Understanding long-term scenarios for fisheries: efforts to improve modeling and advice

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Diana Stram, NPFMC
Alan Haynie, NOAA
Jonathan Reum, UW
Kerim Aydin, NOAA
Al Hermann, UW
André Punt, UW
+ ACLIM Team

July 21, 2021
U.S. – Japan workshop on climate change and fisheries

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AFSC
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ACLIM TEAM

Building climate resilience through climate-informed Ecosystem Based Management

Lead PIs: Anne Hollowed, Kirstin Holsman, Alan Haynie, Jon Reum, Andre Punt, Kerim Aydin, Al Hermann

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Jim Ianelli
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Amanda Faig
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David Kimmel
Mike Jacox

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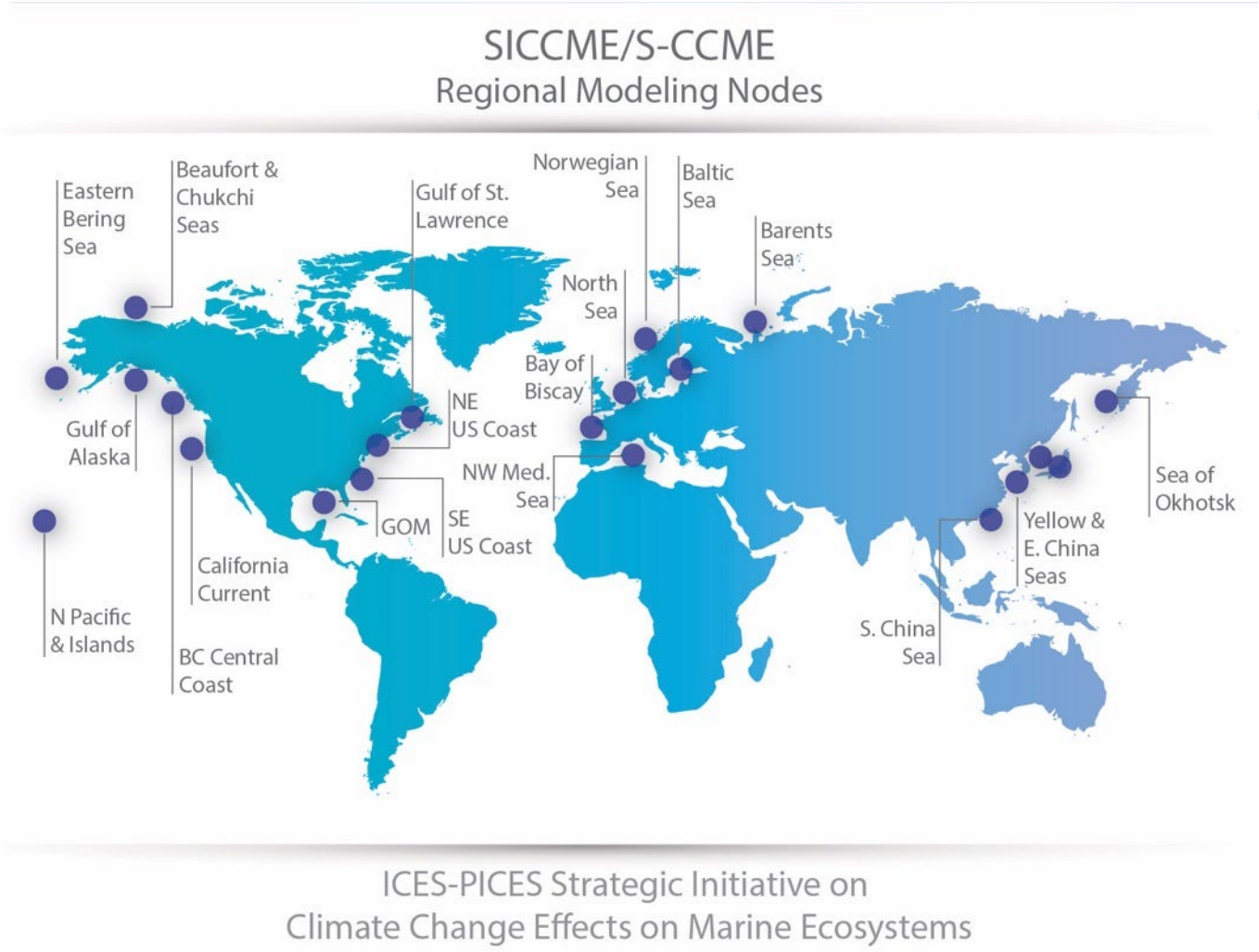
Rolf Ream
Elizabeth Siddon
Phyllis Stabeno
Charlie Stock
Chris Rooper
Jordan Watson
Diana Stram
Lauren Rogers
Ben Laurel

www.fisheries.noaa.gov/alaska/ecosystems/alaska-climate-integrated-modeling-project



ICES/PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems

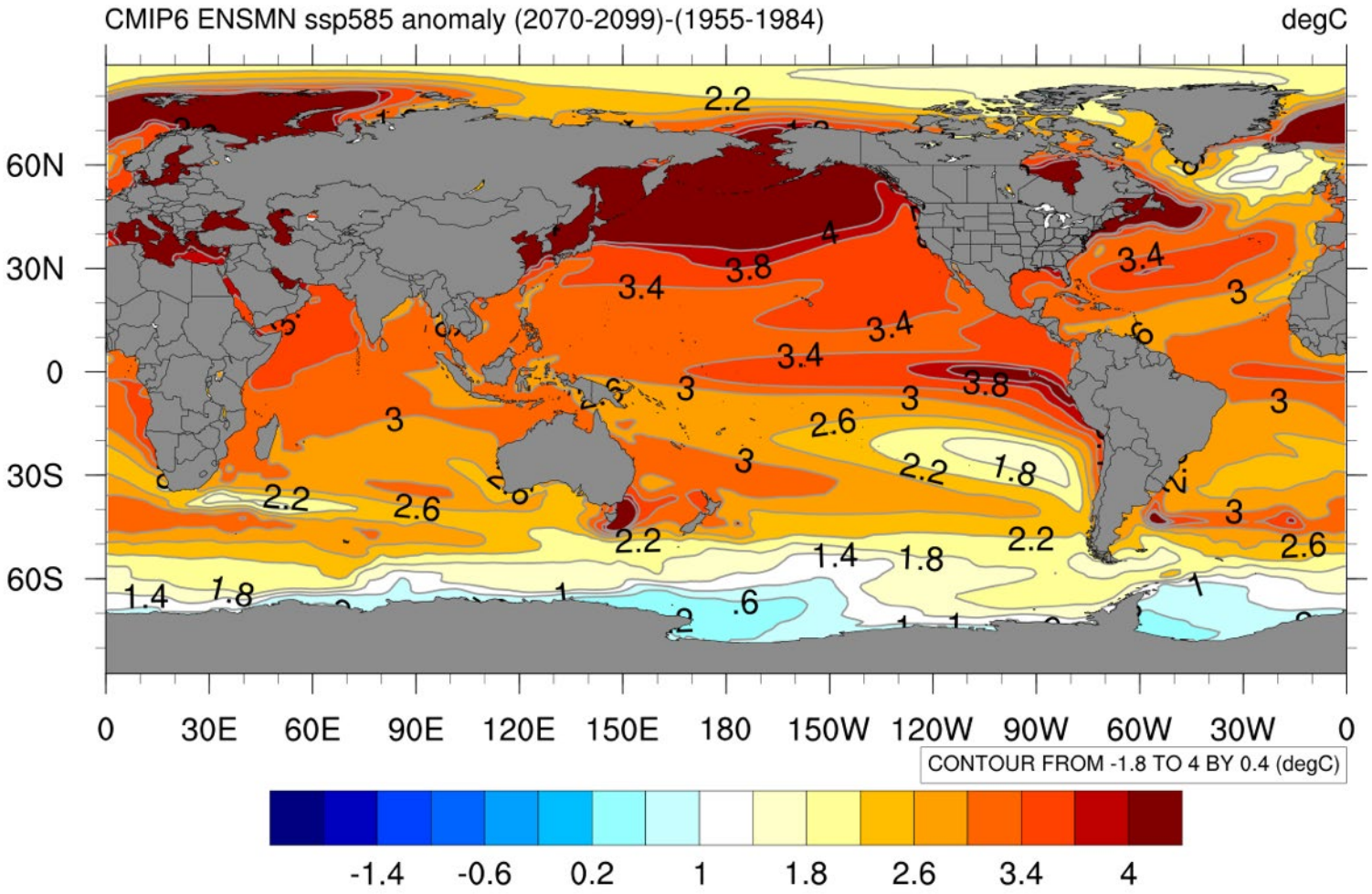
2011- present

Chairs:

Kirstin Holsman (USA, PICES)
Shan Xiujuan (People's Republic of China, PICES)
Christian Möllmann (Germany, ICES)
Mark Payne (Denmark, ICES)

PICES S-CCME: https://meetings.pices.int/members/sections/S-CCME#products
ICES SICCME : https://www.ices.dk/community/groups/Pages/SICCME.aspx

