ACLIM 2.0

BUILDING PATHWAYS TO RESILIENCE THROUGH EVALUATION OF CLIMATE IMPACTS, RISK, & ADAPTATION RESPONSES OF MARINE ECOSYSTEMS, FISHERIES, & EBS COASTAL COMMUNITIES

Presented by Alan Haynie, Jon Reum, and Al Hermann
on behalf of the ACLIM Team

ACLIM2 Team

Building Pathways To Resilience Through Evaluation of Climate Impacts, Risk, & Adaptation Responses of Marine Ecosystems, Fisheries, & EBS Coastal Communities

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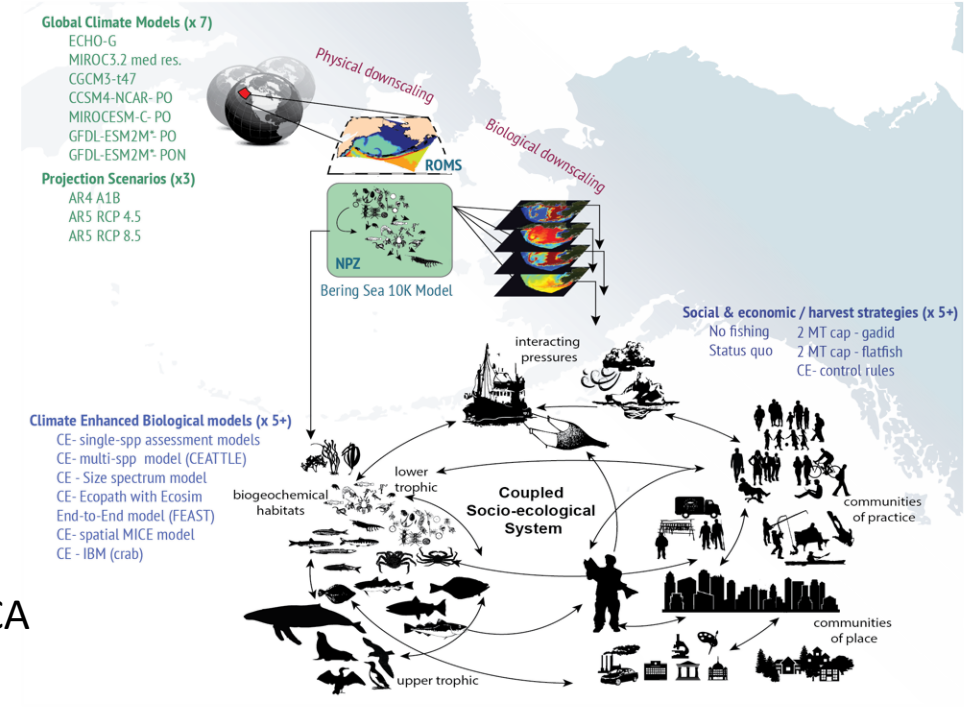
www.fisheries.noaa.gov/alaska/ecosystems/alaska-climate-integrated-modeling-project

The Alaska Climate Integrated Modeling Project

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



NOAA COCA
AFSC

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

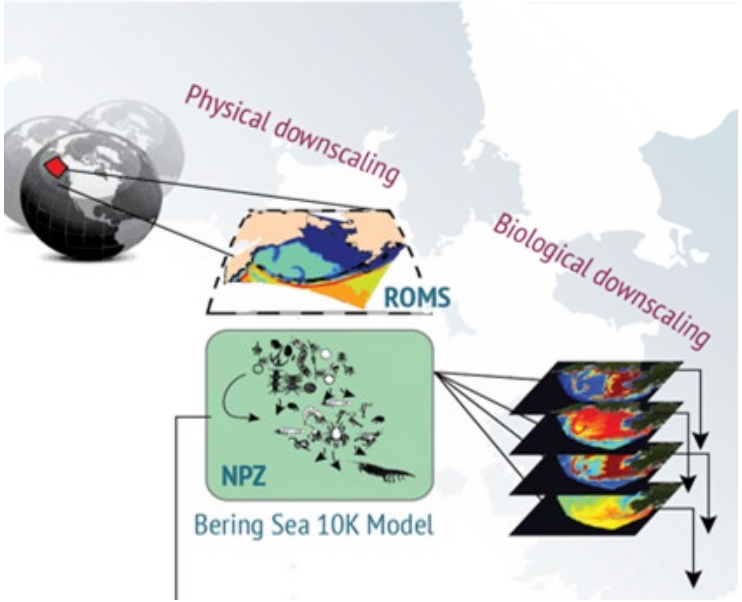
ACLIM1 findings

Downscaling is needed	Projections based on global climate models may underestimate future variance
Ecological projections need to account for trophic interactions	Accounting for predation changed the direction of projections from increases (single-sp model) to declines (multi-sp)
Mitigation is lower risk	Most pollock and cod scenarios crashed under business as usual emissions (RCP8.5) by 2100; carbon mitigation (RCP 4.5) may lessen or prevent declines
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.

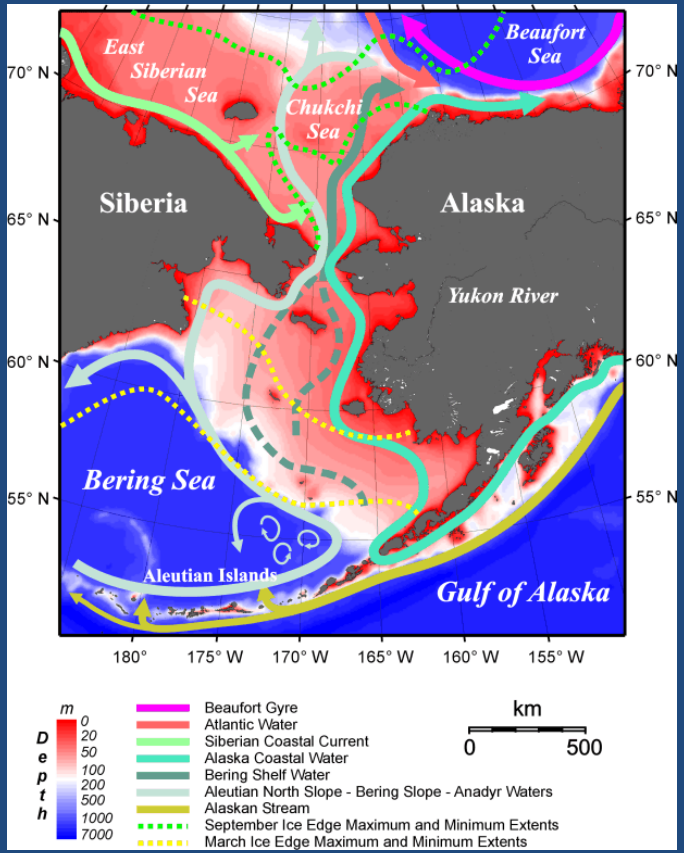
Examine the past and future of the Bering Sea through **dynamical downscaling**

- NOAA uses numerical models to assimilate data and create a dynamically consistent map of temperatures, winds and currents at **global** scales. These models are used in weather prediction (“50% chance of rain…”). Similar types of global models (but without data assimilation) are used by IPCC for multidecadal climate projections

- We use the output from these large-scale hindcast, forecast, and projection models to drive smaller-scale, **regional** dynamical models. For estimates of past or present states, the data assimilated by the global model has a strong influence on the regional model results.

