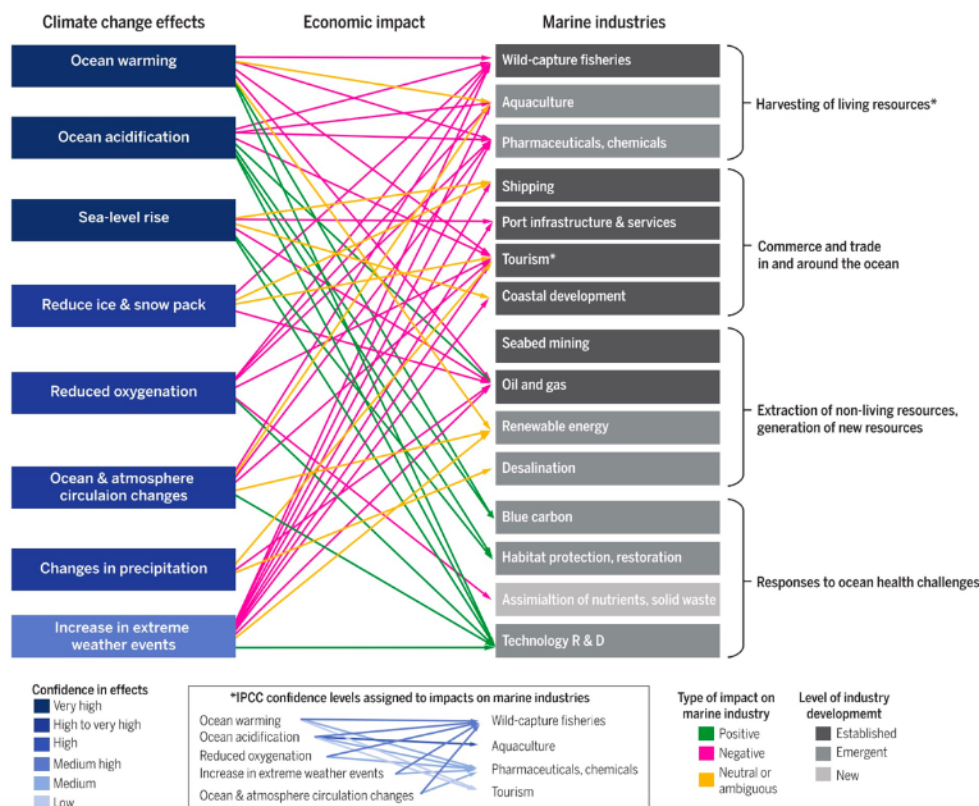


Figure 2. Climate change impacts on marine systems. From Alisson and Bassett 2015.

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 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.

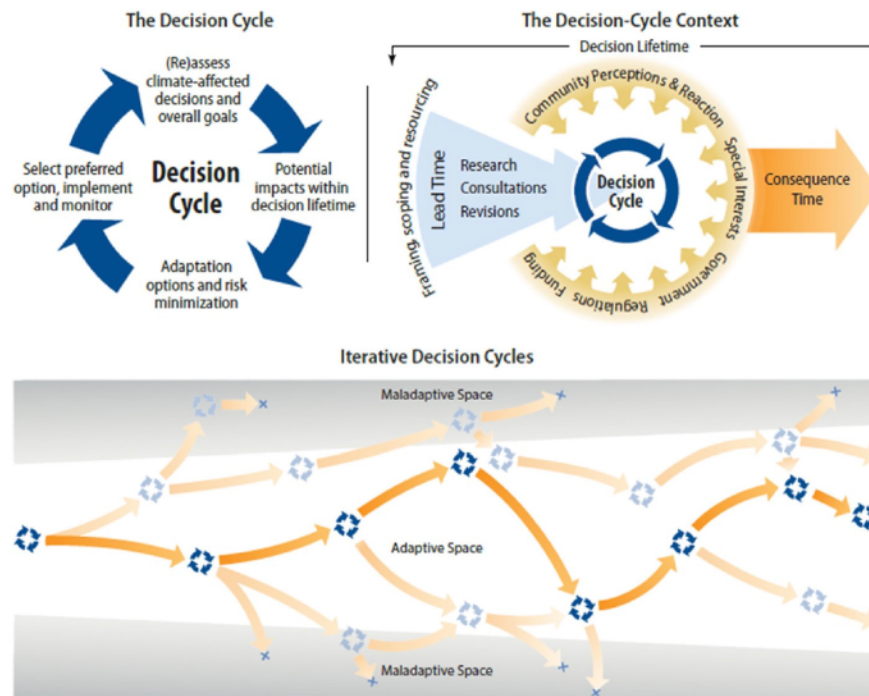


Figure 3. Climate adaptation pathways. From Wise et al. 2014.