CMIP6: SST Anomaly from 1955-1984 climatology



https://psl.noaa.gov/ipcc/cmip6/

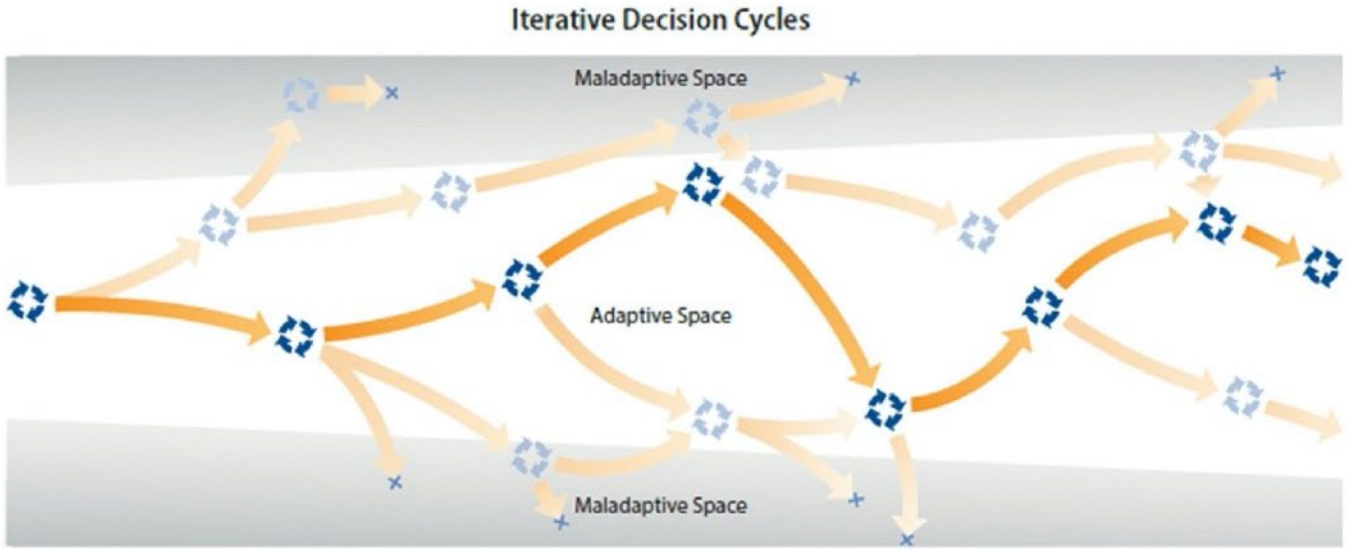
Climate resilient adaptation pathways

Test new & existing tools

Adaptation

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

transformational adaptation, especially to address/prevent marginalization and promote equitable well being and diverse values.



Build capacity to revaluate & enable transformative actions

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

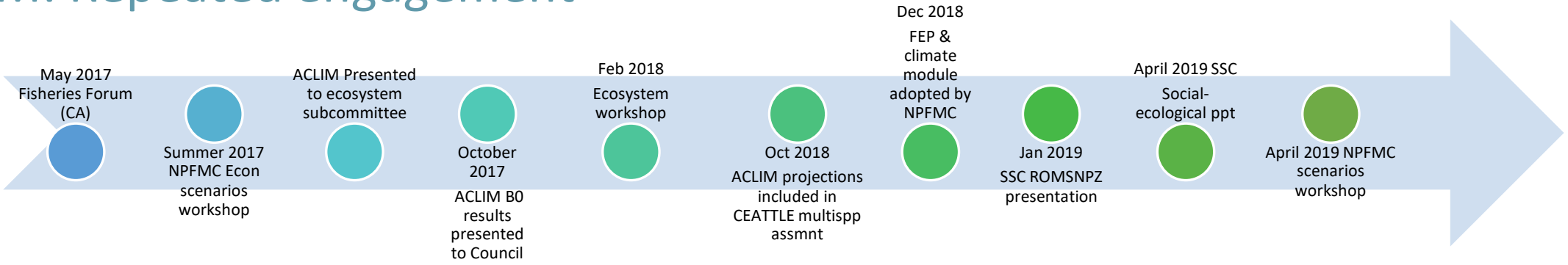
Challenges to evaluating adaptation options

- **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

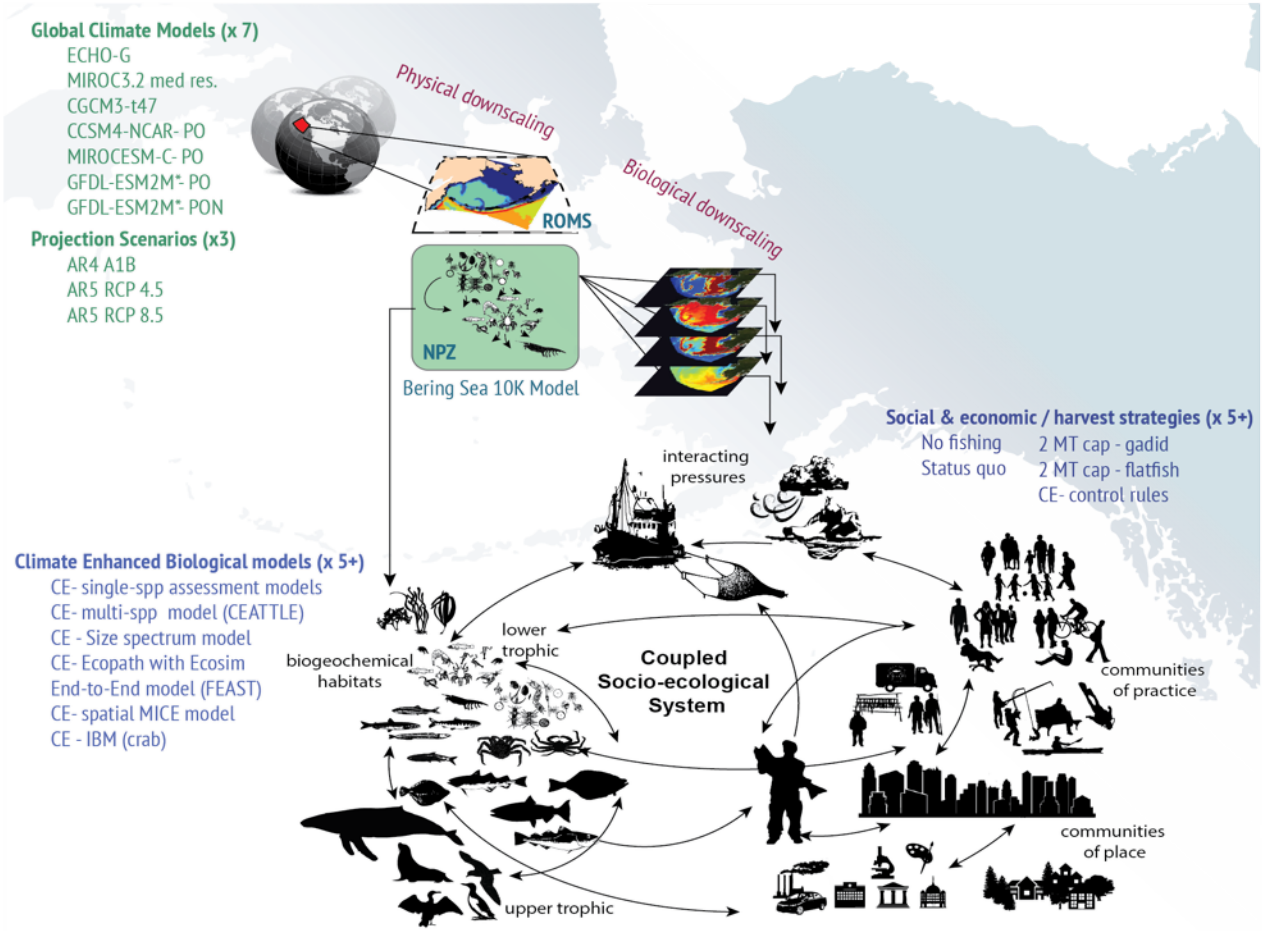
ACLIM: Repeated engagement



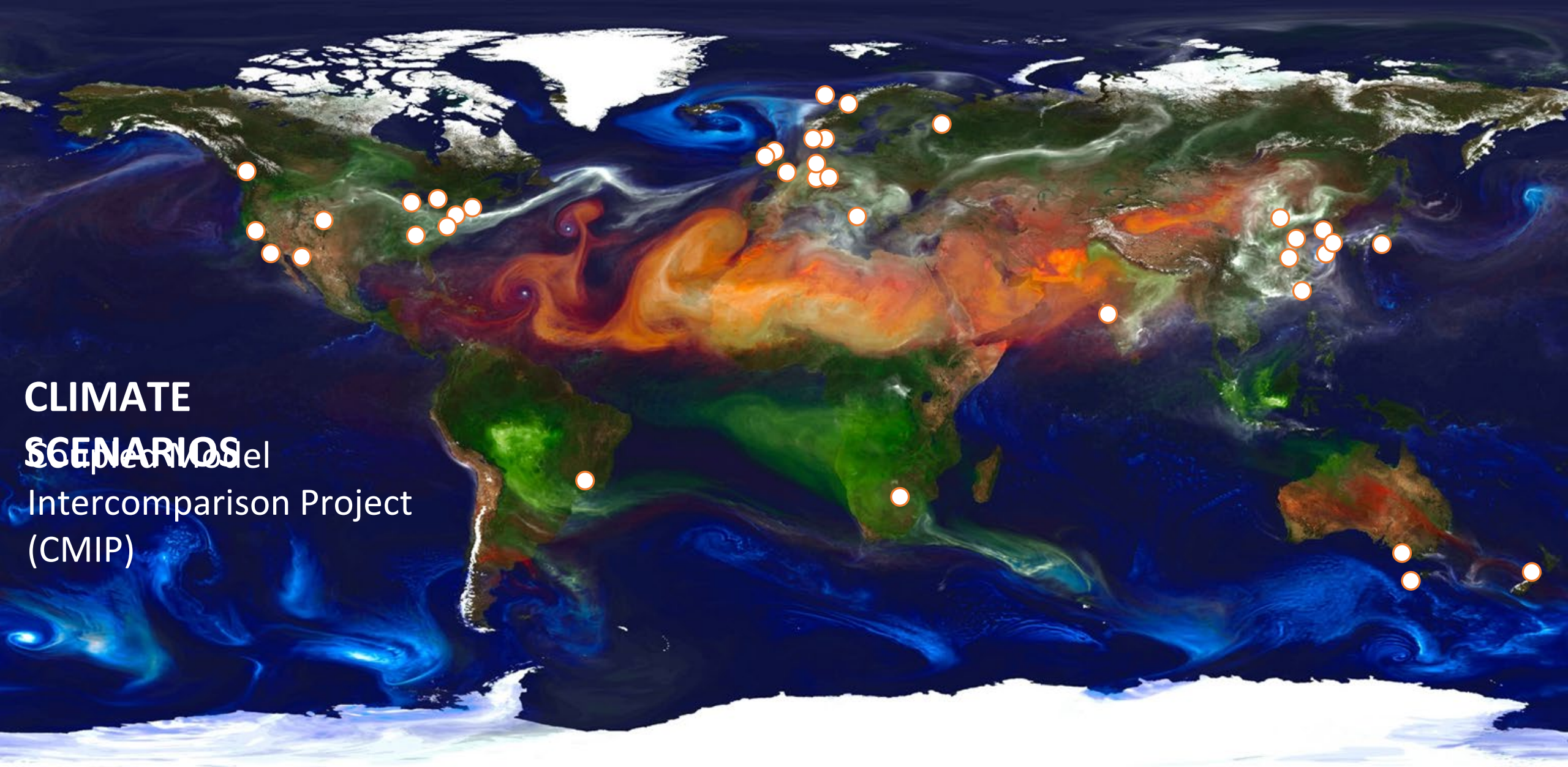
The Alaska Climate Integrated Modeling Project