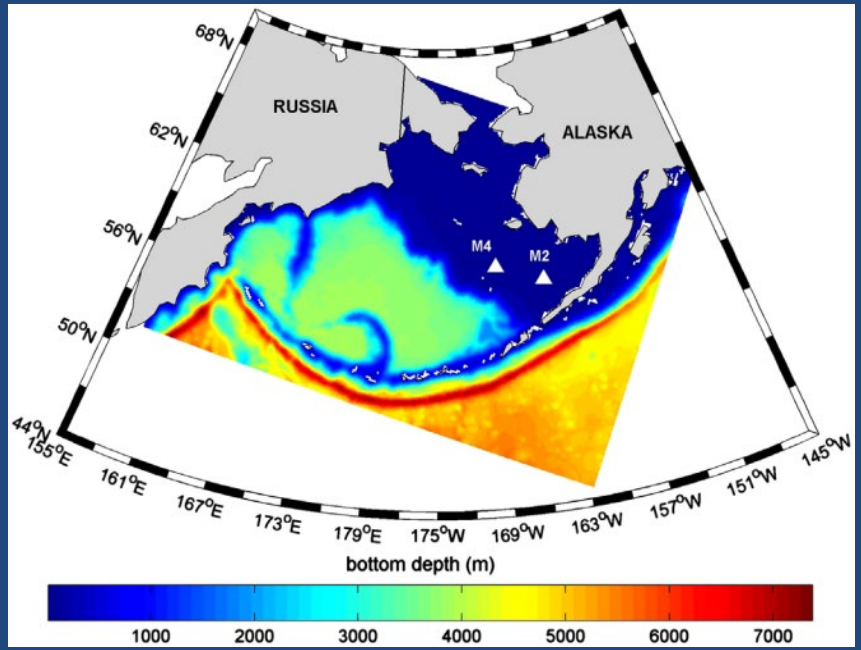


What is unique about the Bering Sea?



- Physical
  - Seasonal ice pushed south by the winds
  - Tidal mixing sets up distinct physical and biological domains
- Biological
  - Ice plankton are a major food source to higher trophic levels
  - Benthic food chain is a major player

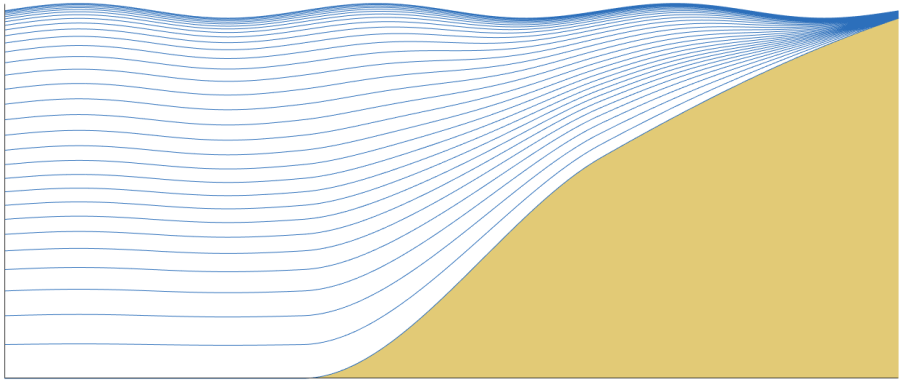
The Bering10K regional model



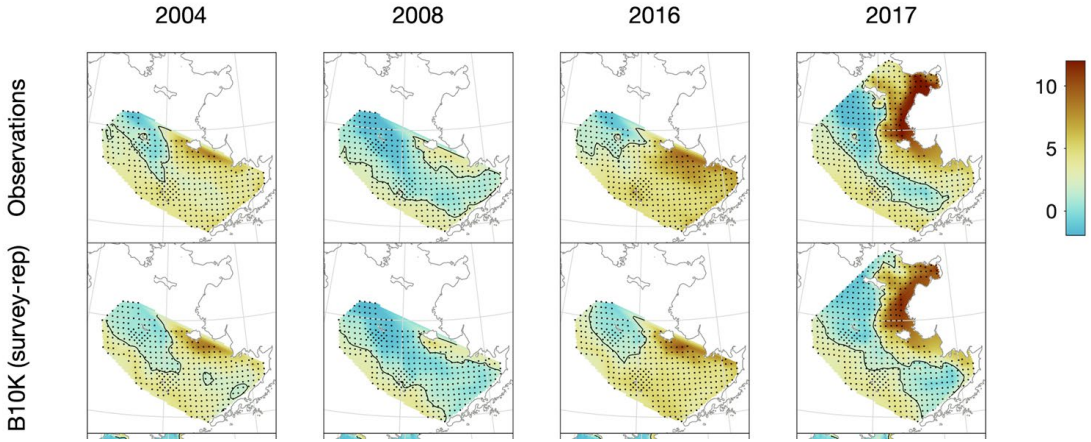
- Regional Ocean Modeling System (ROMS)
- 30 layers, 10-km grid
  Includes ice and tides
- Details in Kearney et al. (2020) and Hermann et al. (DSR2, 2013, 2016)

What is ROMS, exactly?

ROMS is a free-surface, terrain-following, primitive equations model"



ROMS has realistic ocean physics based on comparisons to observed properties such as bottom temperature



Bering Seasons workshop
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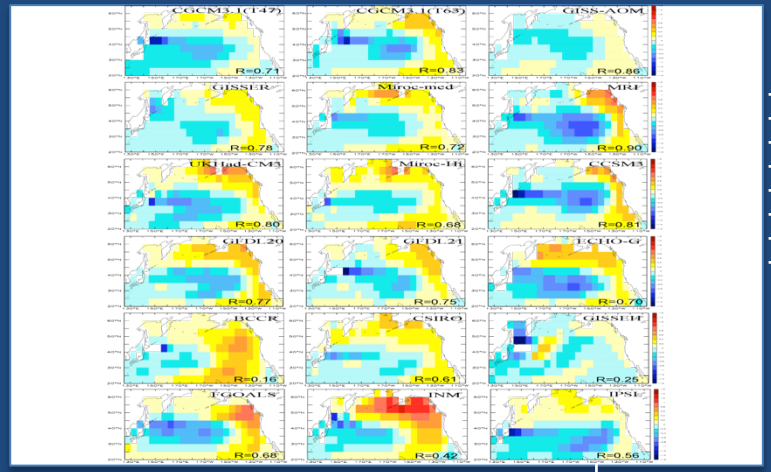
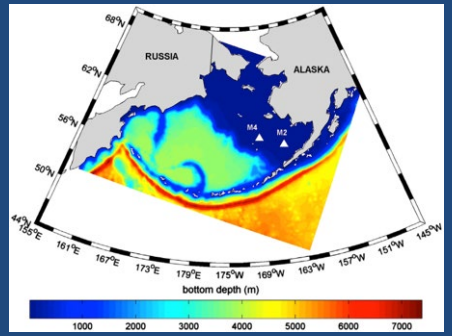
Climate models provide BCs/ICs to *regional coupled models*

