Developing a workplan for the FEP Climate Change Module

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Alaska Fisheries Science Center

Climate Task Force Meeting 1
Jan, 2020
Today: Agenda

• Intro to Task Force
• Brief background
• Module objective & goals
• Module outcomes & products
• CCTF planning & logistics
TODAY’S GOALS:

1. Finalize a draft workplan to send to the Council next week
2. Derive a list of issues / questions we’d like feedback on specifically
3. Clarify our goals, process, and logistics
# Google docs

## File List

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<tr>
<th>Name</th>
<th>Owner</th>
<th>Last modified</th>
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<tbody>
<tr>
<td>01 CCTF Supporting Docs</td>
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<td>Dec 20, 2019 me</td>
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<tr>
<td>CCTF Meetings</td>
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<td>Dec 17, 2019 me</td>
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<tr>
<td>01 CCTF Timeline and Important data</td>
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<td>02 Helpful Links</td>
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<td>03 Contact info for CCTF members</td>
<td>me</td>
<td>Dec 20, 2019 me</td>
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<td>04 Glossary of Terms</td>
<td>me</td>
<td>Jan 8, 2020 Jamal Moss - NOAA</td>
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<td>Dec 17, 2019 me</td>
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<td>Meeting Notes</td>
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<td>Pre-meeting Homework</td>
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<td>Working_Draft_Climate change Ac...</td>
<td>me</td>
<td>Jan 17, 2020 Diana Stram - NOAA</td>
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</table>
Survey results
### Connection to the Bering Sea:

<table>
<thead>
<tr>
<th>Years</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>17 years with NPFMC, have coordinated plan teams for BSAI groundfish, BSAI crab, worked on BSAI halibut and salmon bycatch issues and management amendments</td>
</tr>
<tr>
<td>21</td>
<td>21 years of marine mammal research in Alaska</td>
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<tr>
<td></td>
<td>extensive work with communities and other partners on fisheries management, climate change, marine mammals, marine debris, governance, and other issues in the Bering Sea</td>
</tr>
</tbody>
</table>

**Fisheries Management Specialist with the Alaska Regional Office.**

**I work as a social scientist with Bering Sea Tribes, Tribal organizations, and communities. I also used to live in Nome.**

**Run a natural resources department for a tribal government**

**Work with the Fishing Industry and Council on Data & Policy issues**
What are some of your primary sources of information on current climate impacts on the Bering Sea?

9 responses

- First-hand experience (local knowledge): 5 (55.6%)
- Indigenous knowledge: 2 (22.2%)
- News and media: 7 (77.8%)
- Scientific reports or studies: 9 (100%)
- IPCC documents: 2 (22.2%)
- Council reports: 7 (77.8%)
- Government reports: 7 (77.8%)
- Social media: 1 (11.1%)
- Network of other knowledge holders and ...: 1 (11.1%)
What do you hope the Climate Change Task Force / Climate Change Module can accomplish in the next 3-5 years of the Task Force timeframe? (2020-2025)

What do you hope the Climate Change Task Force / Climate Change Module can accomplish in the next 10-20 years?
What are your TOP 3 goals for this first CCTF meeting?

1. Identify goals for the task force and module (28%)
2. Gain a better understanding of the FEP and the climate module (16%)
3. Meet the rest of the CCTF team and build connections (24%)
Background
CMIP5 ENSMN Annual SST anomaly (°C)
(2050 to 2099) - (1956 to 2005)

Projection data from CMIP5 (Taylor et al., 2012) avail. at: www.esrl.noaa.gov/psd/ipcc/ocn

Modified from Fig. 6.2 Holsman et al. 2018 [in ] Barange et al. (Eds.) 2018. Impacts of climate change on fisheries and aquaculture. TP 627.
CMIP5 ENSMN Annual Ocean pH anomaly (2050 to 2099) - (1956 to 2005)

CO2 mitigation scenario
CMIP5 ENSMN RCP2.6 anomaly (2050-2099)-(1956-2005)

High baseline scenario ("Business as usual")
CMIP5 ENSMN RCP8.5 anomaly (2050-2099)-(1956-2005)

Projection data from CMIP5 (Taylor et al., 2012) avail. at: www.esrl.noaa.gov/psd/ipcc/ocn

Anomaly from 1961-1990 climatology, 1 degree, weekly resolution

NOAA/NWS/NCEP/EMC Marine Modeling and Analysis Branch Oper H.R.

RTG_SST_HR Anomaly (0.083 deg X 0.083 deg) for 06 May 2019


http://polar.ncep.noaa.gov/sst/rtg_high_res
Increased warming (2090-2099)-(2010-2019)

“We find that mean SST change was the dominant driver of increasing MHW exposure over nearly two thirds of the ocean, and of changes in MHW intensity over approximately one third of the ocean.”
Fall in fish catch threatens human health

Christopher Golden and colleagues calculate that declining numbers of marine fish will spell more malnutrition in many developing nations.

How will the 10 billion people expected to be living on Earth by 2050 obtain sufficient and nutritious food? This is one of the greatest challenges humanity faces. Global food systems must supply enough calories and protein for a growing human population and ensure food is available in nutritious and affordable forms. Fish are crucial sources of micronutrients, often in highly bioavailable forms. And fish intakes are declining. Most worryingly, this new view underscores the need for nutrition-sensitive fisheries policies.

