The Alaska Climate Integrated Modeling (ACLIM) Project

Photo: Mark Holsman

Evaluating EBS fishery management strategies under different climate futures

Kirstin Holsman[1] & Alan Haynie[1]

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5. School of Aquatic and Fisheries Science, University of Washington

NOAA FISHERIES

The ACLIM team


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Amanda Faig


Jonathan Reum


Michael Dalton


Paul Spencer

Tom Wilderbuer

William Stockhausen

Contributors

YOU!

Introduction to ACLIM

Introduction to ACLIM

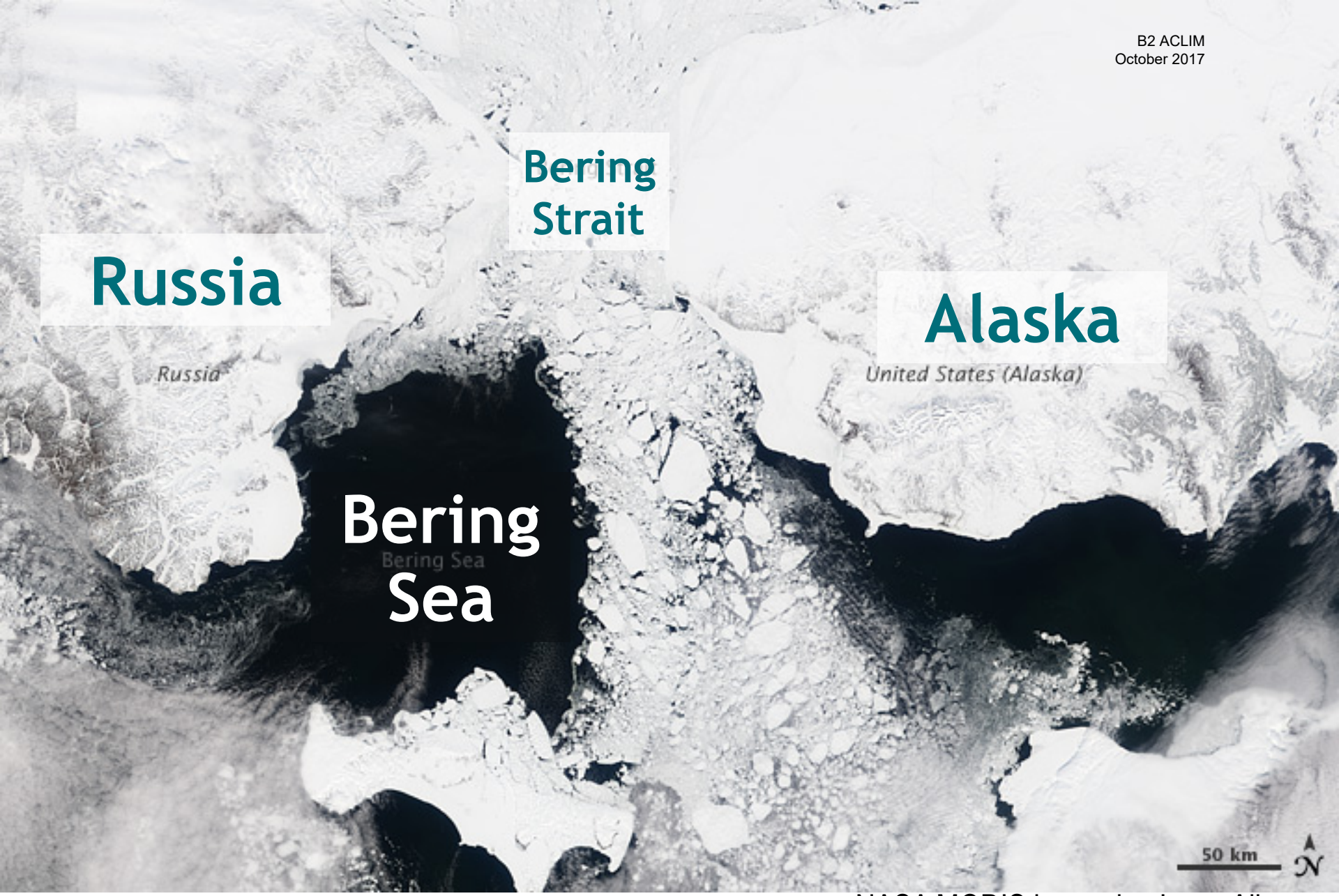
Preliminary results

Photo: Mark Holsman

Introduction to ACLIM

Preliminary results

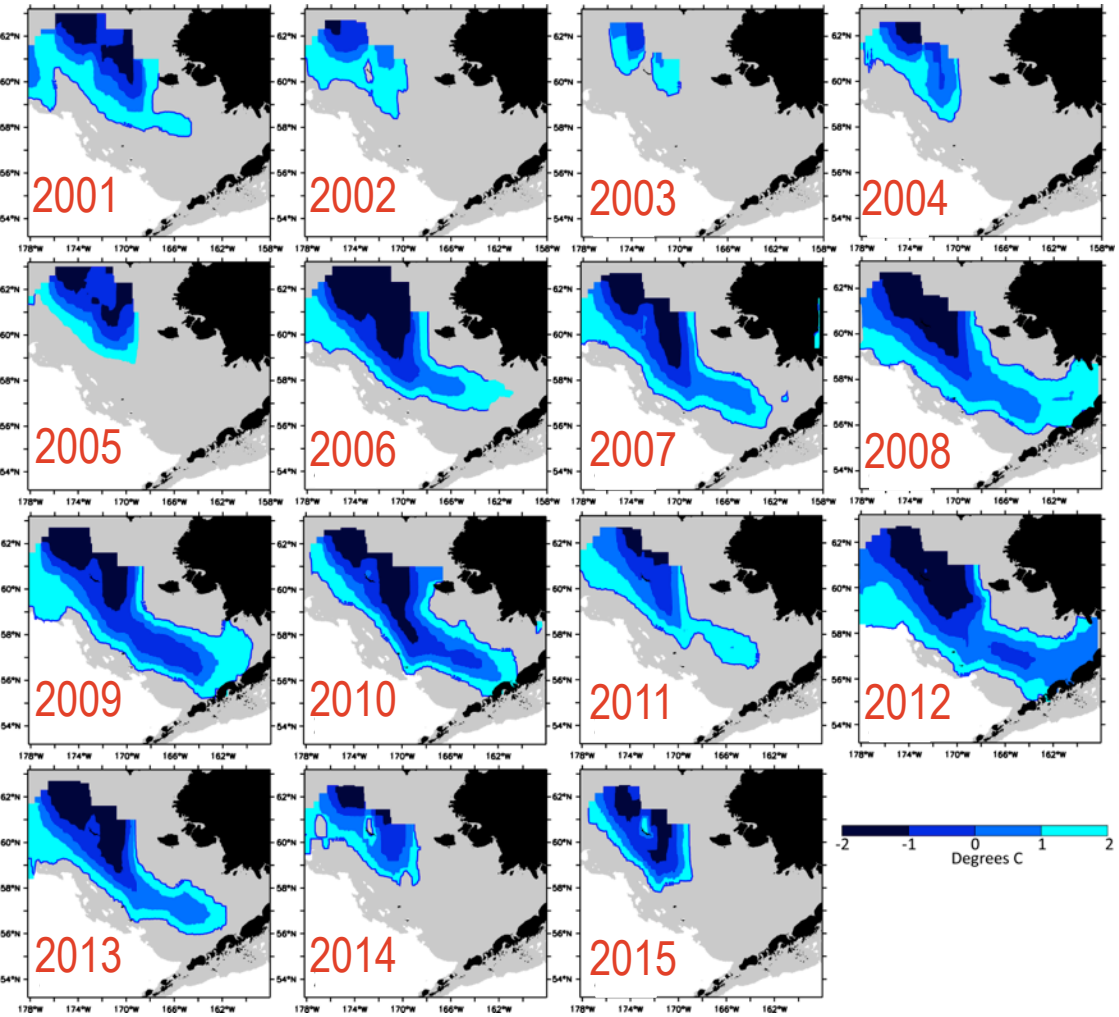
Discussion of fishing scenarios



NASA MODIS image by Jesse Allen

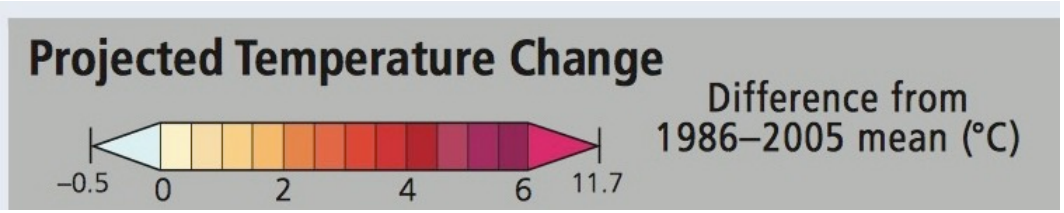
Bering Sea & Climate variability

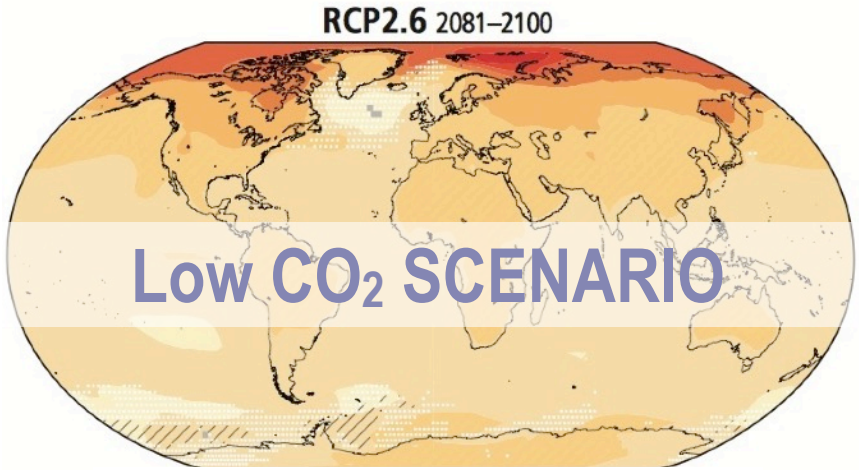
Bering Sea "Cold Pool" 2001-2015



Graphic: J. Overland, P. Stabeno, M. Wang, C. Ladd, N. Bond, and S. Salo, PMEL/NOAA