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 CO₂. 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:

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

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

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

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 new and emergent climate change information, both immediate and long-term in scope (most

long-term information is currently not included in ESRs and other 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 (such as the Ecosystem Status Report teams) 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 card and executive summary (similar in structure to the Ecosystem Status Report but with a strategic rather than tactical goal to differentiate from the purpose of the ESR in informing the specifications process).

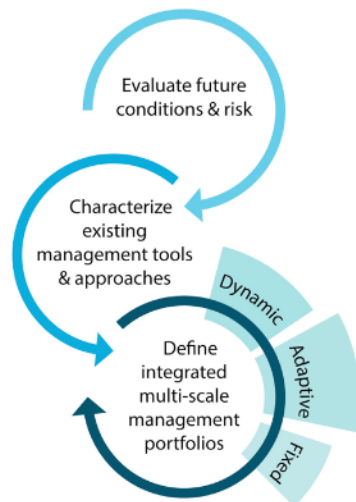


Figure 4. Iterative climate-resilient fisheries management approach. Modified from Holsman et al. 2019.

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.

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 Indigenous Knowledge; Traditional Knowledge; Local Knowledge; ongoing, proposed, and completed projects (e.g., ACLIM); 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). Of particular interest to the Council might be 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.

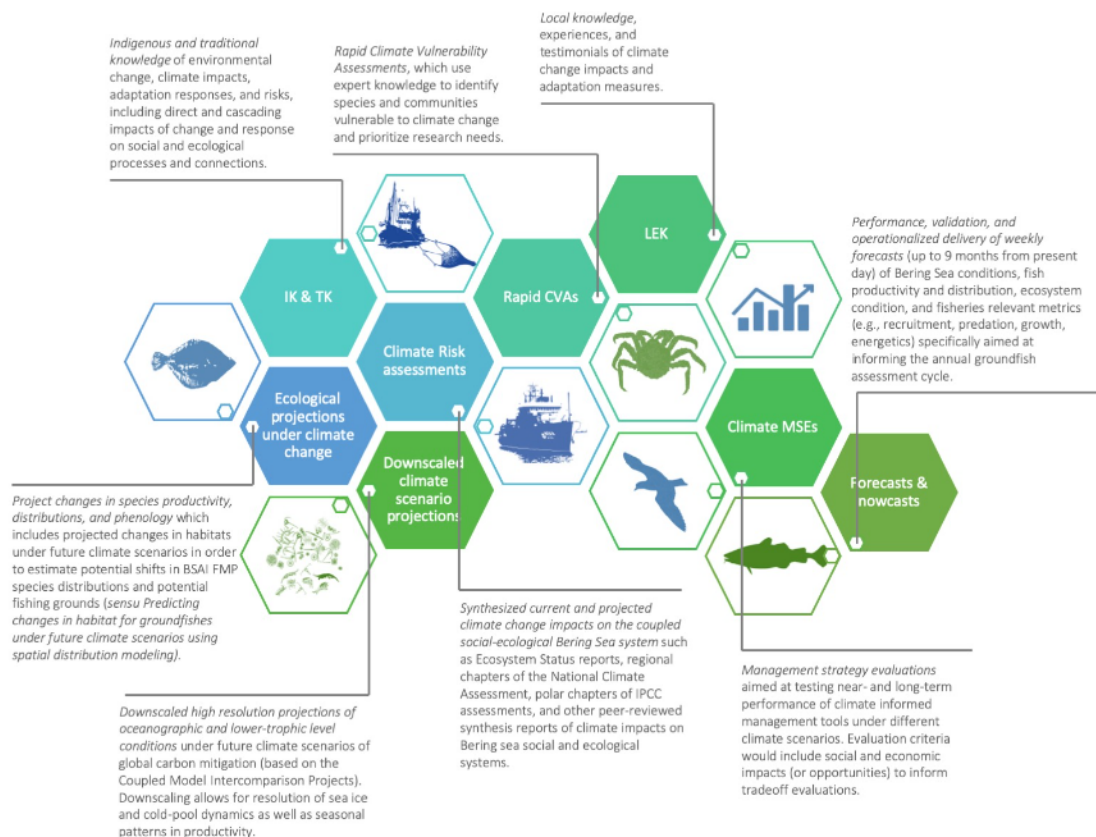


Figure 5. Example of potential sources of information to be synthesized by the CCTF.