Fig 4. Baseline and projected percentage contributions to the DRI from total seafood in First Nations by (A) gender and (B) by age groups, under ‘strong mitigation’ (RCP 2.6) and ‘business-as-usual’ (RCP 8.5) climate change scenarios. DRI—dietary reference intakes using recommended dietary allowance (RDA) and recommended intake (RI) for EPA+DHA.

https://doi.org/10.1371/journal.pone.0211473.g004
Consider nested scales of management & adaptation

Adaptation: increased flexibility

Adaptation: climate-enhanced stock assessments

Adaptation: nowcast/ forecast maps of risk/ sea ice/spp distributions

Test new & existing tools

Adaptation

incremental (normative) adaptation to preserve current livelihoods, health, and well being and meet future demands

transformational adaptation, especially to address/prevent continued marginalization and promote diverse well being, values, and views

Build capacity to reevaluate & enable transformative actions

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Fig. 1 from Wise et al. 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environmental Change 28: 325–336
HOW?

FEP Climate Change Module
Module goal:

”facilitate and support equitable climate change adaptation pathways and long-term resilience for the coupled social-ecological system of the Eastern Bering Sea”

i) evaluate management tools to develop incremental (normative) adaptation measures to preserve livelihoods, health and wellbeing across fisheries and dependent coastal communities

ii) enable transformative adaptation needed to ensure the productivity and sustainability of the coupled social-ecological Bering Sea system
“knowledge and culture construct societal limits to adaptation, but these limits are mutable”
- Adger et al. (2009).
✓ Risk inherently depends on values
✓ Include a “plurality of perspectives” *
✓ Consider interacting (non-linear) pressures

✓ Risk inherently depends on values
✓ Include a “plurality of perspectives” *
✓ Consider interacting (non-linear) pressures

“Interconnections among risks can span sectors and regions with multiple climatic and non-climatic influences, including societal responses to climate change and other issues (Helbing 2013; Moser and Hart 2015; Oppenheimer 2013).”
- Mach et al. 2016
“One ongoing challenge is developing and addressing research questions from a Traditional Knowledge lens rather than solely from a western researcher's perspective.”


How best to coordinate with TK / LK module?
Objectives / tasks:

"To achieve this, the climate change module will be used to..."

✓ **synthesize current knowledge** regarding climate change effects on the EBS system,

✓ **identify potential climate-resilient management measures** that can improve adaptive capacity and avoid maladaptation

✓ **evaluate the risk, timescale, and probability of success of various climate-resilient management policies** under future scenarios of change

✓ **provide prioritized recommendations for actions research and MSEs that could be taken to advance the goals and minimize the risks identified.**

**Policy relevant not policy prescriptive**

*(climate-resilient management would go through the existing Council process)*
**May**

Climate knowledge briefing:
- Review of testimonials & presentations of recent findings & results; 1 page reports; ID research priorities, key risks, red flags.

**Jun**

Update QNM/conceptual model; develop/update climate indicators

**Sep**

Draft synthesis report, report card & send to TK/LK TF for review, then to FEP PT for review

**Jan**

Brief Ecosystem committee, Council, SSC, AP at Jan meeting; deliver report; update research priorities

TK & LK Task Force

FEP Plan Team
PAUSE
Workplan: Goals & objectives
GOAL:

“facilitate and support equitable climate change adaptation pathways and long-term resilience for the coupled social-ecological system of the Eastern Bering Sea”

i) evaluate management tools to develop incremental (normative) adaptation measures to preserve livelihoods, health and wellbeing across fisheries and dependent coastal communities

ii) enable transformative adaptation needed to ensure the productivity and sustainability of the coupled social-ecological Bering Sea system
“The primary goal [objective?] of this climate module is to provide information, pathways, and tools that can be used to ensure climate resilience in the region’s fishery management. Specifically, the module will leverage ongoing, proposed, and completed projects at AFSC and [ADD other institutions] to address the following objectives:”
Discussion: Outcome & goals

• How best to monitor and measure success towards CC Module goals?
• Should the BSFEP Team monitor? Or should the CCTF monitor?
• Can we develop metrics and outreach to evaluate goals and outcomes?
  • “e.g. asking key stakeholder groups who are engaged at the Council (e.g. 'Do you feel management measures are sufficiently adaptive in addressing climate effects on fisheries?')”
  • doing keyword analysis of Council meetings
  • Working with some of the Council bodies - e.g. Ecosystem Committee and CEC