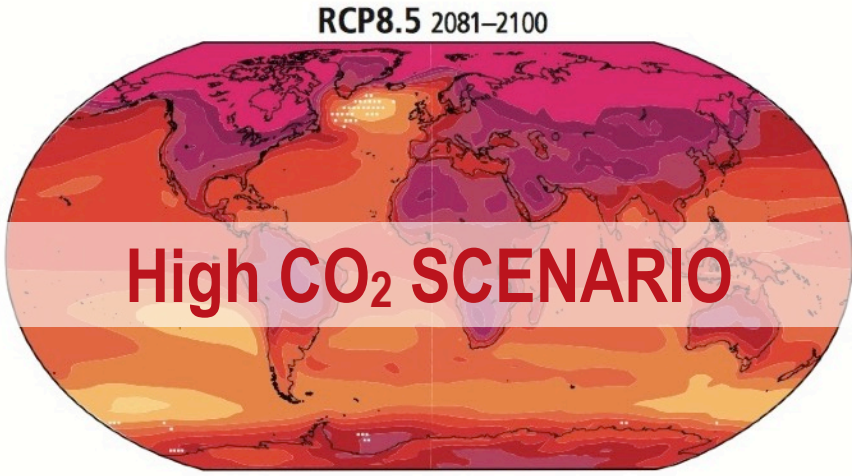
Intergovernmental Panel on Climate Change (IPCC)
5th Assessment Report (2013, 2014)





Low CO_2 SCENARIO

"Paris COP21 agreement"



High CO_2 SCENARIO

"Business as usual"

https://www.ipcc.ch/report/ar5/

Improve management **foresight** in a changing climate

Project changes in Bering Sea ocean conditions and fish populations

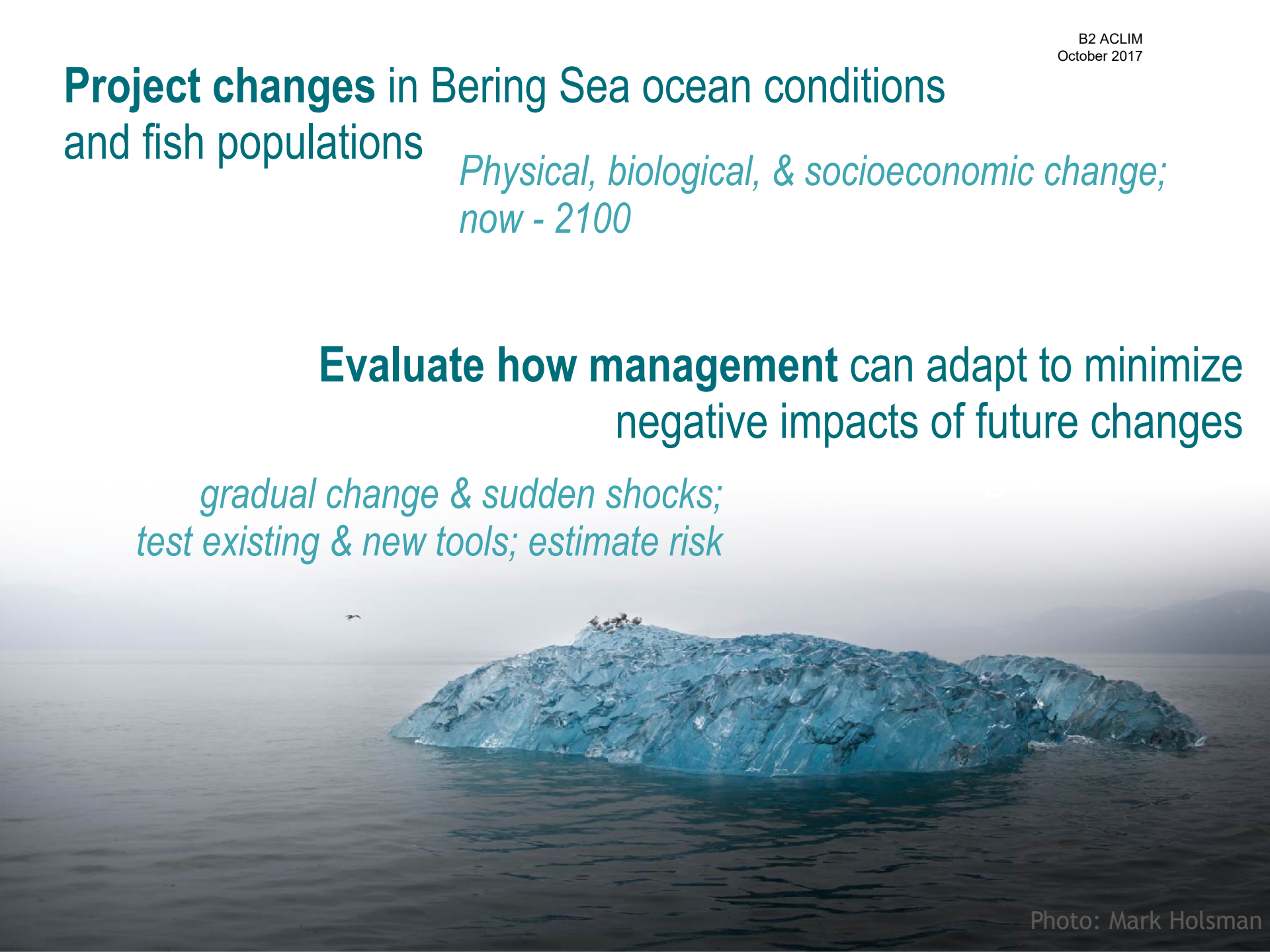
Physical, biological, & socioeconomic change; now - 2100