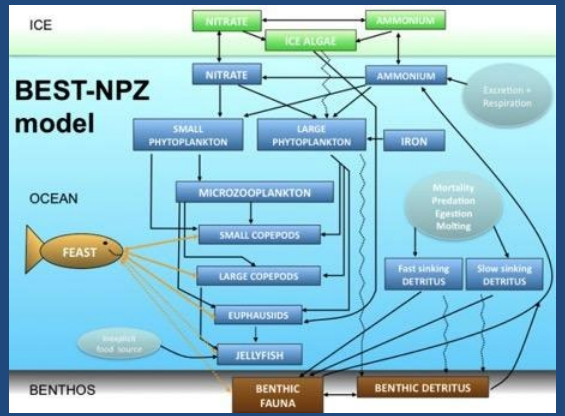


ensemble of runs

Bering10K



NPZ



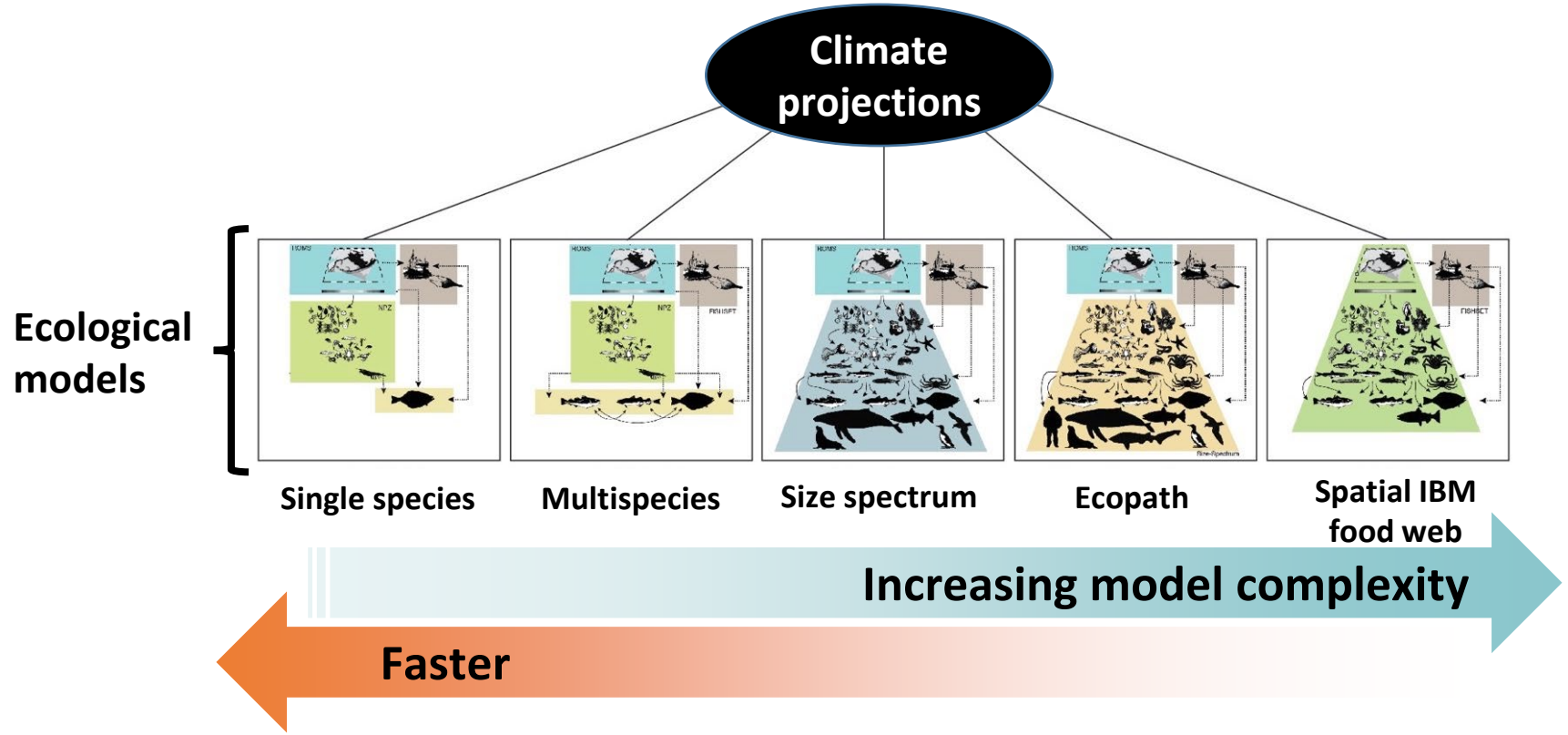
D. Pilcher has added carbonate!

Statistical methods

ensemble of projected futures

MSE

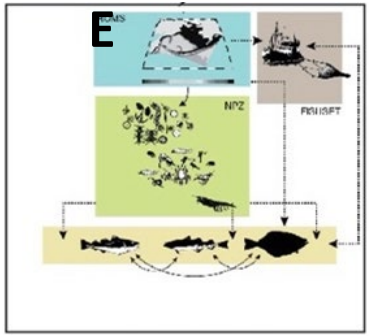
GOAL: seasonal to *mutidecadal* projections of physics and biology in the Bering Sea



- Anticipate possible futures
- Test management strategies
- Characterize uncertainty

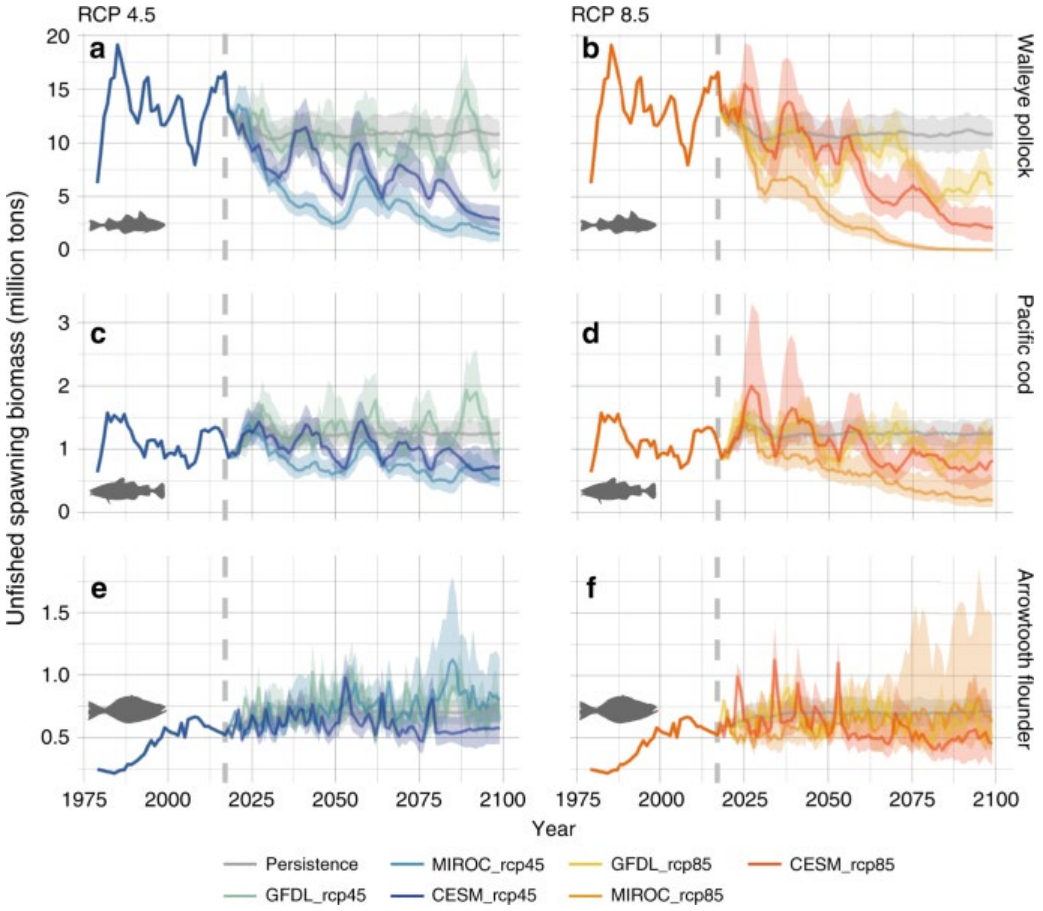
Test management strategies

CEATTL



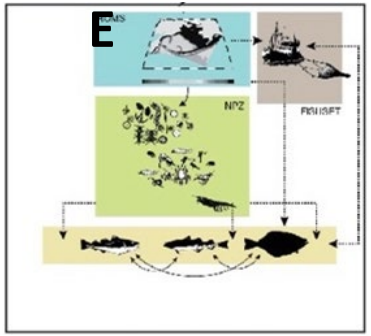
Take home message : EBFM (2mt cap) reduces climate change impacts and risk to fisheries

Holsman et al. (2020) Ecosystem-based fisheries management forestalls climate-driven collapse. Nat Comm