• Can we try to link to the ecosystem goals of the council?
Objectives

Alaska-wide

- Council's Ecosystem Vision Statement
- Ecosystem Goals 1-6

Specific to the Bering Sea FEP

- Process objectives: How do we want to achieve Ecosystem Goals for Bering Sea management through the FEP?
- Research objectives: What do we want to do first? How do we prioritize among possible Action Modules?
- Ecosystem objectives: How do we monitor and measure progress towards meeting Bering Sea Ecosystem Goals?
<table>
<thead>
<tr>
<th>Ecosystem Goal 1: Maintain, rebuild, and restore fish stocks at levels sufficient to protect, maintain, and restore food web structure and function</th>
<th>Ecosystem Objectives</th>
<th>Module evaluations</th>
<th>Metrics &amp; indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Maintain target biomass levels for target species, consistent with optimum yield, using available tools.</td>
<td>MSE: test climate informed biological reference points; test spatial and temporal regulations to address shifting distributions</td>
<td>long-term B/B0; total yield; volatility in B or C; access to subsistence resources; catch--&gt;wellbeing analyses</td>
<td></td>
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<tr>
<td>2. Maintain healthy populations and function of non-target and forage species.</td>
<td>Identify species at Risk/exposure to Climate change for non-target species (maybe based around long-term projections, scenarios, and recent extreme events)</td>
<td>Rapid vulnerability and Risk synthesis (IK/TK based and expert opinion); LK observations of change; long-term shifts in monitoring timeseries; ID uncertainty/gaps</td>
<td></td>
</tr>
<tr>
<td>3. Adjust fishing-related mortality from the system to be commensurate with total productivity and continue to limit optimum yield to 2 million metric tons for the BSAI groundfish fisheries.</td>
<td>MSE: test climate informed multispecies reference points; test spatial and temporal regulations to address shifting distributions</td>
<td>Aggregate yield; long-term B/B0; total yield; volatility in B or C; access to subsistence resources; catch---&gt;wellbeing analyses</td>
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</table>

<table>
<thead>
<tr>
<th>Ecosystem Goal 2: Protect, restore, and maintain the ecological processes, trophic levels, diversity, and overall productive capacity of the system</th>
<th>Ecosystem Objectives</th>
<th>Module evaluations</th>
<th>Metrics &amp; indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Maintain key predator/prey relationships.</td>
<td>MSE &amp; spatial analyses: evaluate changes to species overlap; project food-webs</td>
<td>Risk of collapse; changes in overlap; changes in diet &amp; food web interactions</td>
<td></td>
</tr>
<tr>
<td>5. Conserve structure and function of ecosystem components.</td>
<td>MSE and spatial analyses: project scenario changes in Fishing X Climate change scenarios through coupled social-ecological system</td>
<td>Benthic/pelagic productivity ratios; length of food-chain; access to key subsistence resources; economic and social indicators</td>
<td></td>
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</table>

**LINK TO EXCEL SPREADSHEET**
Discussion: Adaptation

• What do we mean by adaptation/maladaptation?

• What helps EBS communities and commercial fisheries adapt?
  • New fisheries and FMPs for novel species in the EBS?
  • Flexibility and diversity in subsistence and target fisheries?
  • There was a suggestion to cut “and, develop or expand fisheries for species anticipated to be favored under climate change”, thoughts?

• Perhaps we need to be specific with regards the potential risks and outline the ideal process for evaluating risks and tradeoffs?

• The challenge that remains is to
  • identify management measures that provide scope for fisheries adaptation to future climate conditions and
  • to establish a process that ensures that diverse perspectives are considered when assessing risks, impacts and tradeoffs.
Discussion: Other topics

- Geographic boundaries for CC module (FEP boundaries) – add a map?

- Rather than winners and losers, frame in terms of maladaptive risk? [BRY, JS, LD]

- Climate resilient tools: maybe make ”living” as a web based spreadsheet and or table in our report to the council?
PAUSE
Workplan: Deliverables
”To achieve this, the climate change module will be used to...”

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TK & LK Task Force

FEP Plan Team
1 Page reports from each contributor
• Characterize contribution (testimonial, research, observation)
• ID management connection/relevance
• Define scope in time and species:
  • CORE spp and BROAD (non-focal spp)
  • Short, medium, long term

ID red flags and emergent issues:
• Flag these for the report next step

ID Research needs and priorities
• Identify indirect impacts of climate driven changes
1 Page reports from each contributor
• Characterize contribution (testimonial, research, observation)
• ID management connection/relevance
• Define scope in time and species:
  • CORE spp and BROAD (non-focal spp)
  • Short, medium, long term

ID red flags and emergent issues:
• Flag these for the report next step

ID Research needs and priorities
• Identify indirect impacts of climate driven changes
Categorize types of information

Indicators (aim for ~10)
• Climate trends
• Productivity trends
• Upper trophic trends
• Human dimension trends

Conceptual model/ QNM:
• Identify direct known and potential connections
• Identify indirect impacts of climate driven changes
• Identify indirect impacts of management actions

Research needs and priorities
• Use model to identify needs

Report card
• Summary of climate related trends/ indicators

Synthesis
• Emergent issues
• Future risks
• Novel/emerging tools

Contributions (based on form)
• See example

Table of Example Management/adaptation actions:
• short, medium, long term
• Tactical vs strategic
• ID who should be included in risk assessment process
• Rapid response vs incremental adjustment

Research needs and priorities
**Arctic Answers**

Policy-relevant questions are answered in 1-2 page briefs written by experts and posted in Arctic Answers. Each brief is the top of a "knowledge pyramid" supported by scientific literature organized in underlying tiers of increasing detail.

To read a brief or see the supporting literature, click on the question. PDF's are available by clicking on "Download Brief."

For further information on a topic or to suggest edits or updates, contact the experts listed for each question.