- Southeast Bering Sea
- Funding: NMFS S&T (FATE+SAAM+NPCREP), IEA, RTAP, Economic and Human Dimensions Program, AFSC, OAR)
- Operational suite of coupled socio-ecological models for climate fisheries hindcasts, forecasts, projections and Management Strategy Evaluation

www.fisheries.noaa.gov/alaska/ecosystems/alaska-climate-integrated-modeling-project



Hollowed et al. 2020. Frontiers in Mar. Sci. doi: 10.3389/fmars.2019.00775

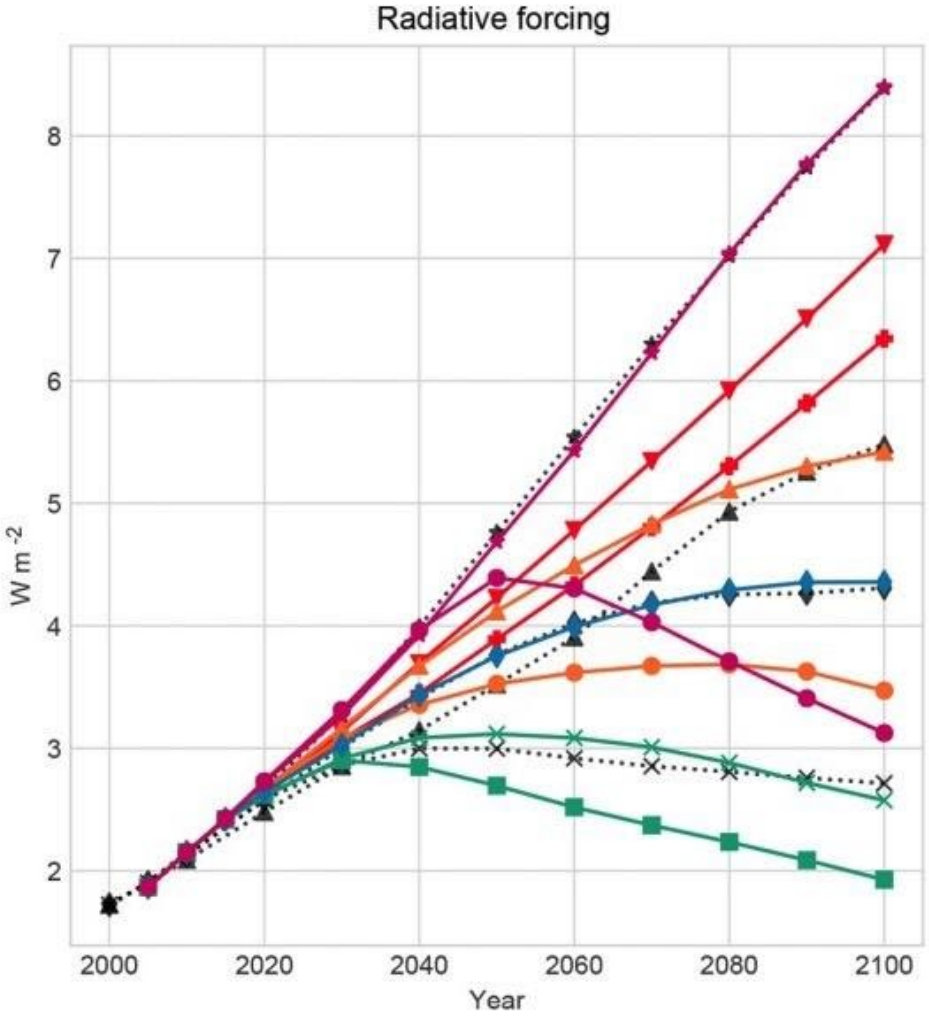


CLIMATE SCENARIOS

Coupled Model Intercomparison Project (CMIP)

This portrait of global aerosols was produced by a GEOS-5 simulation at a 10-kilometer resolution. Dust (red) is lifted from the surface, sea salt (blue) swirls inside cyclones, smoke (green) rises from fires, and sulfate particles (white) stream from volcanoes and fossil fuel emissions.
Image credit: William Putman, NASA/Goddard https://www.nasa.gov/multimedia/imagegallery/image_feature_2393.html

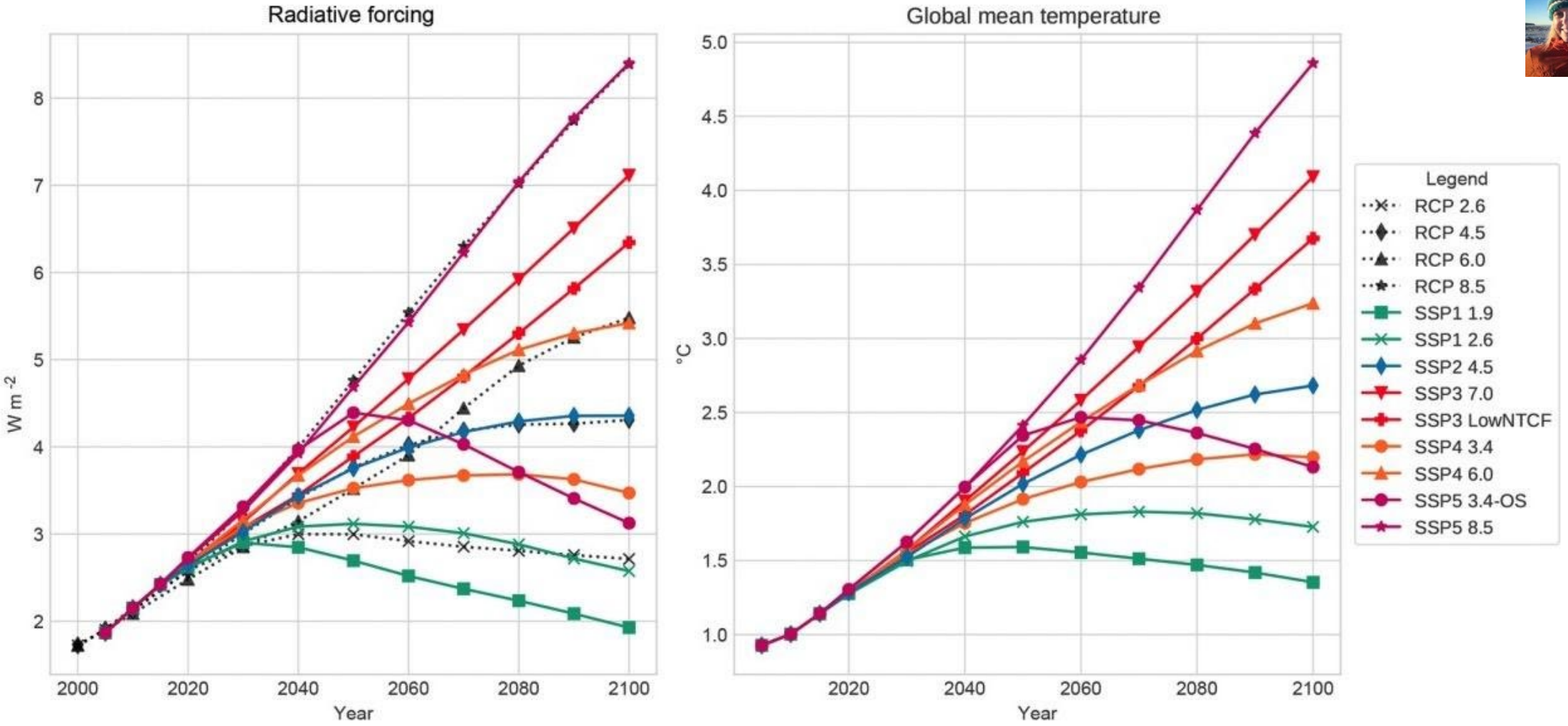
Carbon Emission Scenarios



*"**plausible descriptions** of how the future may evolve with respect to a range of variables…they are not meant to be policy prescriptive, (i.e. **no likelihood or preference is attached** to any of the individual scenarios of the set)"*