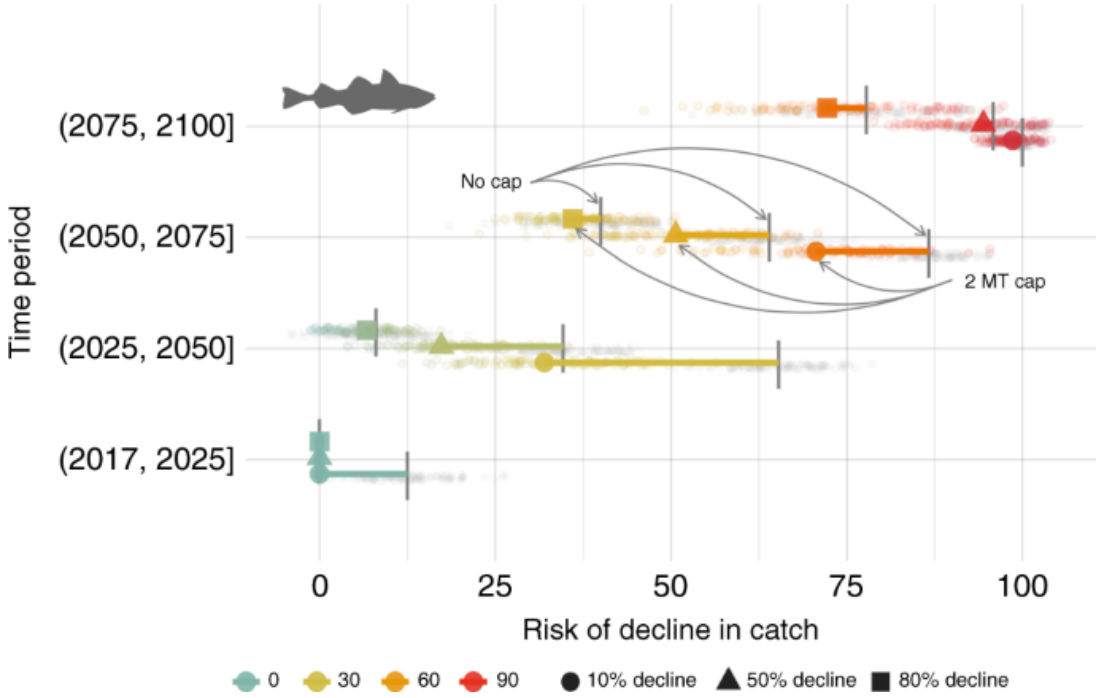


Test management strategies

CEATTL



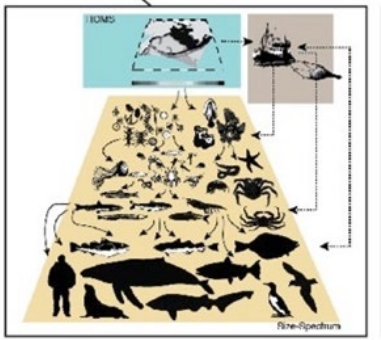
Take home message : EBFM (2mt cap) reduces climate change impacts and risk to fisheries... but climate change overwhelms benefit around 2050+



Holsman et al. (2020) Ecosystem-based fisheries management forestalls climate-driven collapse. Nat Comm

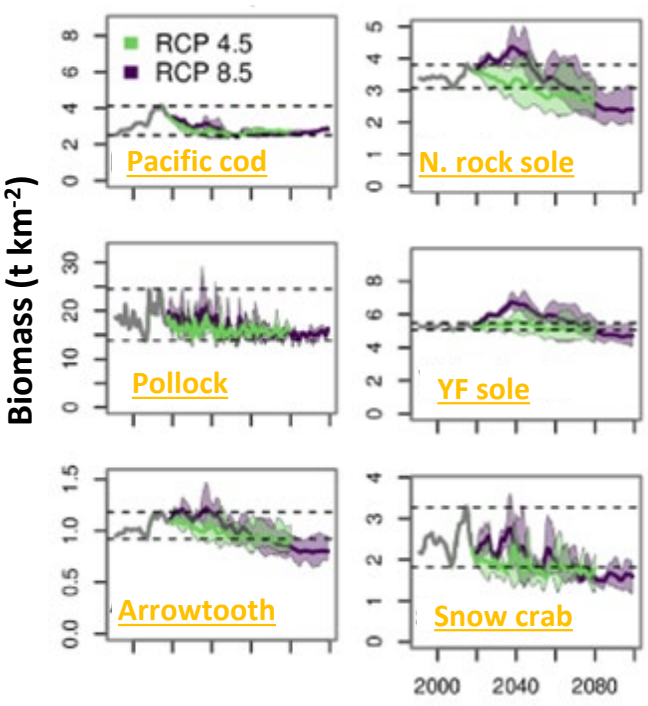
Community-wide responses

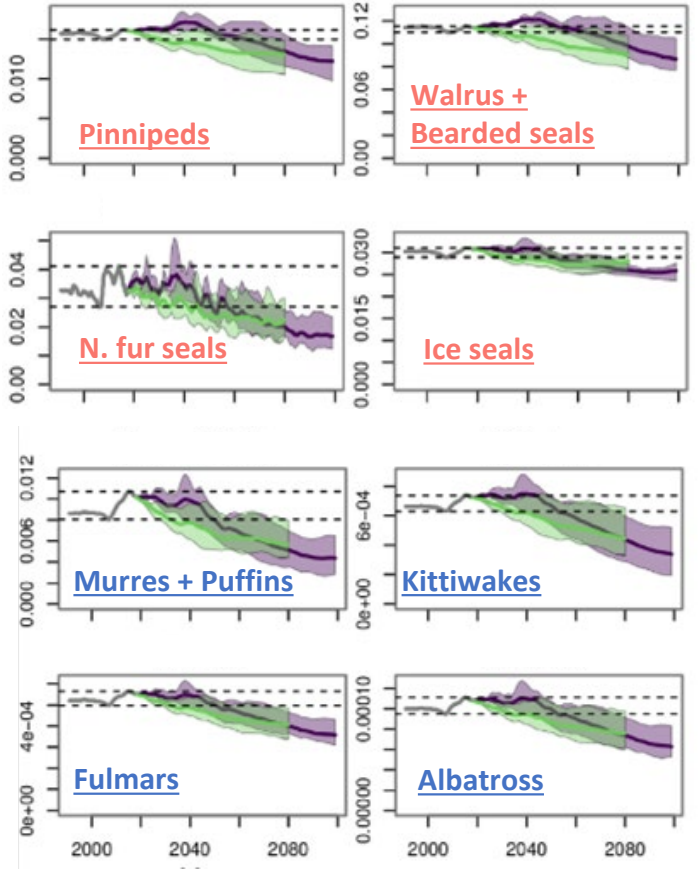
Ecopath



Whitehouse et al. (2021) Bottom-up impacts of forecasted climate change on the eastern Bering Sea food web. Frontiers Mar. Sci.