To suggest additional questions to be addressed on Arctic Answers or to volunteer to author a brief, contact Brendan Kelly (bpkelly@alaska.edu). When a proposed question is accepted for inclusion as an Arctic Answer, the author will receive a manuscript number and further instructions. Each brief will be reviewed for scientific accuracy and accessibility to readers with broad backgrounds.

<table>
<thead>
<tr>
<th>Sea Ice Questions</th>
<th>Expert Contacts</th>
<th>Science Brief</th>
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<tbody>
<tr>
<td>What do we know about the future of Arctic sea-ice loss?</td>
<td>Marika Holland &amp; Walt Meier</td>
<td>Download Brief (PDF - 750 KB)</td>
</tr>
<tr>
<td>How is diminishing Arctic sea ice influencing lower latitude weather patterns?</td>
<td>Jennifer Francis &amp; Stephen Vavrus</td>
<td>Download Brief (PDF - 393 KB)</td>
</tr>
<tr>
<td>Arctic Meltdown and Unruly Tropical Storms: Are They Connected?</td>
<td>Jennifer Francis</td>
<td>Download Brief (PDF - 218 KB)</td>
</tr>
<tr>
<td>How is diminishing Arctic sea ice influencing coastal communities?</td>
<td>Henry Huntington &amp; Matthew Druckermiller</td>
<td>Download Brief (PDF - 2.9 MB)</td>
</tr>
<tr>
<td>How is diminishing sea ice influencing marine ecosystems?</td>
<td>Brendan Kelly</td>
<td>Download Brief (PDF - 1.9 MB)</td>
</tr>
<tr>
<td>How will the diminishing sea ice affect commercial fishing in...</td>
<td>George Hunt, Lisa Esner, Neysa</td>
<td>Download Brief</td>
</tr>
</tbody>
</table>
How is diminishing Arctic sea ice influencing coastal communities?

**The Issue.** Loss of sea ice, thawing permafrost, reduced snow cover, and rising sea level are reducing hunting and fishing opportunities and degrading infrastructure for rural Arctic communities. Most Alaska Native communities are affected by erosion and flooding, with 31 communities imminently threatened and 12 planning to relocate. Local responses to these stresses are hampered by the nation's highest prices for food and fuel and widespread poverty across rural Alaska.

**Why It Matters.** Climate change amplifies challenges confronting Arctic communities, where 60-80% of households depend on wild game and fish for food, harvesting several hundred pounds per person annually. Already faced with economic, social, and cultural changes, traditional ways of life in rural Alaska are further threatened by climate change impacts on diminishing food security, deteriorating water and sewage systems, increasing risks of accidents, and greater expenditures to construct and maintain infrastructure. Government agencies and other institutions need to promote policies that reduce stresses on Arctic communities and foster responses consistent with local economies and cultures.

**State of Knowledge.** Arctic communities and scientists have worked together to document local observations of climate change; the associated impacts on hunting, fishing, safety, and food security; and the potential impacts of projected changes into the future. More recently, researchers have been assessing the efficacy of local responses. For example, subsistence whalers on St. Lawrence Island in the Bering Sea have initiated a fall harvest to help make up for spring whaling seasons made shorter by changing ice conditions. At Kivalina—a village that is also facing relocation due to erosion—changing spring ice conditions have prevented the harvest of bowhead whales for over 20 years. In other cases, changes can amplify one another. Limited time off from jobs means that whalers from Nuiqsut now have much shorter time available for whaling in fall. In Alaska's Arctic region, 78% of Native Alaskan households combine jobs and subsistence to meet their economic, cultural, and nutritional needs. The benefits of employment are lessened, however, by the reduction in time devoted to harvesting wild foods. Less time to hunt means less chance to wait out fall storms or to adapt to other changes in weather or animal migration patterns. Those migration patterns may be further altered as diminishing sea ice opens opportunities for industrial activities (for example, shipping and offshore petroleum development). The cumulative effects of stresses and changes are broadly recognized but difficult to measure.

**Where the Science is Headed.** More work is needed to understand how local responses can be effective (such as the St. Lawrence fall whaling season) as well as how they fail short of what is needed (such as Kivalina's inability to hunt in spring). In addition, future research must address ways that policies exacerbate or mitigate such impacts, for example by imposing additional constraints on what communities can do, or by supporting flexibility and local initiative to solve problems. Actions made without adequate knowledge of local conditions, no matter how well intentioned, may undermine local well-being by promoting ineffective responses or fostering dependence on outside intervention rather than on local talent, capacity, and creativity. Ultimately, communities need support to identify local solutions.

**Further Reading.**


Report card
• Summary of climate related trends/ indicators

Synthesis
• Emergent issues
• Future risks
• Novel/emerging tools

Contributions (based on form)
• See example

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TK & LK Task Force

FEP Plan Team
Discussion: Products & deliverables

- Proposed products and tasks:
  - Is there anything missing here?
  - How do we promote co-production of knowledge through this process?
  - Will it be responsive enough for unexpected change?
  - Will it be useful for addressing long-term gradual change?

- How prescriptive should we be? Should we aim for “Policy relevant”?  
  - “specifying” [reviewing? Suggesting? Highlighting?] short-, medium-, and long-term management actions to build climate resilience in regional fisheries and fishing communities

- Short, med, long-term examples?
  - add to and edit this and can we make this living as part of the report?