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 LLK/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 and 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 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 and 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. In this spirit, 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 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).

Climate-informed fisheries management: New “on-ramps” and existing coordination

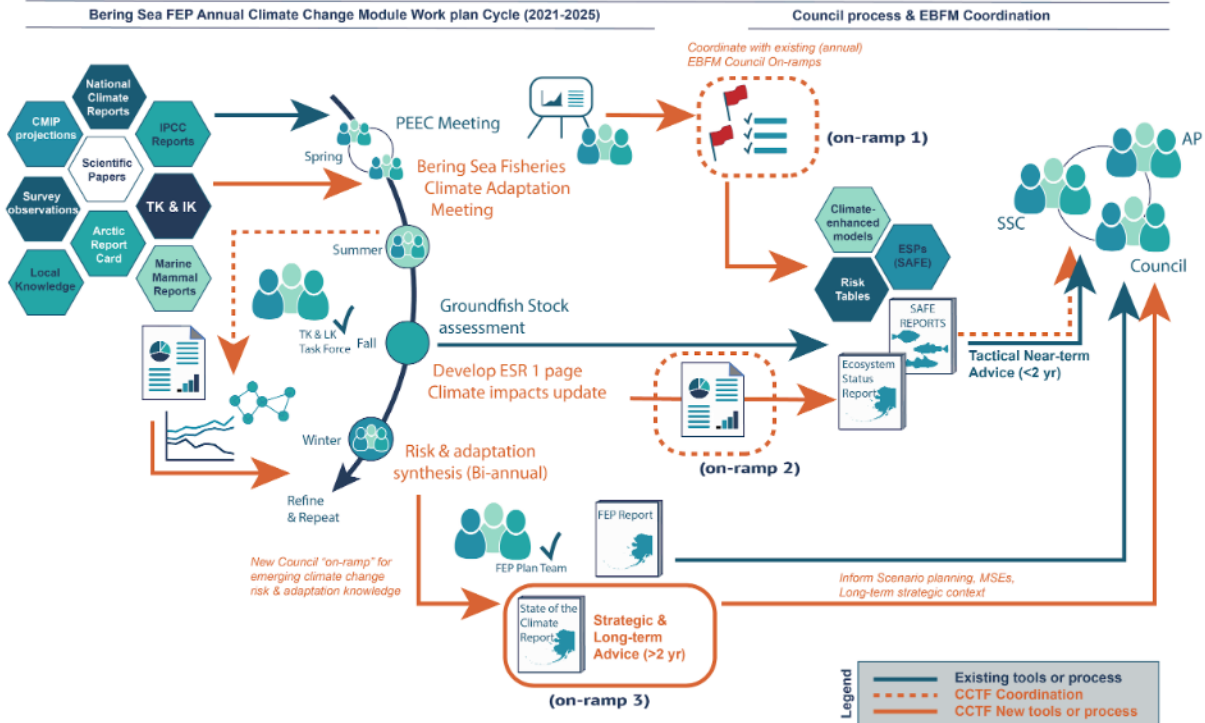


Figure 6. Climate Change Task Force process for synthesis and delivery of information to the Council to support climate-informed management in the Bering Sea. Note the three proposed “on-ramps” for climate change information.

CCTF Activity 3.2 Summarize relevant climate change information as a 1-2 page contribution for inclusion in the annual Ecosystem Status Report (On-ramp 2)

The Ecosystem Status Report (ESR) annually provides ecosystem information to the Council process and provides important strategic context for harvest recommendations. The CCTF will synthesize key climate change findings and contribute updated information as a 1-2 page contribution to the ESR. Long-term projections 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 will add additional perspective to the climate conditions and extreme events currently summarized in the ESR.

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 (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 related 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 deliverables are listed below and discussed in relationship to the Objectives and/or Activities from which they will be developed. Progress towards meeting the CCTF goals is also noted.

Products of the CCTF annual process:

On-ramp 1: Climate-informed stock assessment

- **When:** Annually as part of the annual stock assessment cycle
- **Who:** CCTF will produce this summary based on review of contributions provided during the Climate Adaptation meetings, as well as synthetic analysis of diverse sources of climate information. CCTF will coordinate information holders with Ecosystem and Socio-economic

Profile (ESP) teams and assessment authors to facilitate rapid uptake of climate information into stock assessment.