Project changes in Bering Sea ocean conditions and fish populations

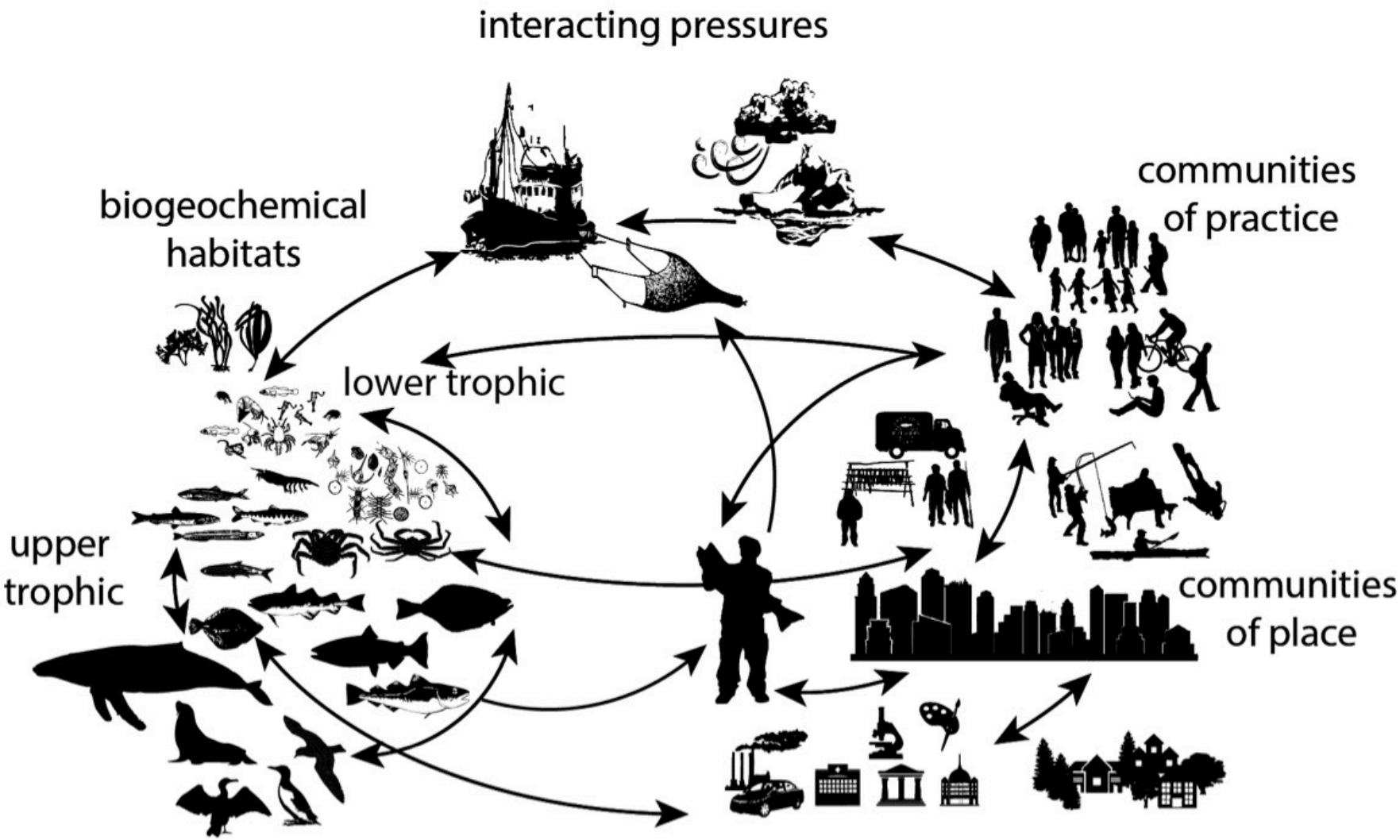
Physical, biological, & socioeconomic change; now - 2100