- Facilitate information to council and ppt:  
  - [BRY]“While not holistic analyses or TK documentation sessions, these vignettes, testimonials, and summaries by, for example, TK experts (representing communities, orgs, co-management bodies, etc.) could be very useful supplementary material that accompanies the on-ramped climate change data into the Council process as well as ongoing evaluations of management strategies.”
PAUSE
Workplan: Logistics
Discussion: Planning & logistics

- TORs for our group

- Coordination with LK/TK module
  - Meetings/joint meetings?

- Coordination with other efforts
  - [BRY] integration with some other as-of-yet not finalized efforts which will have long-term Council impacts
  - LK/TK/Subsistence AM TF, the CEC, and the ongoing work of the Ecosystem Committee and the SSPT.
  - ESR/ESP or stand alone report?

- TF communication – Slack? Google drive, email? Website?
EXTRA SLIDES
An Indigenous approach to ocean planning and policy in the Bering Strait region of Alaska

Julie Raymond-Yakoubian\textsuperscript{a,\textdagger}, Raychelle Daniel\textsuperscript{b}

\textsuperscript{a} Kowerak Incorporated, PO Box 948 Nome, AK 99762, United States
\textsuperscript{b} The Pew Charitable Trusts, 901 E Street NW, Washington DC 20004, United States

\begin{table}[h]
\centering
\begin{tabular}{lll}
\hline
\textbf{Ocean Values} & \textbf{Example} & \textbf{Application to ocean planning} \\
\hline
\textit{Ecosystem} & Knowledge of food web connections & Along with science, provides the knowledge base to better understand impacts \\
\textit{Health and well-being} & Time on the water observing and hunting marine mammals & Informing vessel traffic routing measures \\
\textit{Economic} & Walrus ivory carving & Provides means and ability to actively participate in walrus management \\
\textit{Cultural} & Knowledge of ocean currents & Ability to effectively plan for and respond to maritime disasters \\
\hline
\end{tabular}
\caption{Ocean values from the Bering Strait region and example applications to the governance and decision-making component of ocean planning.}
\end{table}
Modeled effect of coastal biogeochemical processes, climate variability, and ocean acidification on aragonite saturation state in the Bering Sea

March 06, 2019


Due to naturally cold, low carbonate concentration waters, the Bering Sea is highly vulnerable to ocean acidification (OA), the process in which the absorption of human-released carbon dioxide by the oceans leads to a decrease in ocean water pH and carbonate ion concentration. Emerging evidence suggests that a number of important species in the Bering Sea (such as red king crab and Pacific cod) are vulnerable to OA due to direct (e.g., reduced growth and survival rates) and indirect (e.g., reduced food sources) effects. However, the harsh winter conditions, prevalence of sea ice, and large size of

ICES Journal of Marine Science


Contribution to the Symposium: ‘The effects of climate change on the world’s oceans’
Projected biophysical conditions of the Bering Sea to 2100 under multiple emission scenarios

Albert J. Hermann$^{1,2,*}$, Georgina A. Gibson$^3$, Wei Cheng$^{1,2}$, Ivonne Ortiz$^{1,4}$, Kerim Aydin$^6$, Muyin Wang$^{1,2}$, Anne B. Hollowed$^6$, and Kirstin K. Holsman$^6$
Declines in large zooplankton (2090-2099)-(2010-2019)

Figure 13. Ensemble results as in Figure 12, for log$_{10}$ (large crustacean zooplankton).

b) Climate Vulnerability Assessments
Methodology – Framework

Species Vulnerability

Exposure
- Sea surface temperature
- Bottom temperature
- Air temperature
- Salinity
- Ocean acidification (pH)
- Precipitation
- Currents
- Sea surface height
- Large zooplankton biomass
- Phytoplankton biomass and bloom timing
- Mixed layer depth

Sensitivity
- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

Slide credit: P. Spencer
Exposure scoring, general methodology

Compare maps of exposure factors to maps of stock distributions and qualitatively estimate their overlap. Example for Pacific ocean perch shown below.

Z-score for annual bottom temperature

Slide credit: P. Spencer
Example of Species Specific Results (from EBS)

Pacific ocean perch

Bootstrap outcomes:

<1  Very High
10  High
89  Moderate
<1  Low

Slide credit: P. Spencer
Potential next step – linking to social-economic variables

For northeast US study, information on the species composition of different fishing ports was combined with species vulnerability to estimate vulnerability of fishing communities (Colburn et al 2016)
OA Risk Assessment

Himes-Cornell and Kaspersky 2014
Vulnerability of Arctic marine mammals to vessel traffic in the increasingly ice-free Northwest Passage and Northern Sea Route

Donna D. W. Hausera,1,2, Kristin L. Laidrea, and Harry L. Sterna

*Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle, WA 98105

Fig. 2. Vulnerability plot expressing sensitivity and exposure scores across Arctic marine mammal subpopulations exposed to the Northwest Passage or Northern Sea Route. Vulnerability is the product of exposure and sensitivity.