- **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 coordinate knowledge holders with ESP leads to help increase the speed of uptake of climate information into tactical decision making (as is deemed appropriate).

On-ramp 2: Climate-informed strategic advice

- **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 approach of the Ecosystem Status Report), and synthetic analysis of diverse sources of climate information.
- **What:** This short 1-2 page summary contribution for the ESR provides an annual process to:
 - Review climate change tactical and strategic considerations for the coming year.
 - Provide a multiyear context of climate conditions and changes in the Bering Sea (e.g., past and next 5-10 years, as well as 100+ context) to inform near term management decisions.

On-ramp 3: Operational 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 stakeholders and will provide it to the Council and public
- **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.

References

- Allison, E and HR Bassett. (2015). Climate change in the oceans: Human impacts and responses, *Science* 350 (6262), 778-782.
- Cheung, W. W. L., and T. L. Frölicher. 2020. Marine heatwaves exacerbate climate change impacts for fisheries in the northeast Pacific. *Scientific Reports* 10:1–10.
- Duffy-Anderson, J. T., P. Stabeno, A. G. Andrews, K. Cieciel, A. Deary, E. Farley, C. Fugate, C. Harpold, R. Heintz, D. Kimmel, K. Kuletz, J. Lamb, M. Paquin, S. Porter, L. Rogers, A. Spear, and E. Yasumiishi. 2019. Responses of the Northern Bering Sea and Southeastern Bering Sea Pelagic Ecosystems Following Record-Breaking Low Winter Sea Ice. *Geophysical Research Letters* 46:9833–9842.
- Dumas, 1984. Prehistory of the Bering Sea Region. In: Damas (Editor), *Handbook of North American Indians*. Smithsonian Institute, Washington DC, pp. 94-105.
- Fall et al. 2013. Continuity and change in subsistence harvests in five Bering Sea communities: Akutan, Emmonak, Savoonga, St. Paul and Togiak. *Deep-Sea Research Part II*, 94: 274-291.
- Frölicher, T. L., E. M. Fischer, and N. Gruber. 2018. Marine heatwaves under global warming. *Nature* 560:360–364.
- Gadamus, L. and J. Raymond-Yakoubian. 2015. A Bering Strait Indigenous Framework for Resource Management: Respectful Seal and Walrus Hunting. In *Arctic Anthropology* 52(2): 87-101.
- Haynie and Huntington 2016. Strong connections, loose coupling: the influence of the Bering Sea ecosystem on commercial fisheries and subsistence harvests in Alaska. *Ecology and Society*, 21(4).