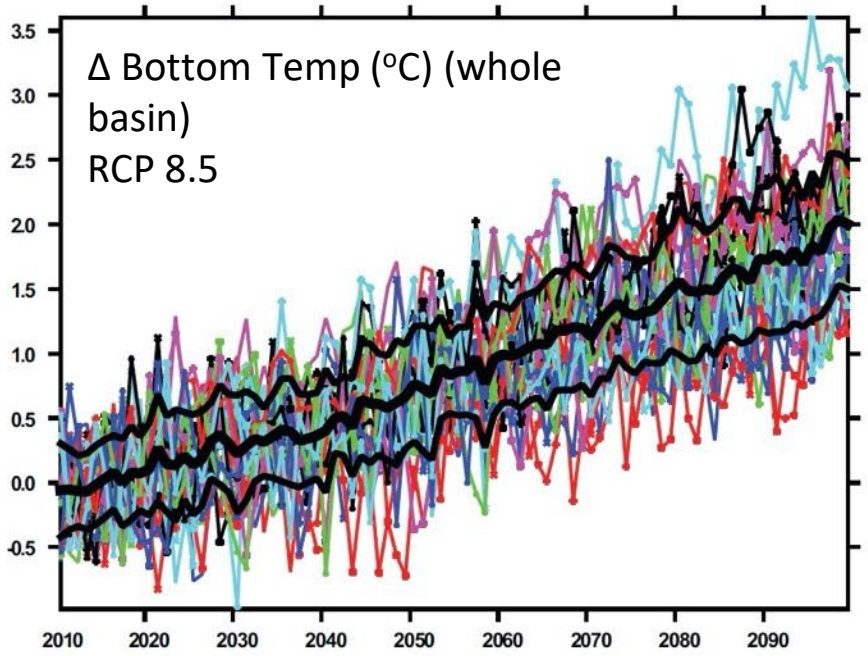
van Vuuren et al. 2011

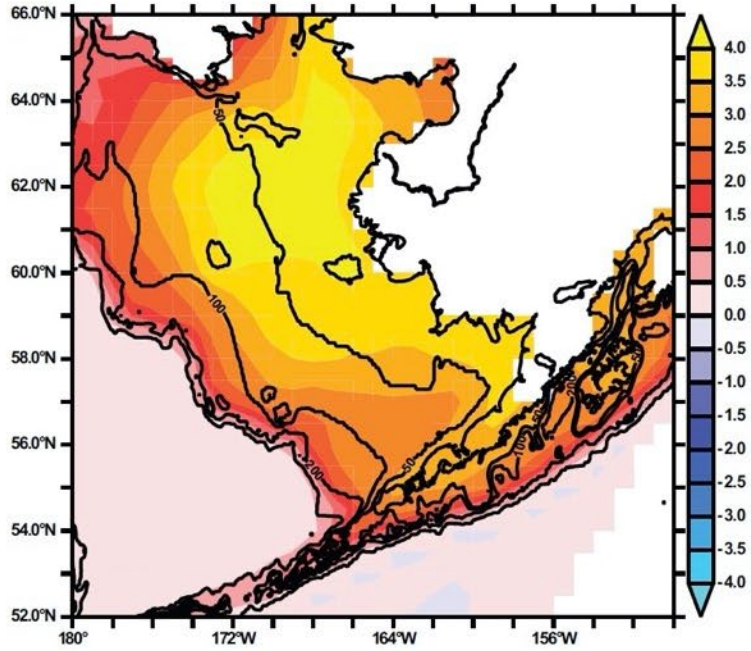
Gidden et al. (2019). Global emissions pathways under different socioeconomic scenarios for use in CMIP6: a dataset of harmonized emissions trajectories through the end of the century. Geosci. Model Dev., 12, 1443–1475, 2019 https://doi.org/10.5194/gmd-12-1443-2019



Gidden et al. (2019). Global emissions pathways under different socioeconomic scenarios for use in CMIP6: a dataset of harmonized emissions trajectories through the end of the century. Geosci. Model Dev., 12, 1443–1475, 2019 https://doi.org/10.5194/gmd-12-1443-2019

Results: Downscaled Bering10K ROMSNPZ high-resolution model (H16)

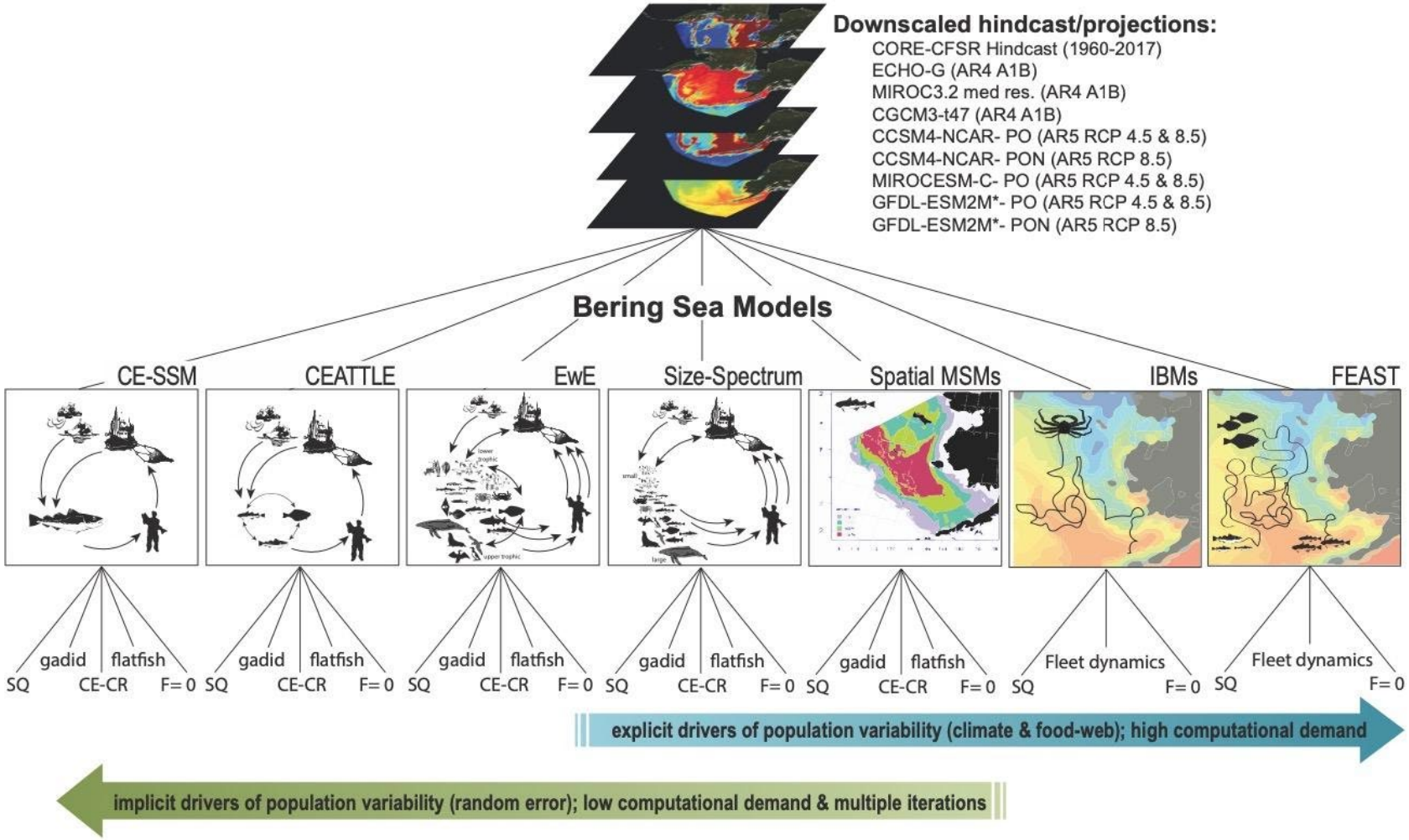




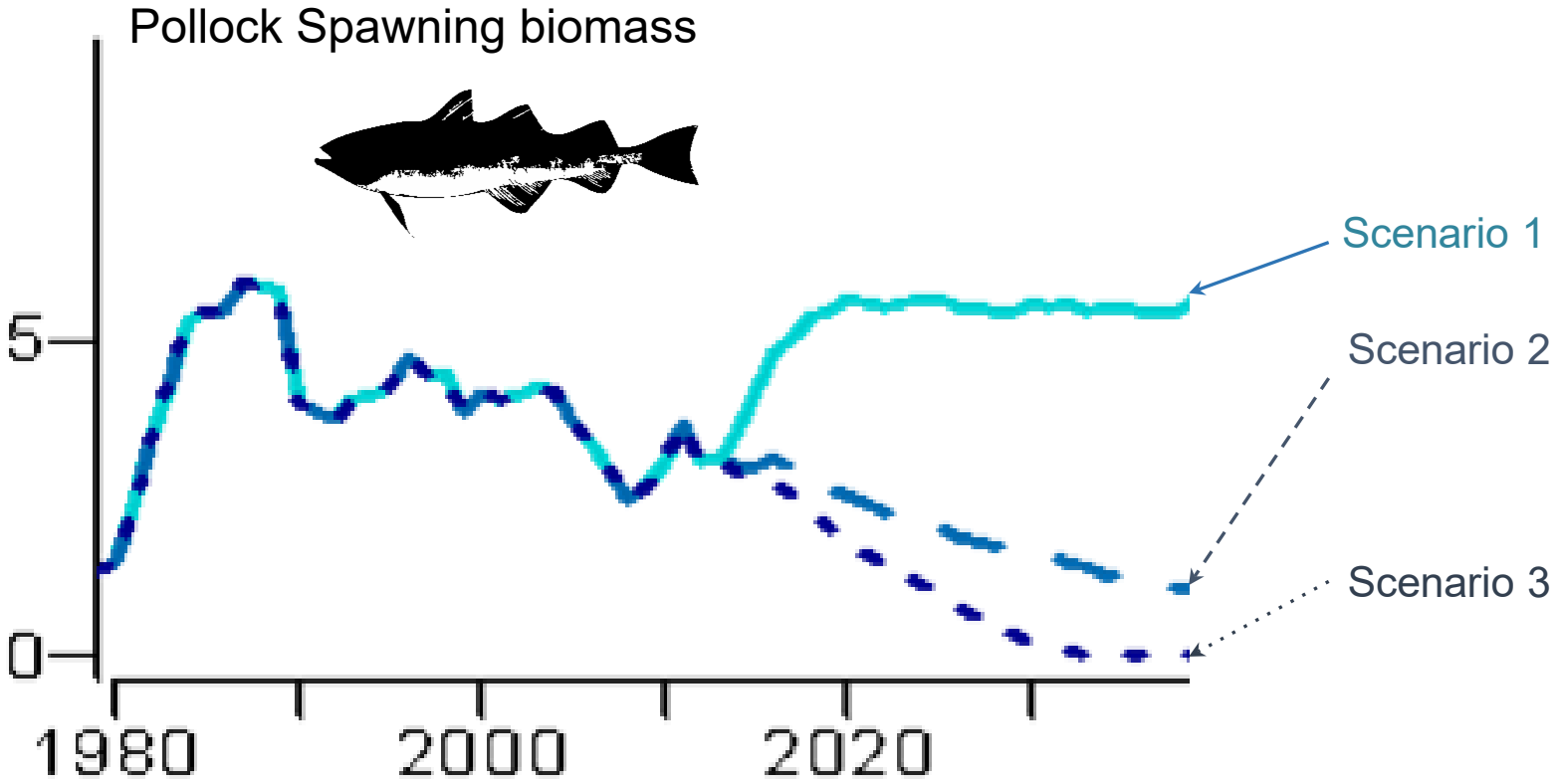
INCREASED WARMING (2090-2099)-(2010-2019)