Fig. 4. Maximum vulnerability scores for all AMM species (Top Left) and taxonomic groups exposed to the Arctic sea routes. Vulnerability color shading corresponds to the vulnerability plot in Fig. 2. The combined ranges of all other AMM subpopulations that did not overlap the Arctic sea routes are shown in gray in the Top Left, including portions of polar bear subpopulations that range onto land during the open-water period.
Vessels, risks, and rules: Planning for safe shipping in Bering Strait

Henry P. Huntington a,⁎, Raychelle Daniel b, Andrew Hartsig c, Kevin Harun d, Marilyn Heiman b, Rosa Meehan e, George Noongwook f, Leslie Pearson g, Melissa Prior-Parks b, Martin Robards h, George Stetson i

Table 1
Comparison of environmental and cultural risks (columns) and regulatory measures (rows). The first four risks are environmental ones and also cultural risks for those who depend on the environment for food and well-being. Note that most or all regulatory measures can be implemented by voluntary, domestic, or international action. Which vessels would be covered by each type of action, and how much of the risk would be reduced, depends on the details of the shipping activities in question.

<table>
<thead>
<tr>
<th>Risk/Regulatory measure</th>
<th>Ship strikes</th>
<th>Noise</th>
<th>Discharges and contamination</th>
<th>Accidental oil spills</th>
<th>Vessel collisions</th>
<th>Disturbance to hunting</th>
<th>Damage to cultural heritage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipping lanes</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Areas-to-be-avoided</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Speed limits</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Communications</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reporting systems</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Emission controls</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Salvage and oil spill prevention and preparedness</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Rescue tug capability</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voyage and contingency planning</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Charting</td>
<td>X</td>
<td></td>
<td></td>
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</tbody>
</table>
Vessels, risks, and rules: Planning for safe shipping in Bering Strait

Henry P. Huntington a,⁎, Raychelle Daniel b, Andrew Hartsig c, Kevin Harun d, Marilyn Heiman b, Rosa Meehan e, George Noongwook f, Leslie Pearson g, Melissa Prior-Parks b, Martin Robards h, George Stetson i

Table 2
Categories of regulatory implementation. Although mandatory measures are not necessarily dependent on having voluntary measures in place (and domestic measures are not required prior to international measures), in practice the development of regulations typically starts with voluntary and domestic measures and moves on from there.

<table>
<thead>
<tr>
<th>Category of implementation</th>
<th>To whom the measures apply</th>
<th>Effectiveness at reducing risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary</td>
<td>All vessels, but with no enforcement power</td>
<td>Depends on compliance, but there is likely to be pressure to comply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can be enhanced if insurers and others regard such measures as appropriate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>standards of care</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can be enhanced by monitoring and communication</td>
</tr>
<tr>
<td>Mandatory (domestic)</td>
<td>Vessels addressed by the regulations that are either (a) registered in the country issuing the regulations, or (b) traveling to or from a port in that country</td>
<td>Depends on the proportion of vessels in the area that are subject to the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>regulations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vessels may comply voluntarily or be required to do so by insurers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can be enhanced by monitoring and enforcement</td>
</tr>
<tr>
<td>Mandatory (international)</td>
<td>All vessels addressed by the regulations</td>
<td>Compliance can be enhanced by monitoring and enforcement</td>
</tr>
</tbody>
</table>
HOW?

c) Operationalized climate change management strategy evaluations (MSEs)
Fig. 3. The Adaptive Policymaking approach to designing a dynamic adaptive plan (Kwakkel et al., 2010a).

M. Haasnoot et al. / Global Environmental Change 23 (2013) 488 485–498
Examples:

<table>
<thead>
<tr>
<th>Climate Exposure</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic Salmon</td>
<td>Ocean Quahog Northern Quahog</td>
<td>Atlantic Halibut Atlantic Sea Scallop Dusky Shark Porbeagle Thorny Skate Tilefish Atlantic Surfclam</td>
<td>Ocean Pout Atlantic Wolfish Witch Flounder Northern Shrimp Green Sea Urchin Sand Tiger Cusk</td>
<td>American Shad Blueback Herring Eastern Oyster Hickory Shad Shortnose Sturgeon Aiewife Rainbow Smelt Atlantic Sturgeon Winter Flounder</td>
</tr>
<tr>
<td>Bay Scallop</td>
<td></td>
<td>Bloodworm Blue Mussel Horseshoe Crab Faught Striped Bass Channeled Whelk Knobbed Whelk Softshell Clam Blue Crab</td>
<td></td>
<td>Red Drum American Eel Conger Eel Black Sea Bass Spotted Seatrout</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sand Lances Barndoor Skate Acadian Redfish Smooth Skate American Lobster Atlantic Haddock</td>
<td>Atlantic Cod White Hake Atlantic Mackerel Rosseta Skate Cancer Crab Pellock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Little Skate Clearnwit Skate Smooth Dogfish Anchovies Monkfish Haddock Atlantic Herring Wrasses Yellowtail Flounder American Plaice</td>
</tr>
</tbody>
</table>

Hare et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756

Holsman et al. 2017
Consider evolving interactions and pathways of adaptation
The ACLIM team

Anne Hollowed  Kirstin Holsman  Alan Haynie  Kerim Aydin  Albert Hermann  Wei Cheng  Stephen Kasperski
Jim Ianelli  Andre Punt  Andy Whitehouse  Jonathan Reum  Amanda Faig  Kelly Kearney  Buck Stockhausen
Paul Spencer  Michael Dalton  Darren Pilcher  Tom Wilderbuer  Cody Szuwalski  Jim Thorson  Ingrid Spies

www.fisheries.noaa.gov/alaska/ecosystems/alaska-climate-integrated-modeling-project
Challenges to evaluating adaptation options:

- **long time horizons** of adaptation outcomes;
- the **shifting baseline and uncertainty** around climate hazards;
- assessing **attribution** of any results;
- addressing the **additional climate risk** and counterfactual scenarios

“an **approach built on mixed methods, participation and learning helps alleviate some of the uncertainties** around interpreting results on adaptation.” Craft & Fisher 2018, Fisher 2015

Repeated engagement
Climate X management dynamic interaction

Pollock Spawning biomass

Status quo

Unfished
Fished

CEATTLE model
Holsman et al. 2016
Climate X management dynamic interaction

Pollock Spawning biomass

CEATTLE model
Holsman et al. 2016
d) Project changes in species distributions and phenology
Future Essential Fish Habitat

(Chris Rooper, Ivonne Ortiz, Ned Laman, Al Hermann, in prep)

Used Slope, SE Bering Sea shelf and Northern Bering Sea data to build EFH models 1982-2017 except when noted

1) AK plaice
2) Arrowtooth flounder (1993- )
3) Flathead sole
4) Northern rock sole (2001- )
5) Pacific cod
6) Walleye pollock
7) Red king crab (1996- )
8) Snow crab
9) Tanner crab
10) Yellowfin sole

Variables used: depth, slope, maximum tidal current, sediment grain size, mean bottom ocean current, bottom temperature

Slide credit: I. Ortiz
P.Cod

(Chris Rooper, Ivonne Ortiz, Ned Laman, Al Hermann, in prep)

Slide credit: I. Ortiz
Arctic Answers

Policy-relevant questions are answered in 1-2 page briefs written by experts and posted in Arctic Answers. Each brief is the top of a "knowledge pyramid" supported by scientific literature organized in underlying tiers of increasing detail.

To read a brief or see the supporting literature, click on the question. PDF's are available by clicking on "Download Brief."

For further information on a topic or to suggest edits or updates, contact the experts listed for each question.

To suggest additional questions to be addressed on Arctic Answers or to volunteer to author a brief, contact Brendan Kelly (bpkelly@alaska.edu). When a proposed question is accepted for inclusion as an Arctic Answer, the author will receive a manuscript number and further instructions. Each brief will be reviewed for scientific accuracy and accessibility to readers with broad backgrounds.

<table>
<thead>
<tr>
<th>Sea Ice Questions</th>
<th>Expert Contacts</th>
<th>Science Brief</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do we know about the future of Arctic sea-ice loss?</td>
<td>Marika Holland &amp; Walt Meier</td>
<td>Download Brief (PDF - 750 KB)</td>
</tr>
<tr>
<td>How is diminishing Arctic sea ice influencing lower latitude weather patterns?</td>
<td>Jennifer Francis &amp; Stephen Vavrus</td>
<td>Download Brief (PDF - 393 KB)</td>
</tr>
<tr>
<td>Arctic Meltdown and Unruly Tropical Storms: Are They Connected?</td>
<td>Jennifer Francis</td>
<td>Download Brief (PDF - 218 KB)</td>
</tr>
<tr>
<td>How is diminishing Arctic sea ice influencing coastal communities?</td>
<td>Henry Huntington &amp; Matthew Druckenmiller</td>
<td>Download Brief (PDF - 2.9 MB)</td>
</tr>
<tr>
<td>How is diminishing sea ice influencing marine ecosystems?</td>
<td>Brendan Kelly</td>
<td>Download Brief (PDF - 1.9 MB)</td>
</tr>
<tr>
<td>How will the diminishing sea ice affect commercial fishing in</td>
<td>George Hunt, Lisa Esner, Neya</td>
<td>Download Brief</td>
</tr>
</tbody>
</table>
How is diminishing Arctic sea ice influencing coastal communities?

**The Issue.** Loss of sea ice, thawing permafrost, reduced snow cover, and rising sea level are reducing hunting and fishing opportunities and degrading infrastructure for rural Arctic communities. Most Alaska Native communities are affected by erosion and flooding, with 31 communities imminently threatened and 12 planning to relocate. Local responses to these stresses are hampered by the nation’s highest prices for food and fuel and widespread poverty across rural Alaska.

**Why It Matters.** Climate change amplifies challenges confronting Arctic communities, where 60-80% of households depend on wild game and fish for food, harvesting several hundred pounds per person annually. Already facing economic, social, and cultural changes, traditional ways of life in rural Alaska are further threatened by climate change impacts on diminishing food security, deteriorating water and sewage systems, increasing risk of accidents, and greater expenditures to construct and maintain infrastructure. Government agencies and other institutions need to promote policies that reduce stresses on Arctic communities and foster responses consistent with local economies and cultures.