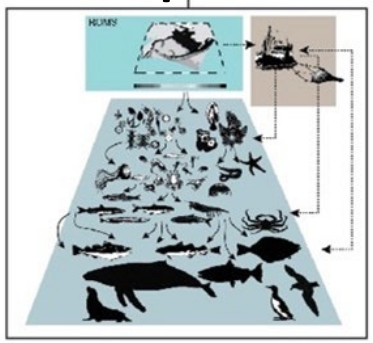
RCP 4.5 Moderate emissions High
RCP 8.5 emissions



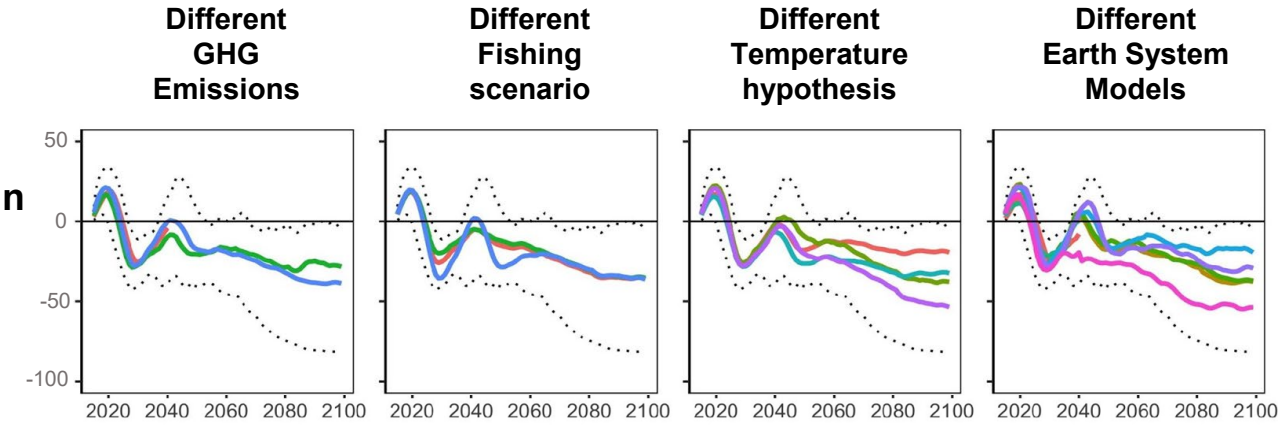


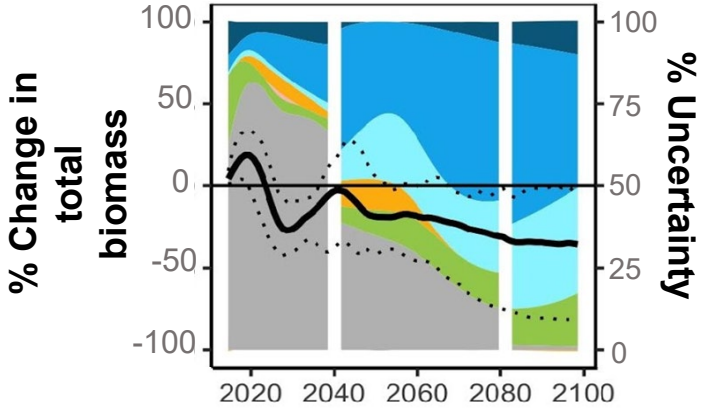
Characterize uncertainty

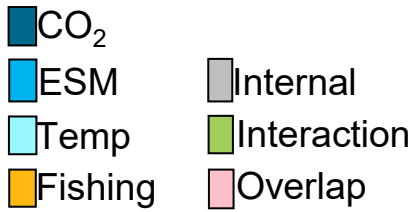
Size spectrum



% Change in total biomass

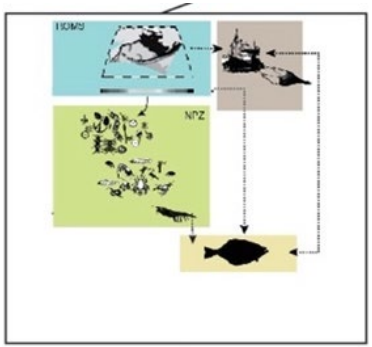






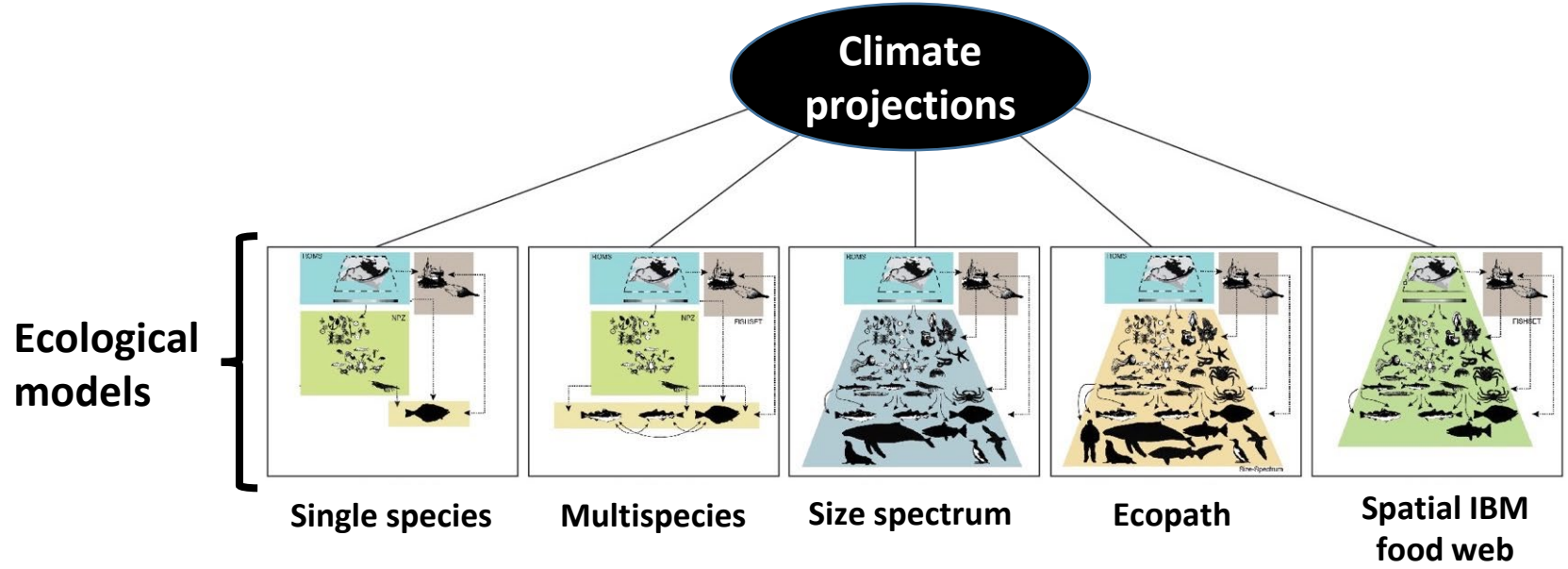
Reum et al. (2020) Ensemble projections of the eastern Bering Sea food web under climate change. Frontiers Mar. Sci.