Hermann, A. J., G.A. Gibson, W. Cheng, I. Ortiz1,K. Aydin, M. Wang, A. B. Hollowed, and K. K. Holsman. (2019) Projected biophysical conditions of the Bering Sea to 2100 under multiple emission scenarios. ICES. doi: 10.1093/ices/fsz043

The Alaska Climate Integrated Modeling Project



QUANTIFY RISK AND UNCERTAINTY



Ianelli, J KK Holsman, AE Punt, K Aydin (2016). Multi-model inference for incorporating trophic and climate uncertainty into stock assessment estimates of fishery biological reference points. Deep Sea Res II. 134: 379-389 DOI: 10.1016/j.dsr2.2015.04.002

Results: Holsman et al. 2020

nature COMMUNICATIONS

ARTICLE

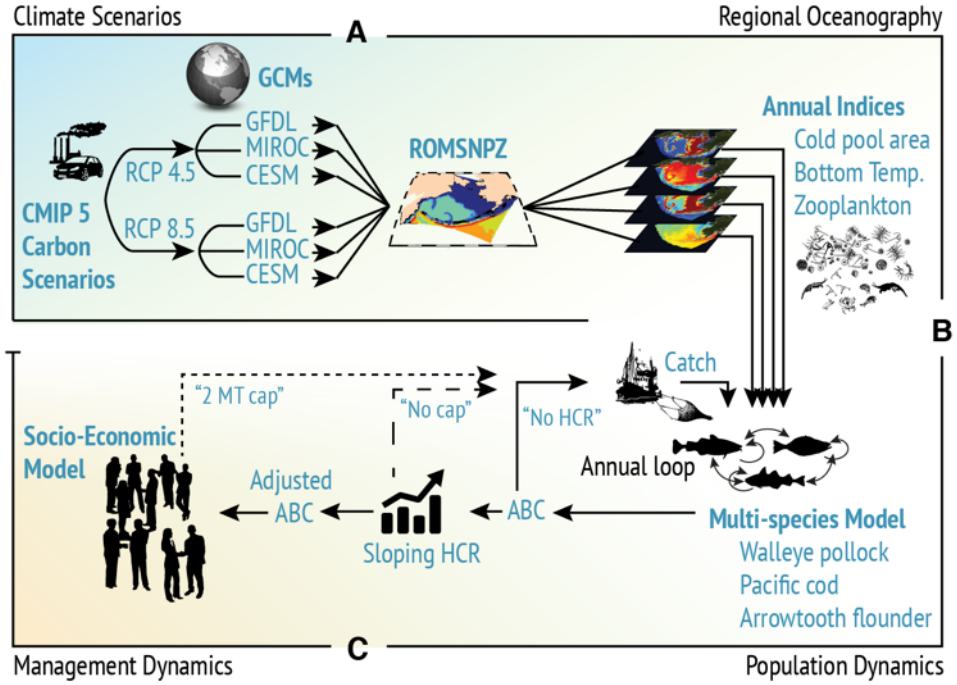
https://doi.org/10.1038/s41467-020-18300-3 OPEN

Check for updates

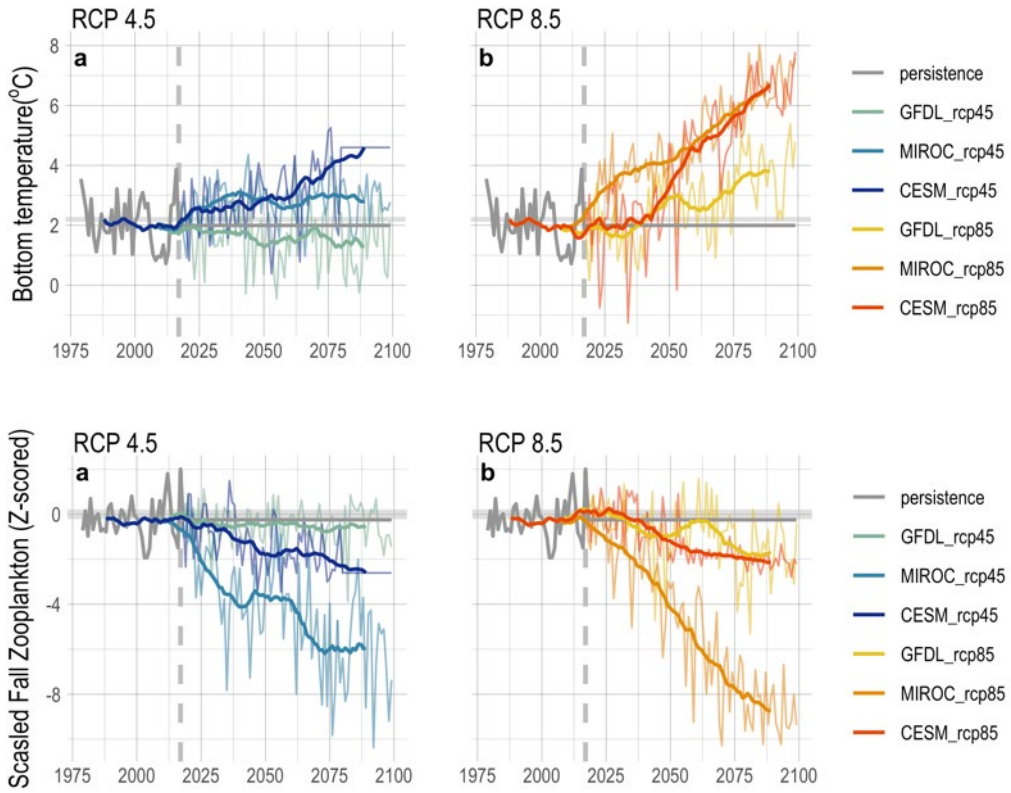
Ecosystem-based fisheries management forestalls climate-driven collapse

K. K. Holsman[1,2✉], A. C. Haynie[1], A. B. Hollowed[1,2], J. C. P. Reum[1,2,3], K. Aydin[1,2], A. J. Hermann[4,5], W. Cheng[4,5], A. Faig[2], J. N. Ianelli[1,2], K. A. Kearney[1,4] & A. E. Punt[2]

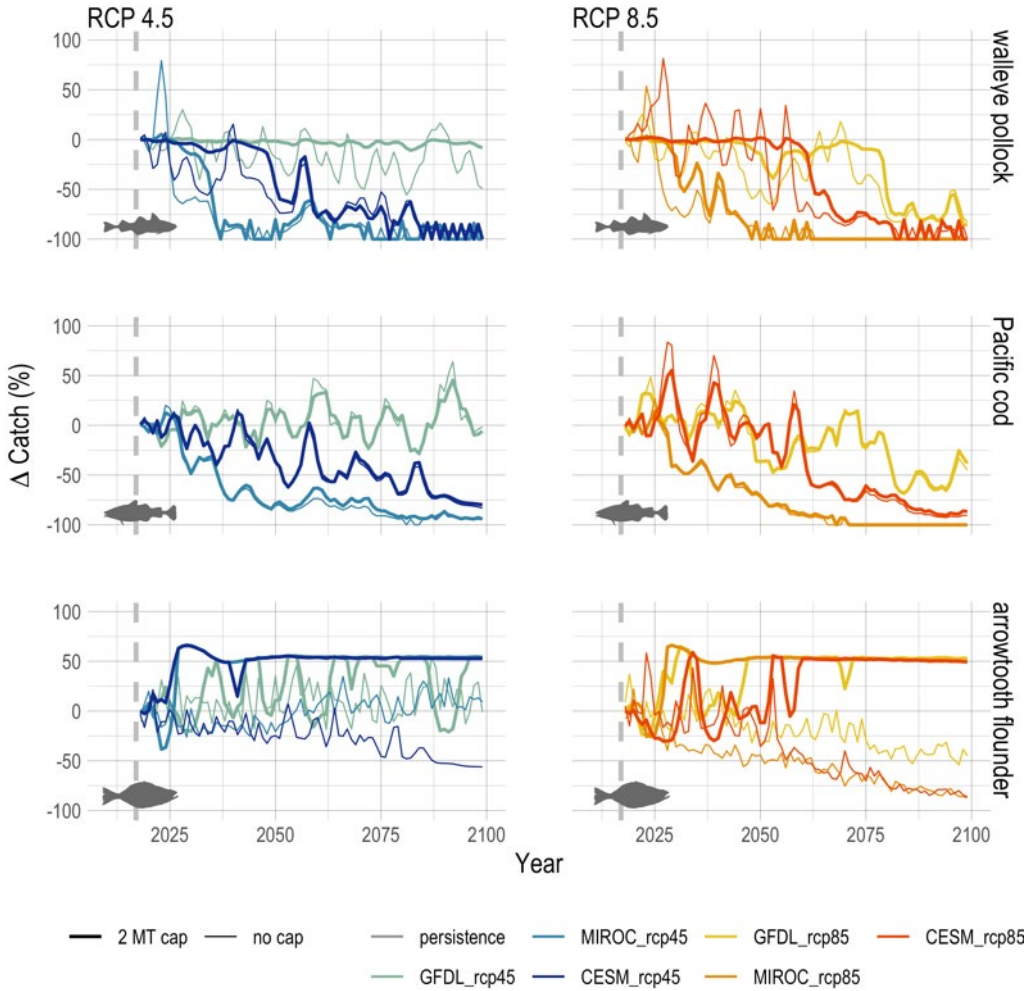
Climate change is impacting fisheries worldwide with uncertain outcomes for food and nutritional security. Using management strategy evaluations for key US fisheries in the eastern Bering Sea we find that Ecosystem Based Fisheries Management (EBFM) measures forestall future declines under climate change over non-EBFM approaches. Yet, benefits are species-specific and decrease markedly after 2050. Under high-baseline carbon emission scenarios (RCP 8.5), end-of-century (2075–2100) pollock and Pacific cod fisheries collapse in >70% and >35% of all simulations, respectively. Our analysis suggests that 2.1–2.3 °C (modeled summer bottom temperature) is a tipping point of rapid decline in gadid biomass and catch. Multiyear stanzas above 2.1 °C become commonplace in projections from ~2030 onward, with higher agreement under RCP 8.5 than simulations with moderate carbon mitigation (i.e., RCP 4.5). We find that EBFM ameliorates climate change impacts on fisheries in the near-term, but long-term EBFM benefits are limited by the magnitude of anticipated change.