**State of Knowledge.** Arctic communities and scientists have worked together to document local observations of climate change; the associated impacts on hunting, fishing, safety, and food security; and the potential impacts of projected changes into the future. More recently, researchers have been assessing the efficacy of local responses. For example, subsistence whalers on St. Lawrence Island in the Bering Sea have initiated a fall harvest to help make up for spring whaling seasons made shorter by changing ice conditions. At Kivalina—a village that is also facing relocation due to erosion—changing spring ice conditions have prevented the harvest of bowhead whales for over 20 years. In other cases, changes can amplify one another. Limited time off from jobs means that whalers from Nuiqsut now have much shorter time available for whaling in fall. In Alaska’s Arctic region, 78% of Native Alaskan households combine jobs and subsistence to meet their economic, cultural, and nutritional needs. The benefits of employment are lessened, however, by the reduction in time devoted to harvesting wild foods. Less time to hunt means less chance to wait out fall storms or to adapt to other changes in weather or animal migration patterns. Those migration patterns may be further altered as diminishing sea ice opens opportunities for industrial activities (for example, shipping and offshore petroleum development). The cumulative effects of stresses and changes are broadly recognized but difficult to measure.

**Where the Science is Headed.** More work is needed to understand how local responses can be effective (such as the St. Lawrence fall whaling season) as well as how they fail short of what is needed (such as Kivalina’s inability to hunt in spring). In addition, future research must address ways that policies exacerbate or mitigate such impacts, for example by imposing additional constraints on what communities can do, or by supporting flexibility and local initiative to solve problems. Actions made without adequate knowledge of local conditions, no matter how well intentioned, may undermine local well-being by promoting ineffective responses or fostering dependence on outside intervention rather than on local talent, capacity, and creativity. Ultimately, communities need support to identify local solutions.

**Further Reading.**


**Contact for further information:**

Henry Huntington, Huntington Consulting
hph@alaska.net

Matthew Druckenmiller, National Snow and Ice Data Center
mdruckenmiller@nsidc.org

SEARCH is supported by the National Science Foundation. SEARCH Science Brief AA.002.
Arctic Futures 2050 Conference
4–6 September 2019
Washington, D.C.

A novel conference of Arctic scientists, Indigenous Peoples, and policy makers jointly exploring the knowledge needed to inform decisions concerning the Arctic in coming decades.

Announcements

**General Travel Award Announced** – The conference Organizing Committee announces a travel award program for potential attendees regardless of background, nationality, or career stage. Applications are due 20 May 2019. For more information, go here.

**Travel Awards Announced** – Early-Career & Indigenous Knowledge Holder Travel Awards - We are pleased to announce travel award opportunities for early-career researchers and Indigenous knowledge holders! Applications are due 20 May 2019. More information is available through the “Travel Awards” link above or go here.

Important Dates

- 15 March: Call for Poster Abstracts
- 1 April: Registration Opens
- 1 April: Travel Award Program Announced
- 20 May: Poster Abstracts Due
- 20 May: Travel Award Applications Due
- 17 June: Poster Decisions and Travel Award Winners Announced
- 10 July: Early-bird Registration Rates End

- The Conference Organizing committee has extended the original May 1st deadline for Poster abstracts and Travel Award applications.
<table>
<thead>
<tr>
<th>What do you hope the Climate Change Task Force / Climate Change Module can accomplish in the next 3-5 years of the Task Force timeframe? (2020-2025)</th>
<th>What do you hope the Climate Change Task Force / Climate Change Module can accomplish in the next 10-20 years?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthesize observations, identify information gaps, and improve our predictive capabilities to better inform climate related management measures/decisions</td>
<td>Implementation of a climate-resilient management measure(s).</td>
</tr>
<tr>
<td>Finalize a working Action Module which brings together western science, IK and TK, and LK - and related concerns, perspectives, information, and values - in a way which provides valuable guidance and tools for the Council to best take into account climate change in Alaska federal fishery management.</td>
<td>Building on what I noted above, I would hope it could have provided useful information, activities, and tools for ensuring sustainability in the face of climate change for fisheries, habitats, and communities which are involved in and impacted by fisheries activities.</td>
</tr>
<tr>
<td>Identifying and framing issues and concerns which pose immediate and long term threats to fisheries and ecosystem in the Bering Sea.</td>
<td>Develop adaptive management measures to help predict impacts of global climate change to the Bering Sea.</td>
</tr>
<tr>
<td>Ideally make some forward looking management recommendations for addressing climate change impacts on fisheries management</td>
<td>Predict how climate change and management choices interact and respond</td>
</tr>
<tr>
<td>Inform the Council on elements required to make informed policy decisions when considering climate change impacts.</td>
<td>Guide policy.</td>
</tr>
<tr>
<td>Identify tools and pathways for the Council and NMFS to account for and integrate climate change modeling and information (western science and indigenous and local knowledge) into fishery management decisions in a holistic, meaningful, and inclusive way.</td>
<td>Broadly, the hope is that we continue to advance ecosystem-based fisheries management in such a way that it becomes increasingly resilient and adaptive to changing conditions. The Module and Task Force can be important, ongoing vehicles to help advance that goal and to ensure that the Council has the information and tools to make the best possible decisions.</td>
</tr>
<tr>
<td>Bringing together already developed tools and models with LTK and increased involvement and participation/ contributions of indigenous stakeholders to inform policy in innovative ways</td>
<td>Shifted paradigm of how different types of information and data are viewed by science and managers, more inclusive and open partnerships with more folks on the ground, strengthened partnerships with agency and communities</td>
</tr>
</tbody>
</table>