Evaluate how management can adapt to minimize negative impacts of future changes

gradual change & sudden shocks; test existing & new tools; estimate risk

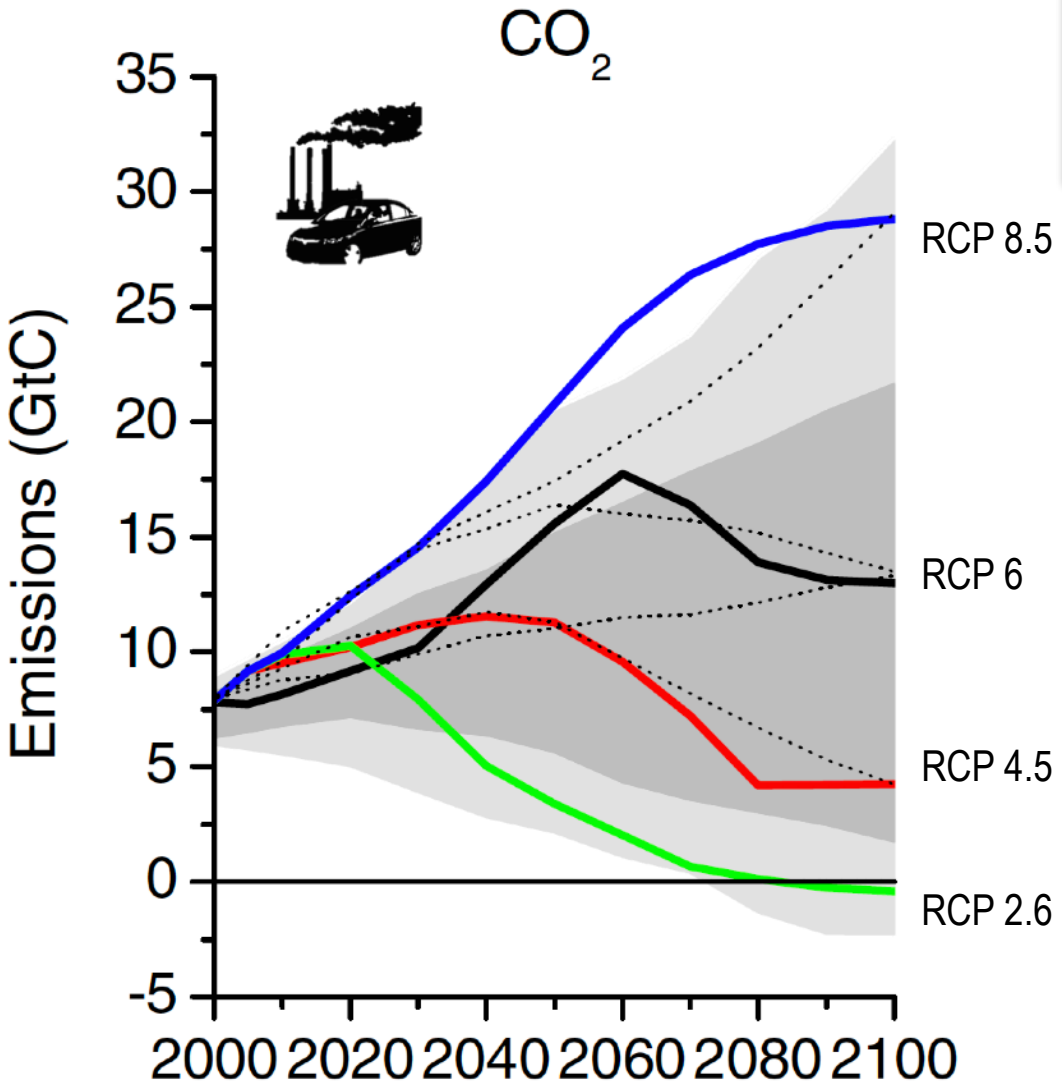


ACLIM utilizes a fully integrated approach



Carbon Emission Scenarios

> *"**plausible descriptions** of how the future may evolve with respect to a range of variables"*
> *van Vuuren et al. 2011*



"High reliance on fossil fuels"

"Significant global reduction in carbon use"