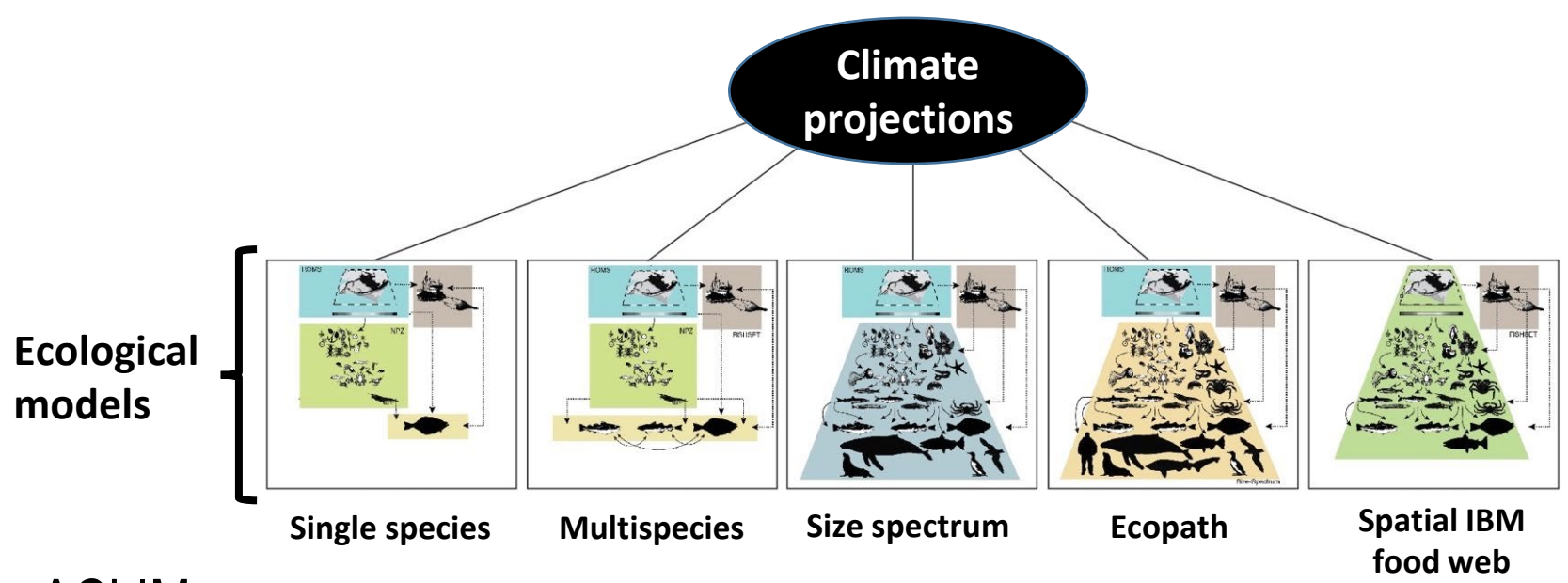
Single species



CE Single species	Model (lead)	Pollock	Pacific cod	ATF	N. Rock sole	YF sole	Snow Crab	Salmon	Other
	Spencer	X							
	Holsman	X							
	Holsman		X						
	Holsman			X					
	Punt				X				
	Spies					X			
	Szuwalski						X		
	Yasumiishi							X	

Multi-species	Model (lead)	Pollock	Pacific cod	ATF	N. Rock sole	YF sole	Snow Crab	Salmon	Other
	Ecopath (Whitehouse)	X	X	X	X	X	X	X	~60
	Mizer (Reum)	X	X	X	X	X	X		~10
	CEATTLE (Holsman)	X	X	X					


Climate projections
Ecological models
Single species
Multispecies
Size spectrum
Ecopath
Spatial IBM food web



ACLIM utilizes economic models of different complexity

- For some models: only need effort and catch response to abundance
- Building more realistic fleet dynamics models to couple with spatial biological models.

ACLIM Socioeconomic Scenarios

ALCIM 1.0 Scenarios

1. No Fishing
2. Current Ecosystem Management with 2 Million ton cap (Status Quo)
3. Increased Pollock-cod share of total allowable catch– max 10% increase the cap
4. Increased Flatfish share of TAC (Flatfish Dominated) – large flatfish increase

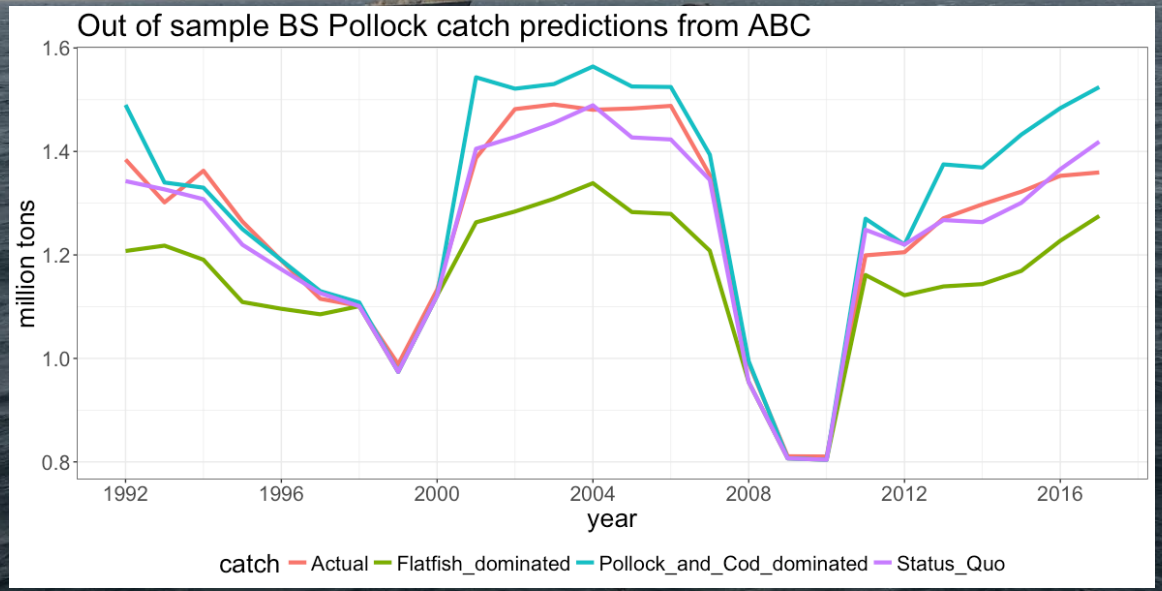
ACLIM 2.0 Scenarios,
Now being developed. Examples:

- 2 million ton cap changes + / -
- Changes in bycatch avoidance technology, allowing higher harvests
- Changes in size-based targeting
- Changes in fishing location/gear
- Price and cost changes.

Council Discussion in October.

ABC To TAC And Commercial Harvest (ATTACH)

- Predicts TAC and harvest under current & alternative policies.
- Accurately captures management & fishing behaviors in the BSAI
- Allows ACLIM (& other) evaluate alternative policies performance







Community and Socio-cultural Questions

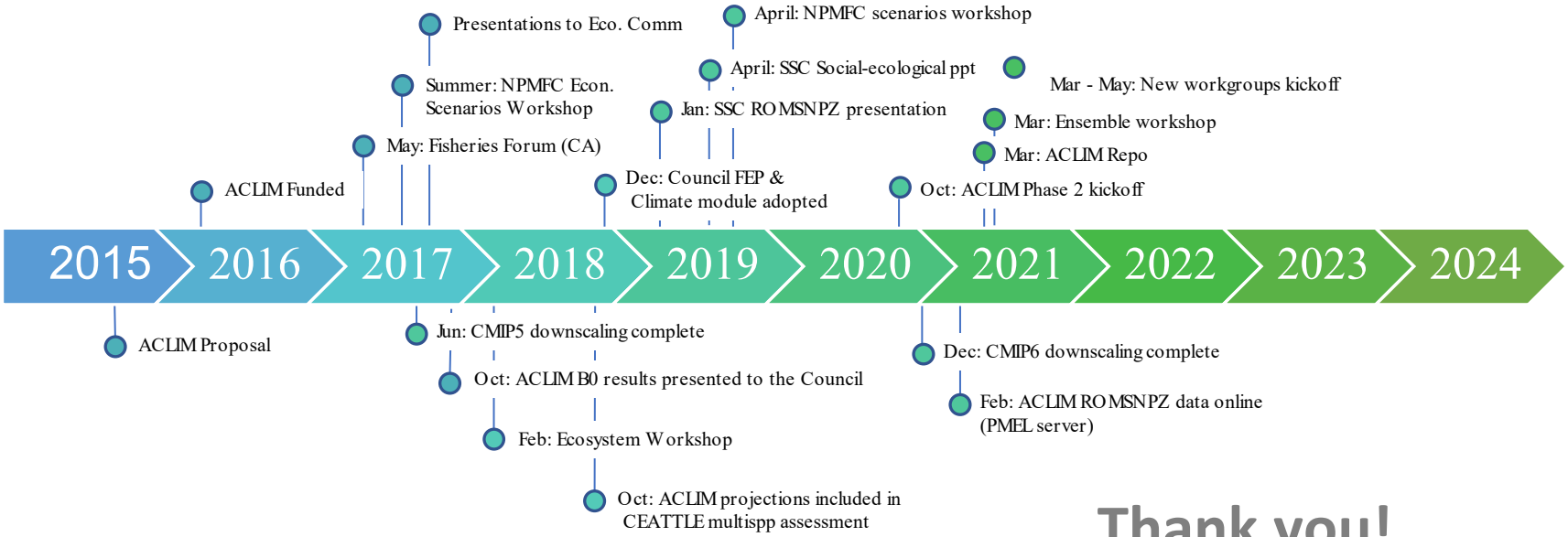
(Wise, Haynie, Kasperski, Seung, Hayes, et al.)