- Hazen, E. L., K. L. Scales, S. M. Maxwell, D. K. Briscoe, H. Welch, S. J. Bograd, H. Bailey, S. R. Benson, T. Eguchi, H. Dewar, S. Kohin, D. P. Costa, L. B. Crowder, and R. L. Lewison. 2018. A dynamic ocean management tool to reduce bycatch and support sustainable fisheries. *Science Advances* 4:doi: 10.1126/sciadv.aar3001.
- Hollowed, A. B., K. K. Holsman, A. C. Haynie, A. J. Hermann, A. E. Punt, K. Aydin, J. N. Ianelli, S. Kasperski, W. Cheng, A. Faig, K. A. Kearney, J. C. P. Reum, P. Spencer, I. Spies, W. Stockhausen, C. S. Szuwalski, G. A. Whitehouse, and T. K. Wilderbuer. 2020. Integrated Modeling to Evaluate Climate Change Impacts on Coupled Social-Ecological Systems in Alaska.
- Holsman, K. K., A. C. Haynie, A. B. Hollowed, J. C. P. Reum, K. Aydin, A. J. Hermann, W. Cheng, A. Faig, J. N. Ianelli, K. A. Kearney, and A. E. Punt. 2020. Ecosystem-based fisheries management forestalls climate-driven collapse. *Nature Communications* 11:4579.
- Holsman, K. K., E. L. Hazen, A. Haynie, S. Gourguet, A. Hollowed, S. J. Bograd, J. F. Samhour, and K. Aydin. 2019. Towards climate resiliency in fisheries management. *ICES Journal of Marine Science*.
- Karp, M. A., J. O. Peterson, P. D. Lynch, R. B. Griffis, C. F. Adams, W. S. Arnold, L. A. K. Barnett, Y. DeReynier, J. DiCosimo, K. H. Fenske, S. K. Gaichas, A. Hollowed, K. Holsman, M. Karnauskas, D. Kobayashi, A. Leising, J. P. Manderson, M. McClure, W. E. Morrison, E. Schnettler, A. Thompson, J. T. Thorson, J. F. Walter, A. J. Yau, R. D. Methot, and J. S. Link. 2019. Accounting for shifting distributions and changing productivity in the development of scientific advice for fishery management. *ICES Journal of Marine Science* 76:1305–1315. <https://doi.org/10.1093/icesjms/fsz048>
- Kawerak. 2017. Kawerak White Paper: Knowledge and Subsistence related terms. <https://kawerak.org/wp-content/uploads/2018/04/Kawerak-Knowledge-and-Subsistence-Related-Terms.pdf>
- Laufkötter, C., J. Zscheischler, and T. L. Frölicher. 2020. High-impact marine heatwaves attributable to human-induced global warming. *Science (New York, N.Y.)* 369:1621–1625.
- Lenton, T. M., J. Rockström, O. Gaffney, S. Rahmstorf, K. Richardson, W. Steffen, and H. J. Schellnhuber. 2019. Climate tipping points — too risky to bet against. *Nature* 575:592–595.
- Meredith et al. 2019. Polar Regions. In: Portner, Roberts, Masson-Delmotte, Zhai, Tignor, Poloczanska, Mintenbeck, Nicolai, Okem, Petzold, Rama and Weyer (Editors), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.
- North Pacific Fishery Management Council (NPFMC), 2019. Bering Sea Fishery Ecosystem Plan.
- Oliver, E. C. J., M. G. Donat, M. T. Burrows, P. J. Moore, D. A. Smale, L. V. Alexander, J. A. Benthuyzen, M. Feng, A. Sen Gupta, A. J. Hobday, N. J. Holbrook, S. E. Perkins-Kirkpatrick, H. A. Scannell, S. C. Straub, and T. Wernberg. 2018. Longer and more frequent marine heatwaves over the past century. *Nature Communications* 9:1–12.
- Piatt, J. F., J. K. Parrish, H. M. Renner, S. K. Schoen, T. T. Jones, M. L. Arimitsu, K. J. Kuletz, B. Bodenstern, M. García-Reyes, R. S. Duerr, R. M. Corcoran, R. S. A. Kaler, G. J. McChesney, R. T. Golightly, H. A. Coletti, R. M. Suryan, H. K. Burgess, J. Lindsey, K. Lindquist, P. M. Warzybok, J. Jahncke, J. Roletto, and W. J. Sydeman. 2020. Extreme mortality and reproductive failure of common mures resulting from the northeast Pacific marine heatwave of 2014-2016. *PLOS ONE* 15:doi: 10.1371/journal.pone.0226087.