Carbon Emission Scenarios

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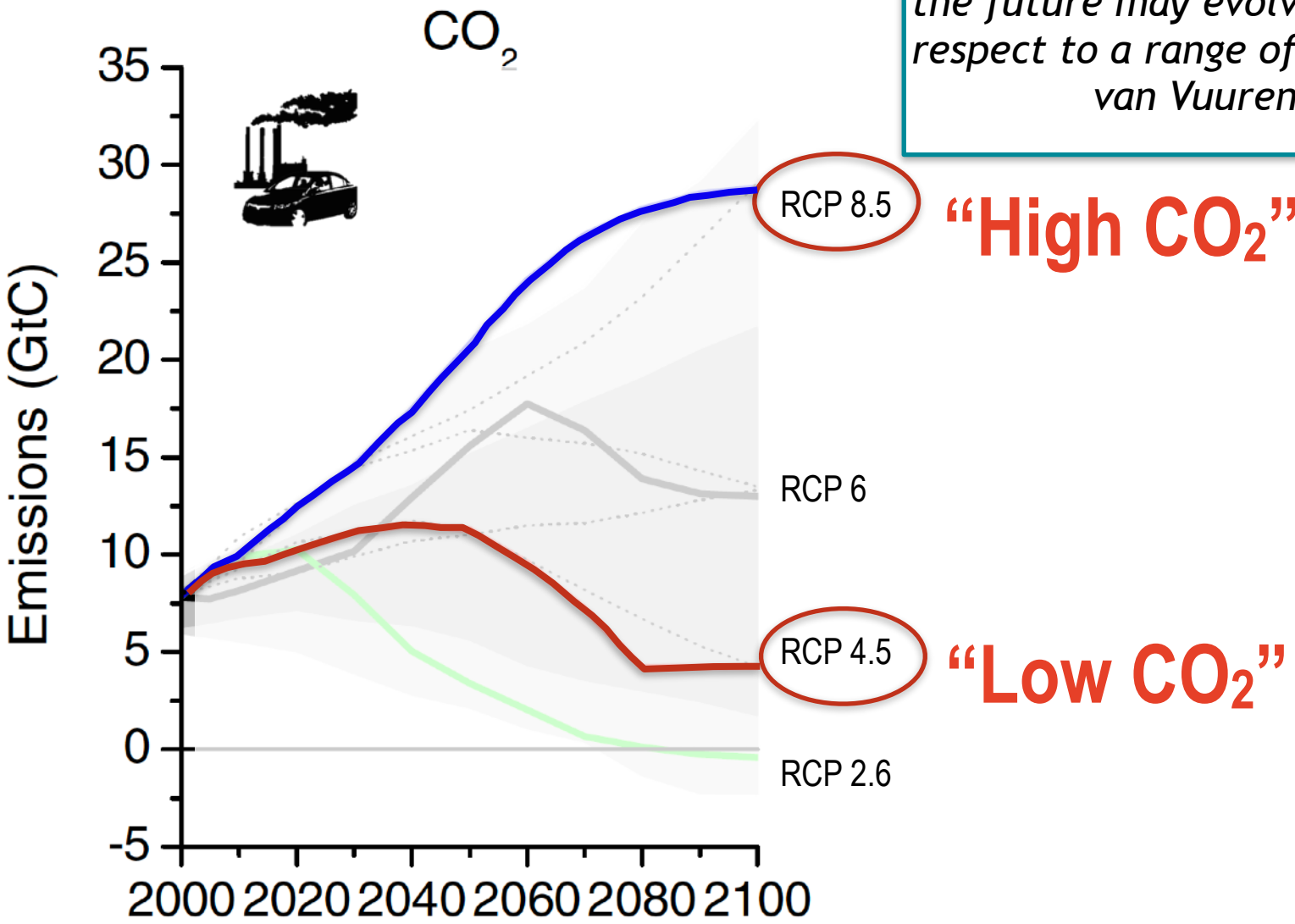

"High CO_2"

"Low CO_2"

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ACLIM
Alaska Climate Integrated Modeling Project

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Amanda Faig (UW SAFS)

FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

Global Climate Models (x 7)
- ECHO-G
- MIROC3.2 med res.
- CGCM3-t47
- CCSM4-NCAR- PO
- MIROCESM-C- PO
- GFDL-ESM2M*- PO
- GFDL-ESM2M*- PON

Projection Scenarios (x3)
- AR4 A1B
- AR5 RCP 4.5
- AR5 RCP 8.5

Physical downscaling

ROMS

Biological downscaling

NPZ

Bering Sea 10K Model

Socio-economic / harvest scenarios (x 5+)
- No fishing
- Status quo
- By-catch changes
- CE-reference points
- MEY