EBFM vs non-EBFM cap

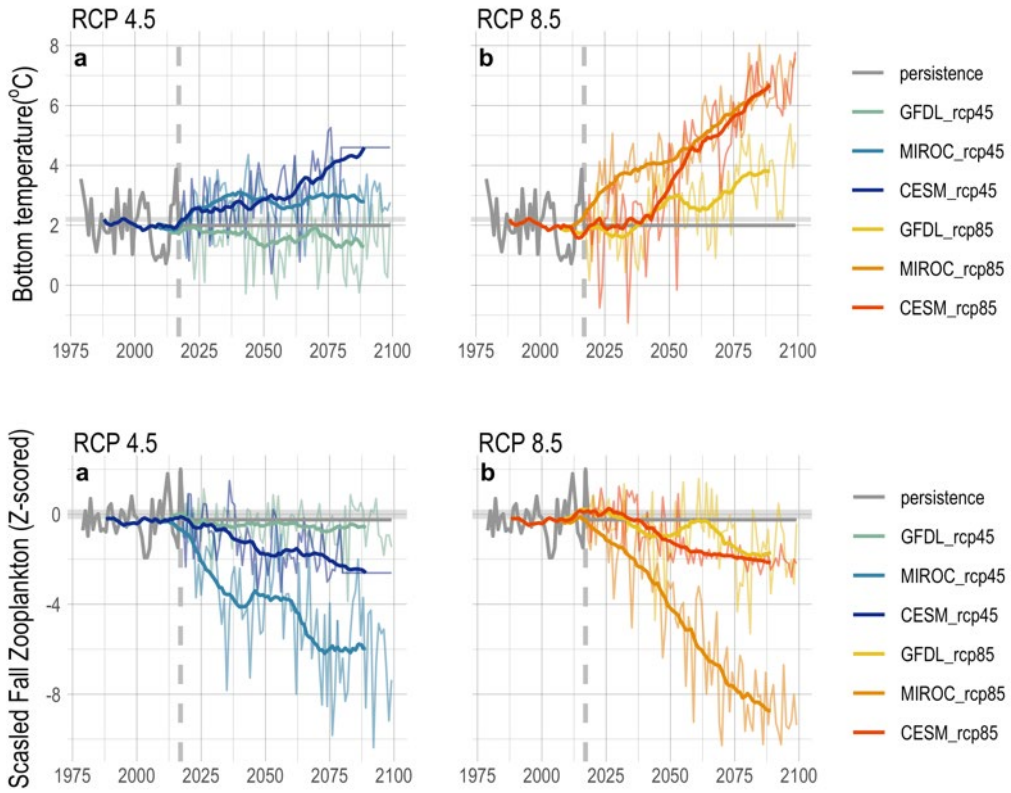


Change in Catch

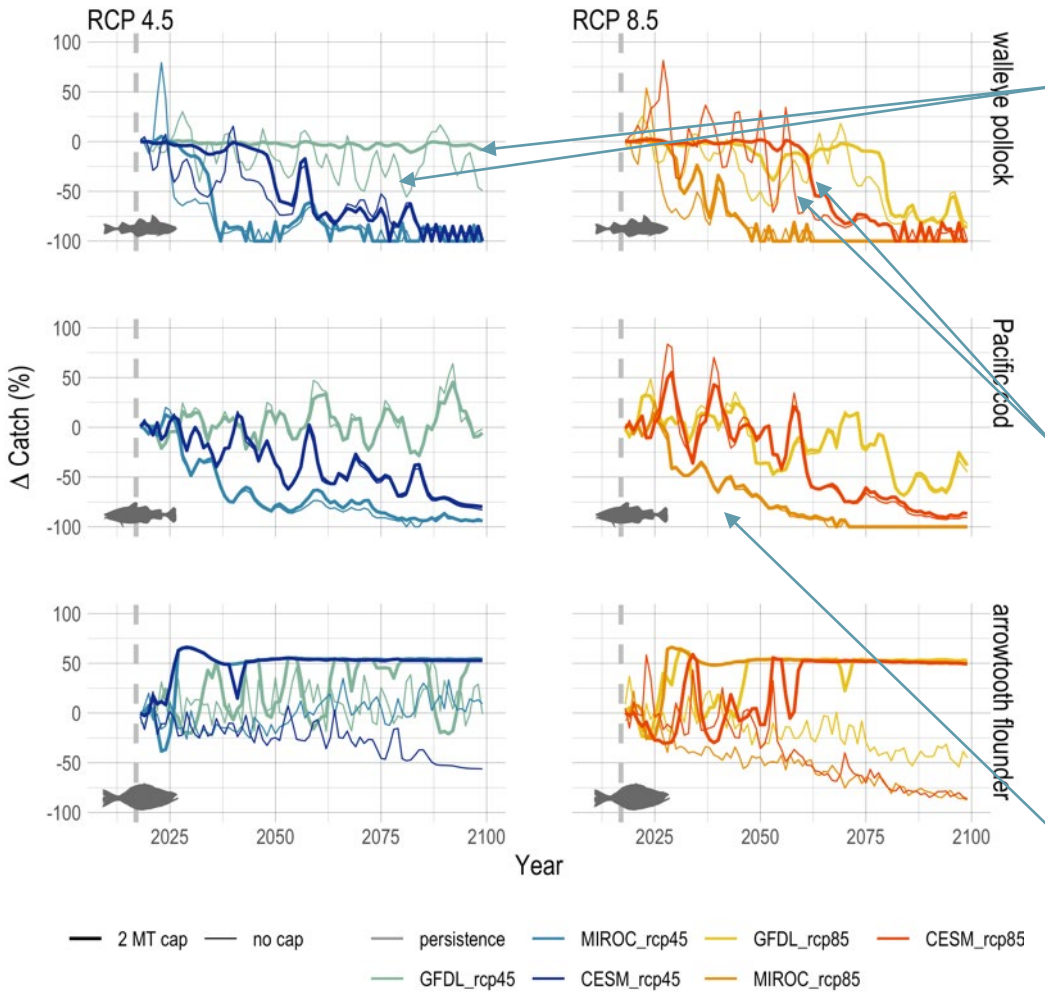


Holsman, K.K., Haynie, A.C., Hollowed, A.B. et al. Ecosystem-based fisheries management forestalls climate-driven collapse. Nat Commun 11, 4579 (2020). https://doi.org/10.1038/s41467-020-18300-3

EBFM vs non-EBFM cap



Change in Catch



EBFM stabilized catches

EBFM forestalled declines (~10yr)

EBFM little effect on P. cod ($)

Holsman, K.K., Haynie, A.C., Hollowed, A.B. et al. Ecosystem-based fisheries management forestalls climate-driven collapse. Nat Commun 11, 4579 (2020). https://doi.org/10.1038/s41467-020-18300-3

Size-spectrum foodweb model (Reum et al. 2020)

frontiers in Marine Science

ORIGINAL RESEARCH
published: 17 March 2020
doi: 10.3389/fmars.2020.00124

Ensemble Projections of Future Climate Change Impacts on the Eastern Bering Sea Food Web Using a Multispecies Size Spectrum Model

Jonathan C. P. Reum[1,2,3], Julia L. Blanchard[2], Kirstin K. Holsman[1], Kerim Aydin[1], Anne B. Hollowed[1], Albert J. Hermann[4,5], Wei Cheng[4,5], Amanda Faig[1,3], Alan C. Haynie[1] and André E. Punt[3]*

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OPEN ACCESS

Edited by:
Erik Olsen, Norwegian Institute of Marine Research (IMR), Norway

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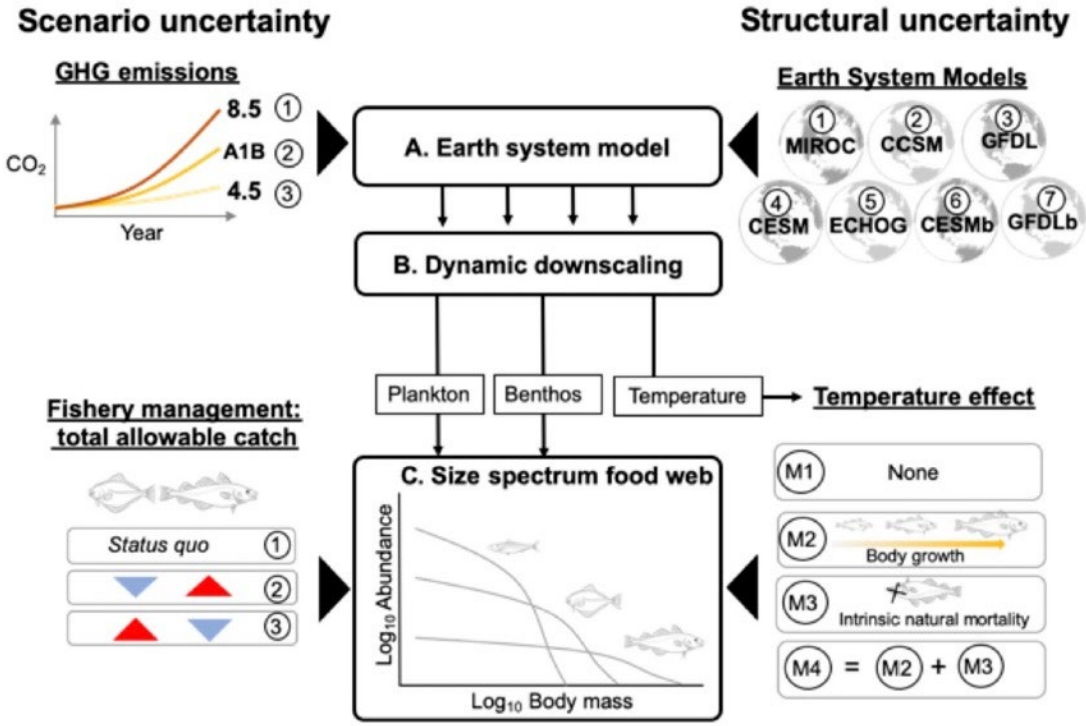
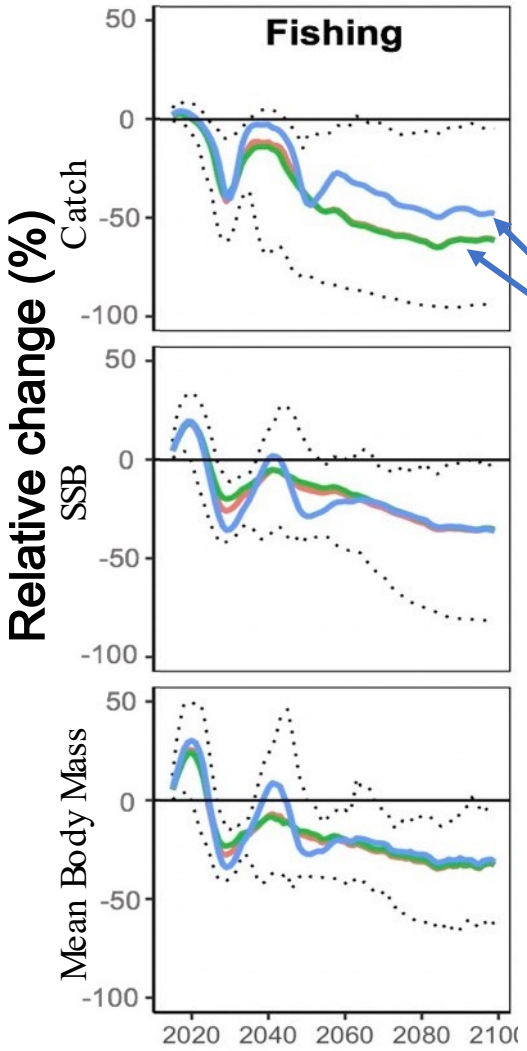
Specialty section:
This article was submitted to