- Poloczanska, E. S., C. J. Brown, W. J. Sydeman, W. Kiessling, D. S. Schoeman, P. J. Moore, K. Brander, J. F. Bruno, L. B. Buckley, M. T. Burrows, C. M. Duarte, B. S. Halpern, J. Holding, C. V Kappel, M. I. O'Connor, J. M. Pandolfi, C. Parmesan, F. Schwing, S. A. Thompson, and A. J. Richardson. 2013. Global imprint of climate change on marine life. *Nature Climate Change* 3:919–925.
- Punt, A. E., R. J. Foy, M. G. Dalton, W. C. Long, and K. M. Swiney. 2016. Effects of long-term exposure to ocean acidification conditions on future southern Tanner crab (*Chionoecetes bairdi*) fisheries management. *ICES Journal of Marine Science: Journal du Conseil* 73:849–864.
- Raymond-Yakoubian, et al. 2017. The incorporation of traditional knowledge into Alaska federal fisheries management. *Marine Policy*, 78: 132-142.
- Raymond-Yakoubian, J. and R. Daniel. 2018. An Indigenous approach to ocean planning and policy in the Bering Strait region of Alaska. In *Marine Policy* 97: 101-108.
<https://doi.org/10.1016/j.marpol.2018.08.028>
- Reum, J. C. P., J. L. Blanchard, K. K. Holsman, K. Aydin, A. B. Hollowed, A. J. Hermann, W. Cheng, A. Faig, A. C. Haynie, and A. E. Punt. 2020. Ensemble Projections of Future Climate Change Impacts on the Eastern Bering Sea Food Web Using a Multispecies Size Spectrum Model. *Frontiers in Marine Science* 7:1–17.
- Siddon, E., and S. Zador. 2019. Ecosystem Considerations 2019: Status of the Eastern Bering Sea Marine Ecosystem. Page NPFMC Bering Sea and Aleutian Islands SAFE. Anchorage, AK.
<https://access.afsc.noaa.gov/REFM/REEM/ecoweb/pdf/2019EBSecosys.pdf>
- Sigler, M, Hollowed, A, Holsman, KK,+9 (2016). Alaska Regional Action Plan for Southeastern Bering Sea Climate Science. NOAA Technical Memo NMFS-AFSC-336 [doi:10.7289/V5/TM-AFSC-336](https://doi.org/10.7289/V5/TM-AFSC-336).
- Smale, D. A., T. Wernberg, E. C. J. Oliver, M. Thomsen, B. P. Harvey, S. C. Straub, M. T. Burrows, L. V. Alexander, J. A. Benthuyssen, M. G. Donat, M. Feng, A. J. Hobday, N. J. Holbrook, S. E. Perkins-Kirkpatrick, H. A. Scannell, A. Sen Gupta, B. L. Payne, and P. J. Moore. 2019. Marine heatwaves threaten global biodiversity and the provision of ecosystem services. *Nature Climate Change* 9:306–312.
- Spencer, P. D., A. B. Hollowed, M. F. Sigler, A. J. Hermann, and M. W. Nelson. 2019. Trait-based climate vulnerability assessments in data-rich systems: An application to eastern Bering Sea fish and invertebrate stocks. *Global Change Biology* 25:3954–3971.
- Spies, I., K. M. Gruenthal, D. P. Drinan, A. B. Hollowed, D. E. Stevenson, C. M. Tarpey, and L. Hauser. 2020. Genetic evidence of a northward range expansion in the eastern Bering Sea stock of Pacific cod. *Evolutionary Applications* 13:362–375.
- Stevenson, D. E., and R. R. Lauth. 2019. Bottom trawl surveys in the northern Bering Sea indicate recent shifts in the distribution of marine species. *Polar Biology* 42:407–421.
- Seung, C., and J. N. Ianelli. 2016. Regional economic impacts of climate change: a computable general equilibrium analysis for an Alaska fishery. *Natural Resource Modeling* 29:289–333.
- Wise et al. 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. *Global Environmental Change* 28: 325–336.

Climate Change Taskforce (CCTF) Membership

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Appendix 1

Working draft of Adaptation in the Bering Sea coupled social- ecological system

Overview:

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 ,as well as attendant metrics and indicators of progress (or limitations) towards implementation and performance. The 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.

Adaptation definition (draft):

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 CO₂. 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.

Metrics of adaptation progress and performance:

[This to be developed collaboratively]

Discussion Questions:

The following is a draft list of key framing questions related to adaptation:

- How do stakeholders of various communities, cultures, and perspectives define adaptation?
- What does it mean to adapt? What does this mean in terms of key factors e.g. economic, social, cultural, etc.?
- What triggers adaptation? What are key indicators of this? What can be seen as evidence for and against?
- What is being adapted to, and at what spatial and temporal scales?
- Who, or what, adapts? And how are different considerations for adaptation tailored in each case?
- What does it mean to adapt “well”? By what means and/or metrics is this ‘measured’? How do we adapt “well,” including considerations of synergies, co-benefits, equity, and inclusiveness?
- What evidence exists that particular adaptation actions have been successful (e.g. case studies, evaluations, etc.)? What evidence is there that particular actions have not been successful?
- What are barriers and limits to adaptation? What types of factors facilitate successful adaptation?
- Which factors make adaptation maladaptive?
- Which timeframes and spatial dimensions are most relevant to particular kinds of adaptation and adaptation measures?
- How do adaptation strategies, needs, and opportunities differ between sectors? Across Communities? Fisheries? Global Within communities (across social strata)?
- What does robust iterative risk management look like?
- How robust are existing fishery management policies to climate change? How can they be made more robust?
- How do we consider policy changes that could encourage adaptation alongside individual actions that will, or are already, being taken (e.g., adaptation that is occurring without policy or within existing policies)?
- Do we need to differentiate climate-necessitated adaptation from adaptation resulting from other external forces (technology, e.g.)?
- What are the linkages between adaptation and access to information?
- What are key sensitivities and existing vulnerabilities and risks/adaptation needs?
- What are existing sources and models of climate resilience and adaptation?
- Regarding adaptation planning, prioritization and implementation: what exists, what do we need to consider, what else can/should be done?
- What are the institutional dimensions for adaptation planning and implementation (what exists, what need to consider, what can/should be done, etc.)?
- In all of this, how do we address equity, rights, synergies/trade-offs, especially with mitigation?
- What are some financing options to support adaptation and reduce impacts?
- Regarding monitoring and evaluation of adaptation planning and implementation, and learning from the processes: what do we need to consider, etc.