- **What are the community and regional economic impacts of changing catch compositions and market changes?**
- **How will groundfish and Community Development Quota (C dependent communities by climate change?**
- **How do changes in salmon runs affect communities?**
  - If salmon runs increase (decrease), how will communities dependent on salmon respond?
  - What are some of the key concerns for communities highly reliant on salmon.
  - How do adaptive responses differ for communities engaged in commercial harvest verses subsistence?

Timeline

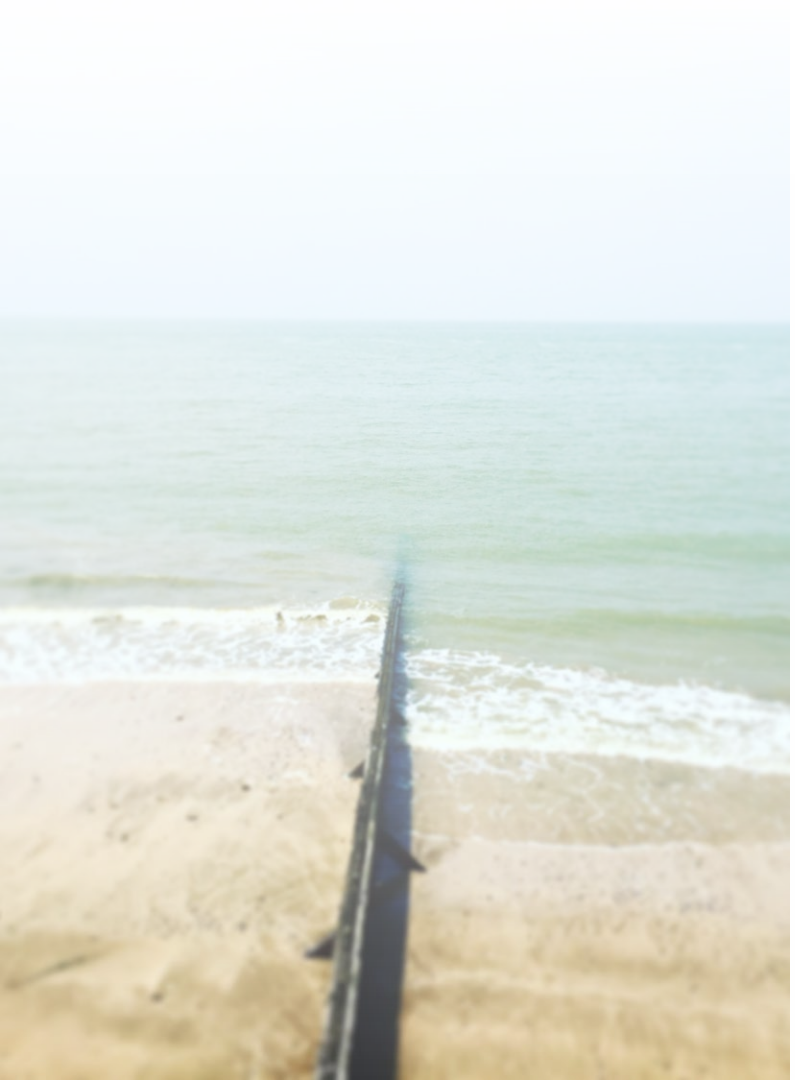

2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
ACLIM Proposal
ACLIM Funded
Presentations to Eco. Comm
Summer: NPMFC Econ. Scenarios Workshop
May: Fisheries Forum (CA)
Jun: CMIP5 downscaling complete
Oct: ACLIM B0 results presented to the Council
Feb: Ecosystem Workshop
Oct: ACLIM projections included in CEATTLE multispp assessment
Dec: Council FEP & Climate module adopted
April: NPMFC scenarios workshop
April: SSC Social-ecological ppt
Jan: SSC ROMSNPZ presentation
Oct: ACLIM Phase 2 kickoff
Mar - May: New workgroups kickoff
Mar: Ensemble workshop
Mar: ACLIM Repo
Dec: CMIP6 downscaling complete
Feb: ACLIM ROMSNPZ data online (PMEL server)

Timeline



Thank you!

Questions?



ACLIM support

- ACLIM 1.0 funding:
  - Fisheries & the Environment (FATE)
  - Stock Assessment Analytical Methods (SAAM)
  - Climate Regimes & Ecosystem Productivity (CREP)
  - Economic and Human Dimensions Program, AFSC, OAR
  - 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:

MAPP Bering Seasons & FATE EFH

- 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

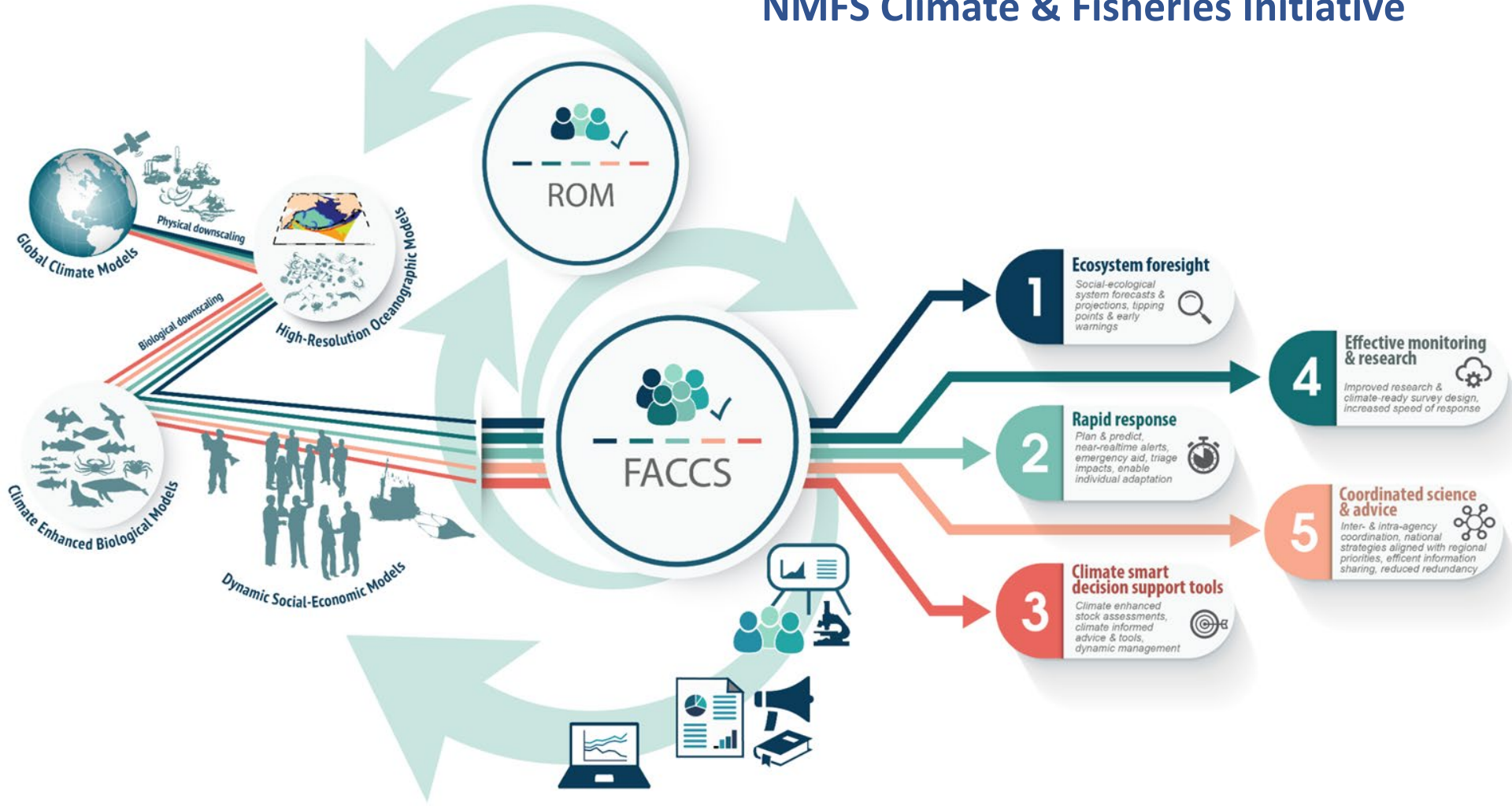
ACLIM1 Publications:

1. (in review) Torre, M. , W. T. Stockhausen, A. J. Hermann, W. Cheng, R. Foy, C. Stawitz, K. Holsman, C. Szuwalski, A. B. Hollowed. (In Review). Early life stage connectivity for snow crab, Chionoecetes opilio, in the eastern Bering Sea: evaluating the effects of temperature-dependent intermolt duration and vertical migration. Deep Sea Research II,
2. (in review) Whitehouse, G. A., K. Y. Aydin, A. B. Hollowed, K. K. Holsman, W Cheng, A. Faig, A. C. Haynie, A. J. Hermann, K. A. Kearney, A. E. Punt, and T. E. Essington. Bottom-up impacts of forecasted climate change on the eastern Bering Sea food web. Frontiers in Mar. Sci.
3. (2020) Holsman, K.K., A. Haynie, A. Hollowed, J. Reum, K. Aydin, A. Hermann, W. Cheng, A. Faig, J. Ianelli, K. Kearney, A. Punt. (2020) Ecosystem-based fisheries management forestalls climate-driven collapse. Nature Communications. DOI:10.1038/s41467-020-18300-3
4. (in review) Thorson, J., M. Arimitsu, L. Barnett, W. Cheng, L. Eisner, A. Haynie, A. Hermann, K. Holsman, D. Kimmel, M. Lomas, J. Richar, E. Siddon. Forecasting community reassembly using climate-linked spatio-temporal ecosystem models. Ecosphere
5. (Accepted) Szuwalski, W. Cheng, R. Foy, A. Hermann, A. Hollowed, K. Holsman, J. Lee, W. Stockhausen, J. Zheng. Climate change and the future productivity and distribution of crab in the Bering Sea. ICES JMS
6. (2020) 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.
7. (2020) 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. Frontiers in Marine Science 6. https://doi.org/10.3389/fmars.2019.00775
8. (2019) Holsman, KK, EL Hazen, A Haynie, S Gourguet, A Hollowed, S Bograd, JF Samhouri, K Aydin, Toward climate-resiliency in fisheries management. ICES Journal of Marine Science. 10.1093/icesjms/fsz031
9. (2019) Hermann, A. J., G.A. Gibson, W. Cheng, I. Ortiz1, K. Aydin, M. Wang, A. B. Hollowed, and K. K. Holsman. Projected biophysical conditions of the Bering Sea to 2100 under multiple emission scenarios. ICES Journal of Marine Science, fsz043, https://doi.org/10.1093/icesjms/fsz043
10. (2019) Reum, J., JL Blanchard, KK Holsman, K Aydin, AE Punt. Species-specific ontogenetic diet shifts attenuate trophic cascades and lengthen food chains in exploited ecosystems. Okios DOI: 10.1111/oik.05630
11. (2019) Reum, J., K. Holsman, KK, Aydin, J. Blanchard, S. Jennings. Energetically relevant predator to prey body mass ratios and their relationship with predator body size. Ecology and Evolution (9):201–211 DOI: 10.1002/ece3.4715

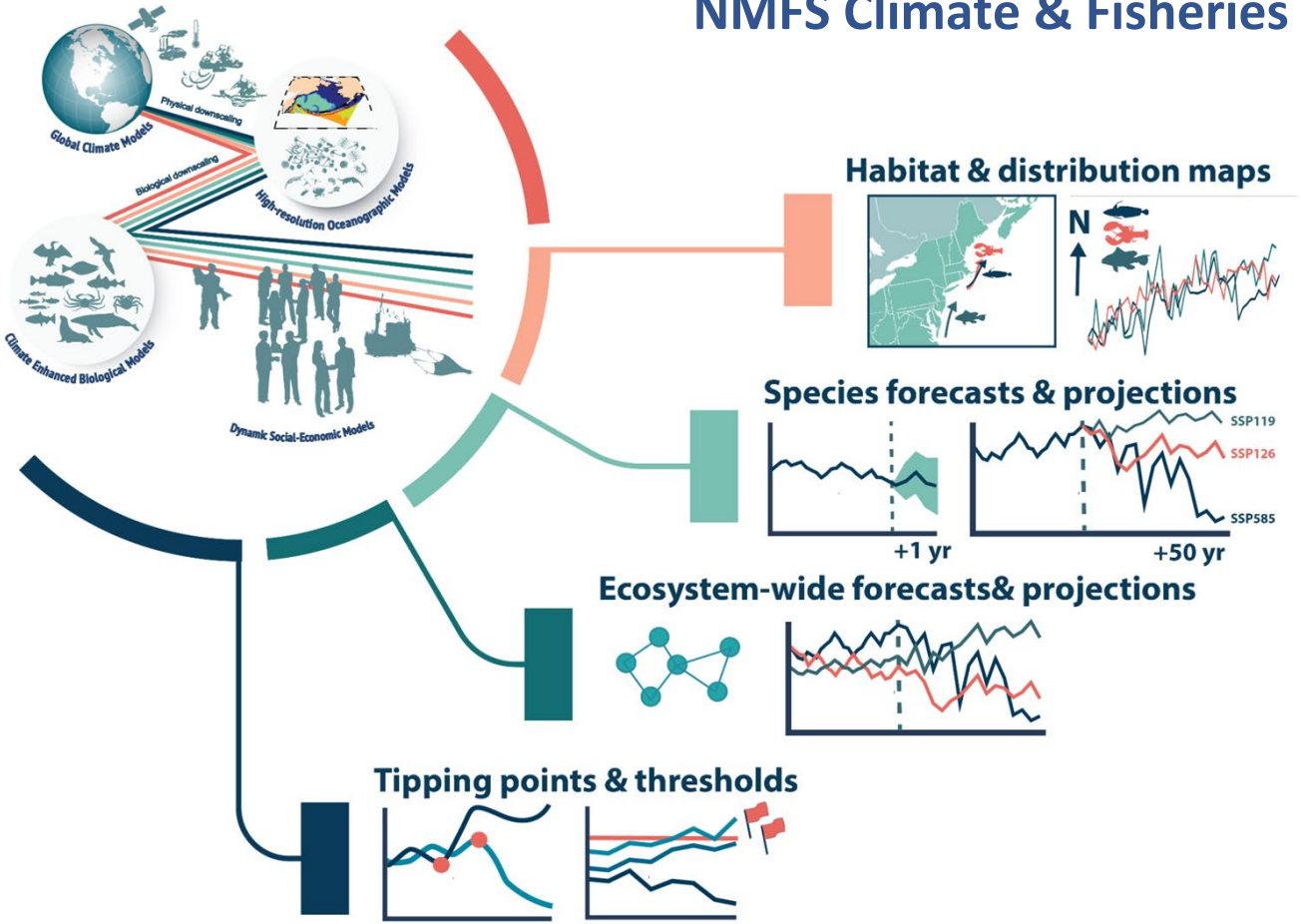
GLOSSARY OF TERMS

- IPCC : UN 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

NMFS Climate & Fisheries Initiative



NMFS Climate & Fisheries Initiative



INTEGRATED ECOSYSTEM ASSESSMENT

Regional Action Plans (RAPs)