Characterization of uncertainty (variance) in ecosystem projections under climate change is still rare despite its importance for informing decision-making and prioritizing research. We developed an ensemble modeling framework to evaluate the relative importance of different uncertainty sources for food web projections of the eastern Bering Sea (EBS). Specifically, dynamically downscaled projections from Earth System Models (ESM) under different greenhouse gas emission scenarios (GHG) were used to force a multispecies size spectrum model (MSSM) of the EBS food web. In addition to ESM and GHG uncertainty, we incorporated uncertainty from different plausible fisheries management scenarios reflecting shifts in the total allowable catch of flatfish and gadids and different assumptions regarding temperature-dependencies on biological rates in the MSSM. Relative to historical averages (1994–2014), end-of-century (2080–2100 average) ensemble projections of community spawner stock biomass, catches, and mean body size (±standard deviation) decreased by 36% (±21%), 61% (±27%), and



Size-spectrum foodweb model (Reum et al. 2020)



MANAGEMENT SCENARIOS

- Status quo
- More gadid
- More flatfish

(1) TAC = recent historical patterns ("status quo")
(2) pollock and Pacific cod TAC </= status quo + 10% (at the cost of lower flatfish TAC)
(3) flatfish TAC TAC </= status quo + 10% (at the cost of lower pollock and Pacific cod TAC)

Slight change in management flexibility can result in ~10% increase in catch over status quo

Incremental adjustments can increase adaptive scope (slightly)

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.

Downscaling is needed

Projections based on global climate models may underestimate future variance. Variability among GCMs is large so select multiple scenarios to downscale.

Multiple models of biological & socioeconomic dynamics are needed

Accounting for predation changed the direction of projections from increases (single-sp model) to declines (multi-sp). Modeling management response and adaptation is needed to understand tipping points in the system. Climate impacts are non-additive and dynamics of the social-ecological system may attenuate or amplify impacts. Multiple integrated models are needed to evaluate structural uncertainty.

Mitigation is lower risk

Changes in productivity may induce large declines in fish and crab. Most pollock and cod scenarios crashed under business as usual (RCP8.5) by 2100; carbon mitigation (RCP 4.5) represents a lower risk scenario.

Adaptation through fisheries management

Changing harvest rates through management can help lessen climate impacts, to a point. EBFM can forestall climate declines and provide critical time to adapt.

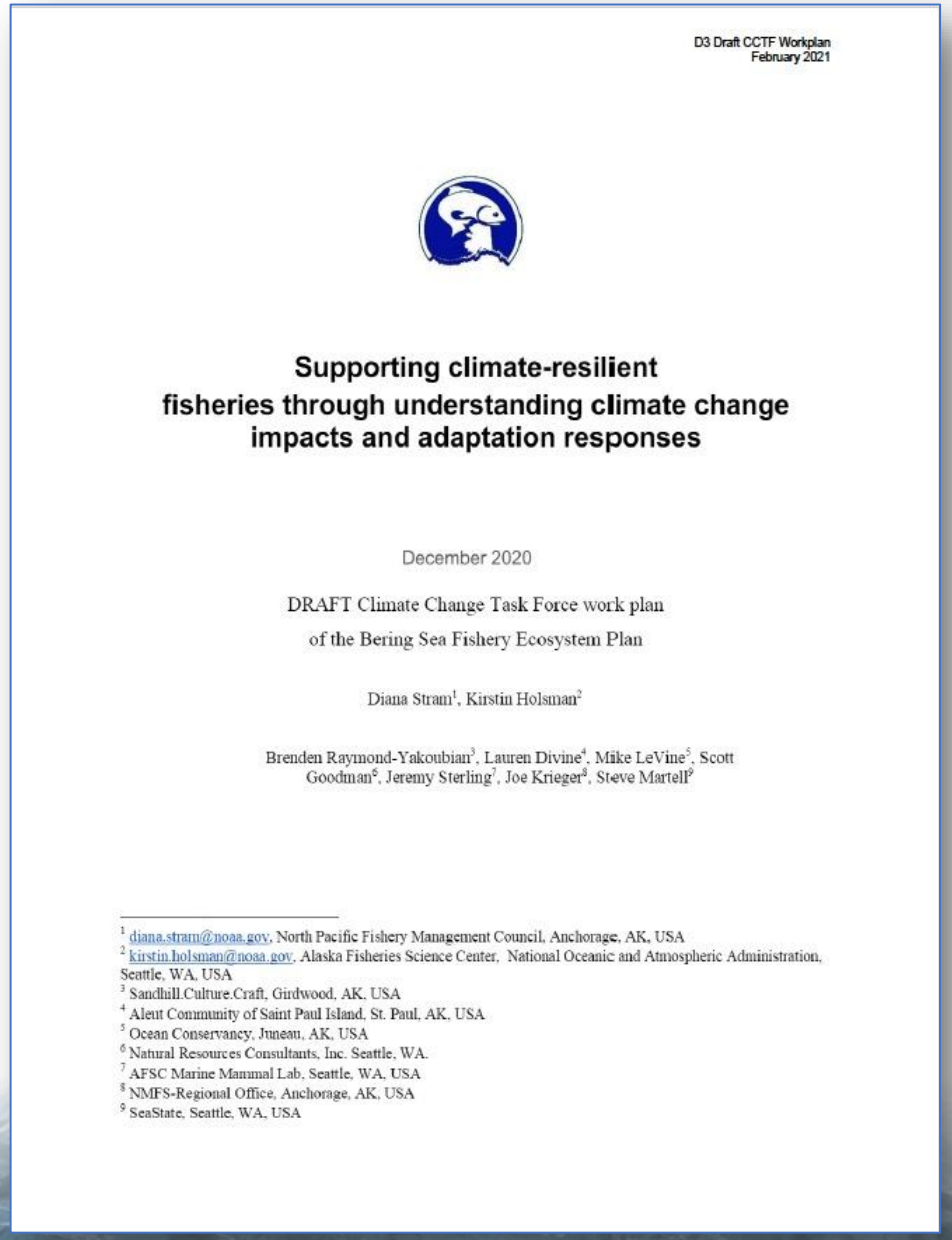
ACTIONABLE ADVICE

N. Pacific Fisheries Management Council: Climate Change Task Force

Taskforce members :

- Diana Stram co-Chair (NPFMC)
- Kirstin Holsman co-Chair (AFSC-Seattle)
- Lauren Divine (Aleut Community of Saint Paul Island)
- Scott Goodman (Natural Resources Consultants)
- Steve Martell (SeaState)
- Joe Krieger (NMFS-Regional Office)
- Brenden Raymond-Yakoubian (Sandhill.Culture.Craft)
- Mike LeVine (Ocean Conservancy)
- Jeremy Sterling (AFSC Marine Mammal Lab)
- Todd Loomis (Ocean Peace, Inc.)

https://www.npfmc.org/climatechangetaskforce/
Stram et al. 2021



D3 Draft CCTF Workplan
February 2021

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

Diana Stram[1], Kirstin Holsman[2]

Brenden Raymond-Yakoubian[3], Lauren Divine[4], Mike LeVine[5], Scott Goodman[6], Jeremy Sterling[7], Joe Krieger[8], Steve Martell[9]

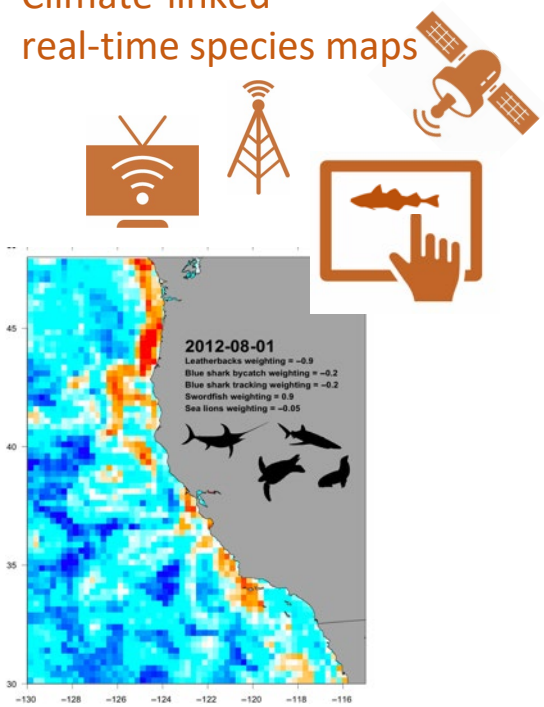
[1] diana.stram@noaa.gov, North Pacific Fishery Management Council, Anchorage, AK, USA
[2] kirstin.holsman@noaa.gov, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[3] Sandhill.Culture.Craft, Girdwood, AK, USA
[4] Aleut Community of Saint Paul Island, St. Paul, AK, USA
[5] Ocean Conservancy, Juneau, AK, USA
[6] Natural Resources Consultants, Inc. Seattle, WA.
[7] AFSC Marine Mammal Lab, Seattle, WA, USA
[8] NMFS-Regional Office, Anchorage, AK, USA
[9] SeaState, Seattle, WA, USA