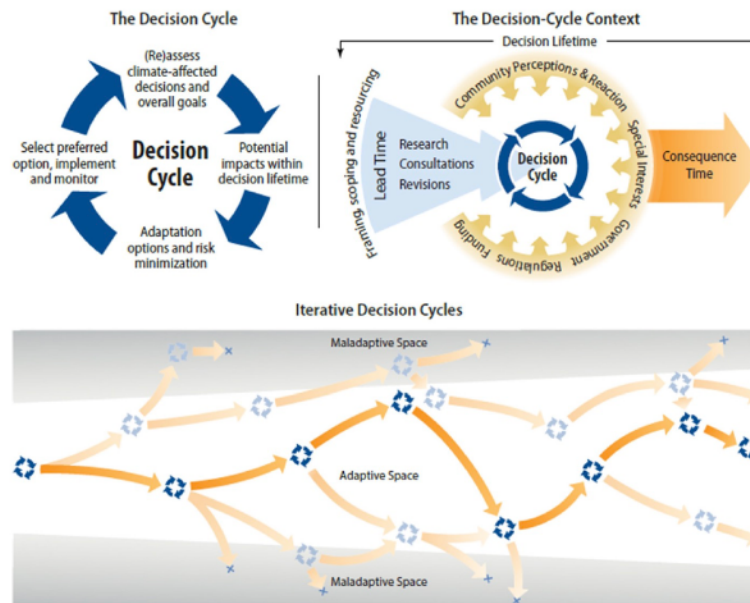
- Regarding realised costs and benefits (including externalities, maladaptation): what are they, who carries the cost of adaptation, etc.?

Assessing these questions necessitates consideration of the following:

- Cross-cultural variability in defining and understanding adaptation
- The need for a diversity of knowledge inputs in order to craft policy and management related to adaptation
- Key sensitivities and existing vulnerabilities and risks/adaptation needs
- Understanding impacts to adaptation for communities, culture, subsistence, and various activities in fisheries
- Existing sources and models of climate resilience and adaptation
- Adaptation planning, prioritization and implementation
- The institutional dimension for adaptation planning and implementation
- Identifying and removing constraints to adaptation (e.g., policies that increase flexibility in catch-shares)
- Addressing equity, rights, and synergies/trade-offs (including with mitigation)
- Monitoring and evaluation of adaptation planning and implementation, and learning from the processes
- Realised costs and benefits (including externalities, maladaptation); who carries the cost of adaptation?
- Links with Sustainable Development Goals (SDGs) and Disaster Risk Reduction (sustainabledevelopment.un.org) especially SDGs 13 & 14.

Appendix 2

Resilience of the Bering Sea coupled social-ecological system



Overview

As the CCTF seeks to provide information recommendations to help the Council advance adaptive management that helps ensure resilient ecosystems, fisheries, and communities, it seems wise to have working definitions of those terms. The IPCC definitions for “adaptation” and “resilience” and the CCTF preliminary definitions of each are provided in the CCTF workplan and included as starting points for discussion. The CCTF intends to work collaboratively with stakeholders to periodically update and revise the working definitions of adaptation and resilience that underlie this work plan and Action Module work products.

Definition of resilience

As with ‘adaptation’, the CCTF will work collaboratively with stakeholders to develop a working definition of the important and linked concept of ‘resilience.’ What is offered herein is a starting point for that work. 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.

Metrics of resilience:

[to be added collaboratively]

Climate resilience means and looks like (draft):

For Human Communities:

- (Meta-level note: Importance of collaborative conceptualization and interpretation of adaptation, resilience, etc)
- (Meta-level note: Preference for and necessity of rich qualitative data)
- Sustained communities, “vibrant” communities, ability to remain within the community (e.g., St. Paul), community viability.
- Strong social cohesion, integration of community and resource and livelihoods
- Ability to thrive despite variability in resource abundance or availability
- A future for the community (youth and culture thriving); may also include pathways for transmission of knowledge between generations
- Mental and physical health. Lack of stress
- Food security
- [maybe?] Portfolio of economic, food, and nutritional resources
- Durability in social and cultural systems and traditions
- Sense of well-being as locally defined
- Self-determination
- Access to information