Climate Enhanced Biological models (x 5+)
- CE- single species assessment models
- CE- multispecies model (CEATTLE)
- CE - Size spectrum model
- CE- Ecopath with Ecosim
- End-to-End model (FEAST)

interacting pressures

lower trophic

biogeochemical habitats

Coupled Socio-ecological System

communities of practice

communities of place

upper trophic

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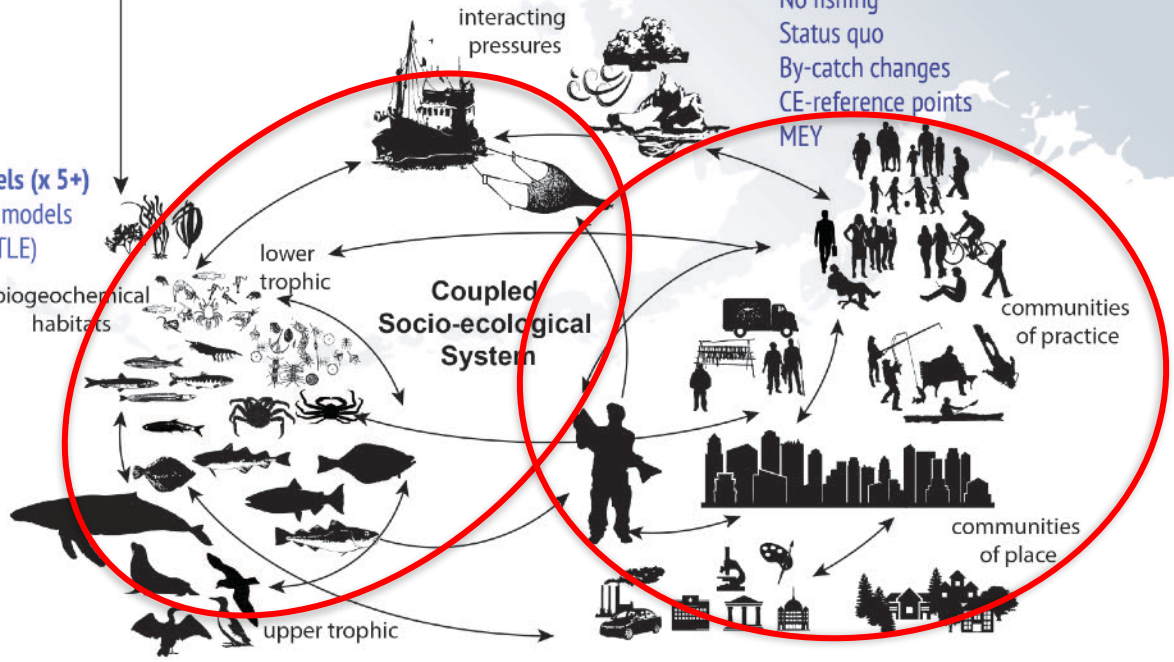
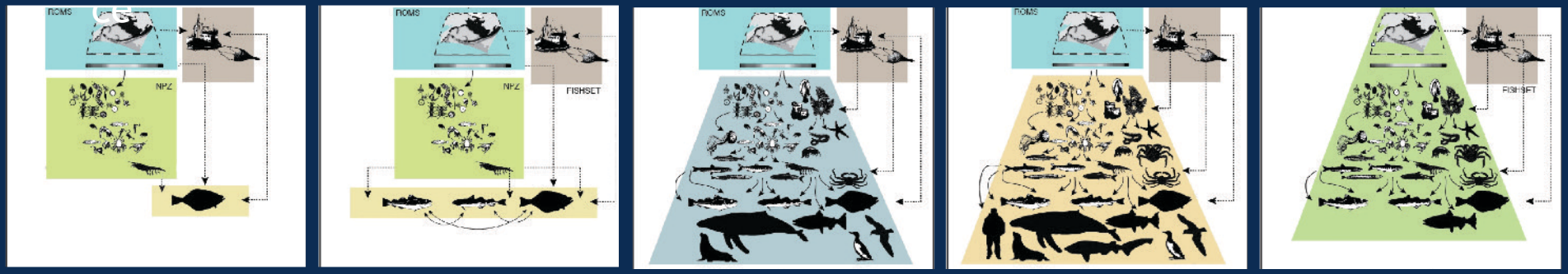


CE-SSM | CE-MSM | CE-EwE | CE-MIZER | FEAST



Fast, mcmc
Statistical
Implicit ecosystem "noise"