E.G., FISHERY CLIMATE ADAPTATION TOOLS

Adapt in real-time
(incremental adaptation)

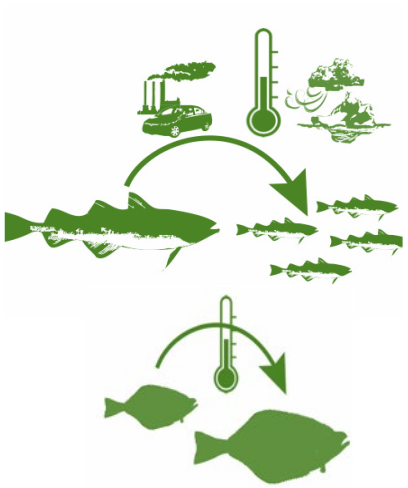
Minimize impacts through holistic planning
(transformational adaptation)

Climate-linked real-time species maps



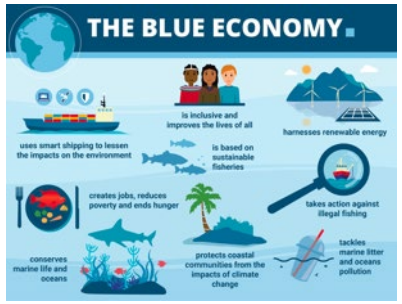
Hazen et al. 2019
https://advances.sciencemag.org/content/4/5/eaar3001

Climate-enhanced stock Assessment models



Holsman et al. 2020
https://www.nature.com/articles/s41467-020-18300-3
Hollowed et al. 2020 (ACLIM)

Climate smart long-term strategies



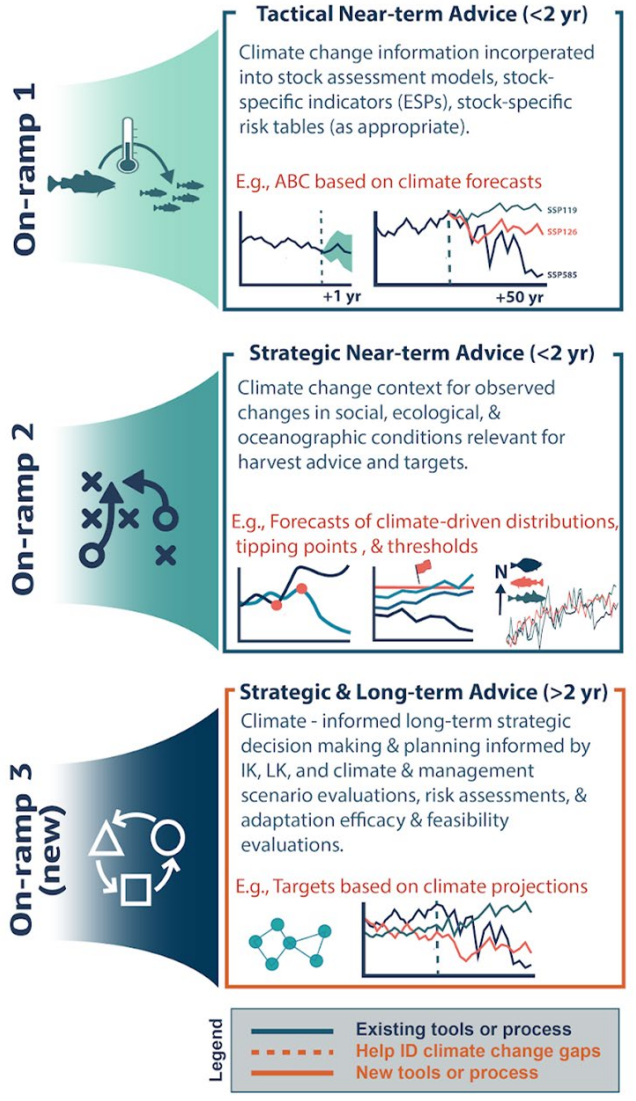
www.blueeconomyconference.go.ke

Santos et al. 2020.
https://www.nature.com/articles/s41893-020-0513-x

N. Pacific Fisheries Management Council: Climate Change Task Force

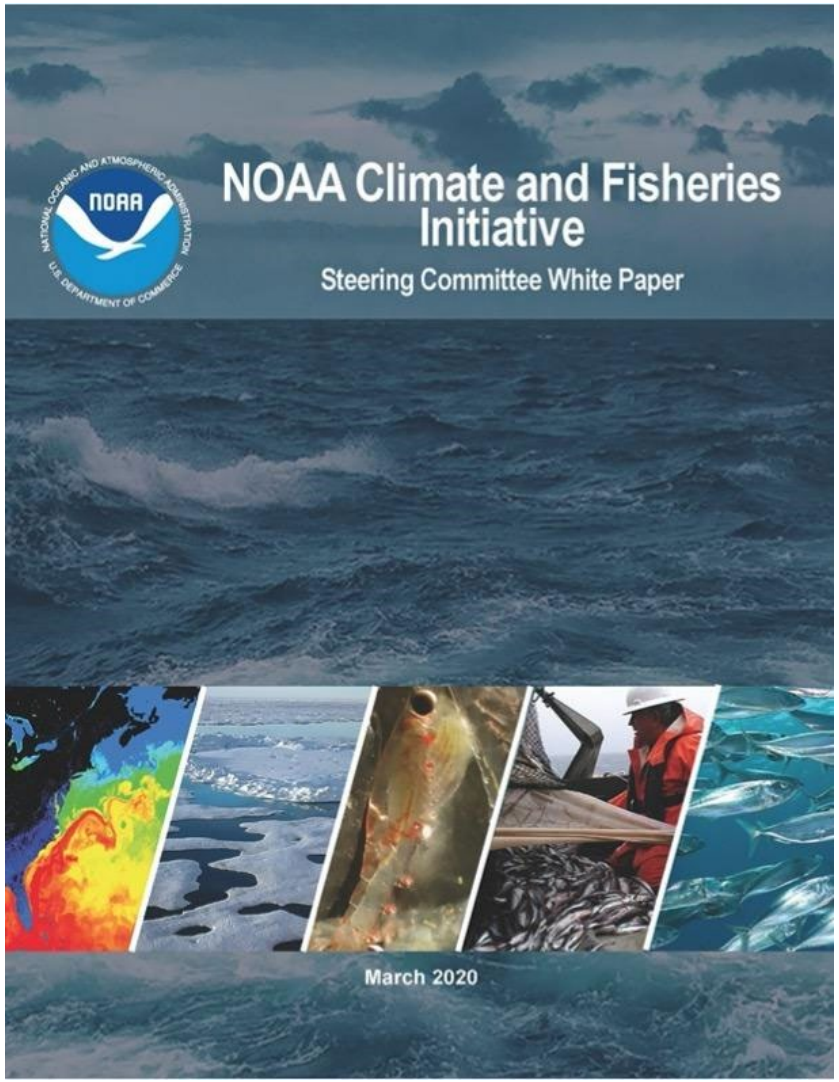
- Don’t need to find perfect solution instead, describe range of results & associated confidence
- Identify climate advice “on-ramps” in order to share information
- Identify existing & new decision support tools
- Management & policy makers can then make “climate informed” decisions

Climate information on ramps for fisheries management



https://www.npfmc.org/climatechangetaskforce/
Stram et al. 2021

Climate Fisheries Initiative (CFI)



ACLIM as a test bed for operationalized climate-informed fisheries advice

IPCC Assessment Reports

ACLIM
The Alaska Climate Integrated Modeling Project
NOAA Alaska Fisheries Science Center

Thanks!

- ACLIM 1.0 funding:
  - Fisheries & the Environment (FATE)
  - Stock Assessment Analytical Methods (SAAM)
  - Climate Regimes & Ecosystem Productivity (CREP)
  - NMFS Economics and Human Dimensions Program
  - NOAA Integrated Ecosystem Assessment Program (IEA)
  - NOAA Research Transition Acceleration Program (RTAP)
  - Alaska Fisheries Science Center
- ACLIM 2.0 funding:
  - NOAA's Coastal and Ocean Climate Applications (COCA) Climate and Fisheries Program
  - NOAA Integrated Ecosystem Assessment Program (IEA)
  - Alaska Fisheries Science Center

Collaboration support:

  - NPRB & BSIERP Team
  - GOA-CLIM Team
  - AFSC REEM, REFM, RACE
  - ICES PICES Strategic Initiative on climate change and marine ecosystems (SICCME/S-CCME)
  - NPFMC Climate change task force, the Ecosystem Committee of the NPFMC
  - FAO
  - MAPP

QUESTIONS ?

kirstin.holsman@noaa.gov

Glossary of Terms

- IPCC : United Nations Intergovernmental Panel on Climate Change
- NOAA : National Oceanic and Atmospheric Administration
- NMFS : National Marine Fisheries Service
- Council : North Pacific Fisheries Management Council
- CE - : “Climate Enhanced” -
- GCM : General Circulation Model (Global in scale)
- RCP : Representative (carbon) Concentration Pathway
- FEP : Fisheries Ecosystem Plan
- ROMS : Regional Ocean Modeling System
- NPZ : Nutrient Phytoplankton Zooplankton Model
- CEATTLE : Climate Enhanced Assessment with Temperature and Trophic Linkages & Energetics Model
- FEAST : Forage and Euphausiid Assessment in Space and Time model
- SES : coupled Social-Ecological System

ACLIM Publications:

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