For Biological resilience:

- Genetic diversity
- physiological scope for enduring variability
- Matched, albeit lagged temporal / spatial scales of variability between drivers and species
- Healthy habitats and resources
- Sustained recruitment
- Balanced trophic structure - sustained upper-trophic productivity

For Coupled social-ecological systems:

- Sustained strong connections between species and people that rely on them
- Management that can adjust to the changes in biological system yet still provide stability under increasing climate variability
- Support of multiple options for fisheries
- Co-management
- Matched, albeit lagged temporal / spatial scales of variability between species and people
- Strong information-based decision making that includes diverse knowledge sources and perspectives; e.g. co-production of knowledge informed decision-making

Appendix 3

Climate briefing

Dear Expert,

The Climate Change Task-Force (CCTF) welcomes your knowledge and perspectives regarding climate change, the marine ecosystem, and management of the federal fishery. As such, we invite you to participate in the Adaptation and Climate change Testimonial (ACT) meeting by filling out the 'Climate Briefing' below.

Background and Context:

The following topics provide the broad context in which we are asking the questions on this form: 1) What are the key emergent risks and impacts and innovative adaptation responses to climate change in the Bering Sea coupled social-ecological system? 2) How do people understand 'adaptation' and 'resilience' as it pertains to climate change?; 3) What key information, perspectives, and concerns do people have with regard to climate change and the Bering Sea, the marine ecosystem, and fisheries management which the NPFMC should be aware of?; and 4) What are the implications for management and adaptation from this information and perspectives?

In that context, please provide below 1 or 2 key points or vignettes which highlight crucial information and perspectives the NPFMC should know regarding climate change, the marine environment, and implications for fisheries management.

How this information will be used:

The answers in the form below will be used to general a 1-2 page document within the "Ecosystem health and Climate Options Report" and we be used to brief the NPFM Council on current understanding regarding climate change impacts and adaptation. We also welcome you to provide citations for further reading or information you would like to share with the Council and public.

Additionally, we optionally ask below for your perspective on defining 'adaptation' and 'resilience' which will guide the development of these concepts within the Fisheries Ecosystem Plan Climate Change module.

Next steps:

After you fill out the form below a CCTF member will contact you to confirm receipt and to provide you a proof of the template for your edit and review. We will also reach out regarding the agenda a proposed 5-10 minute time-slot for your testimonial during the ACT meeting.

Thank you for sharing your knowledge!

Best,

The NPFMC Bering Sea Fishery Ecosystem Plan Climate Change Taskforce

* Required

1. Name: *

2. Email: *

3. Adaptation & Climate Testimonial (ACT) meeting: *

Mark only one oval.

- I will present this 5-10 minute testimonial in person at the ACT meeting
- I will present this 5-10 minute testimonial remotely via teleconference at the ACT meeting
- I would like a Climate Change Task Force member to present this testimonial on my behalf at the ACT meeting
- Option 4
- Other: _____

4. Please provide an Overview Statement which briefly addresses the following: Who you are and where you are from; Who you are speaking on behalf of; What you are providing information about [limit 150 words]

- 5. Please provide a summary of 1 or 2 key points (e.g. headlines, vignettes, observations, findings, etc.) which highlight crucial information and perspectives the NPFMC should know regarding climate change, the marine environment, and implications for fisheries management [limit 250 words]

- 6. Please discuss the implications (for fisheries management adaptation to climate change) of those key points you just described above [limit 250 words]

- 7. Please describe where the information you are presenting comes from and/or how it was gathered (i.e., methods, background, supportive context or observations) [limit 250 words]

- 8. Please list or describe additional sources of information, graphics, or further reading (e.g., links, references, etc.; please use ";" to indicate separate entries).

- 9. We are working to gain insight and input on climate change resilience and adaptation and we would like your perspective on these concepts in general. How do you understand adaptation and resilience as it pertains to climate change? [limit 250 words]

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Google Forms

Appendix 4. Action Module Scoping Summary from Core BSFEP

<p>1. Synopsis including how it will be accomplished</p>	<p>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).</p>
<p>2. Purpose relationship to the BS FEP's strategic objectives</p>	<p>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.</p>
<p>3. How it will inform the Council process</p>	<p>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.</p>

<p>4. How it will be integrated in the Council process</p>	<p>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.</p>
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<p>5. Estimate of time and staff resources</p>	<p>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.</p>
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<p>6. Plan for public involvement</p>	<p>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.</p>
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