Slow, high resolution
Mechanistic
Explicit ecosystem interactions

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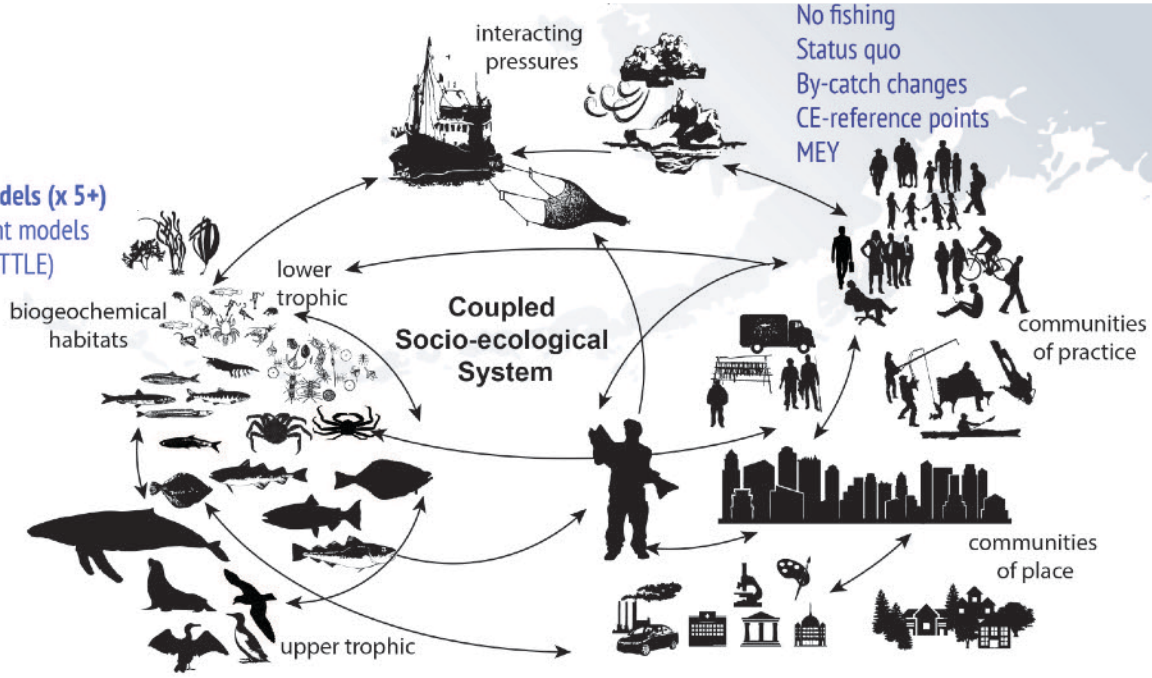


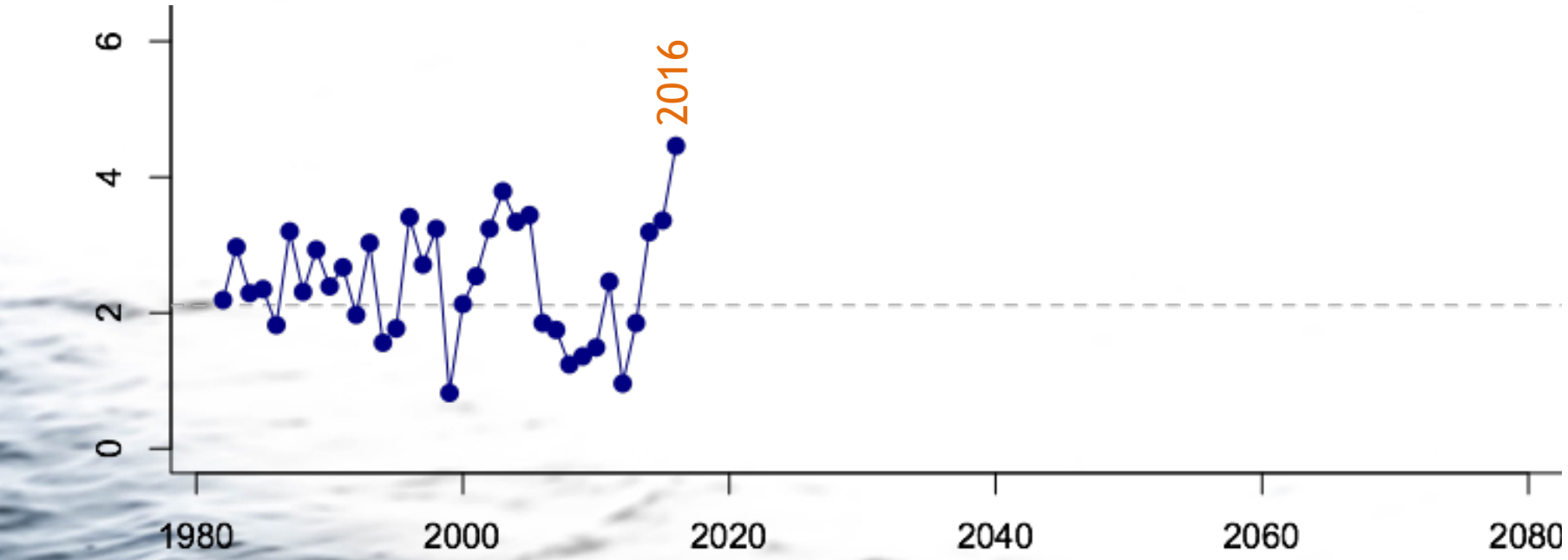
Preliminary Results

(physical projections)

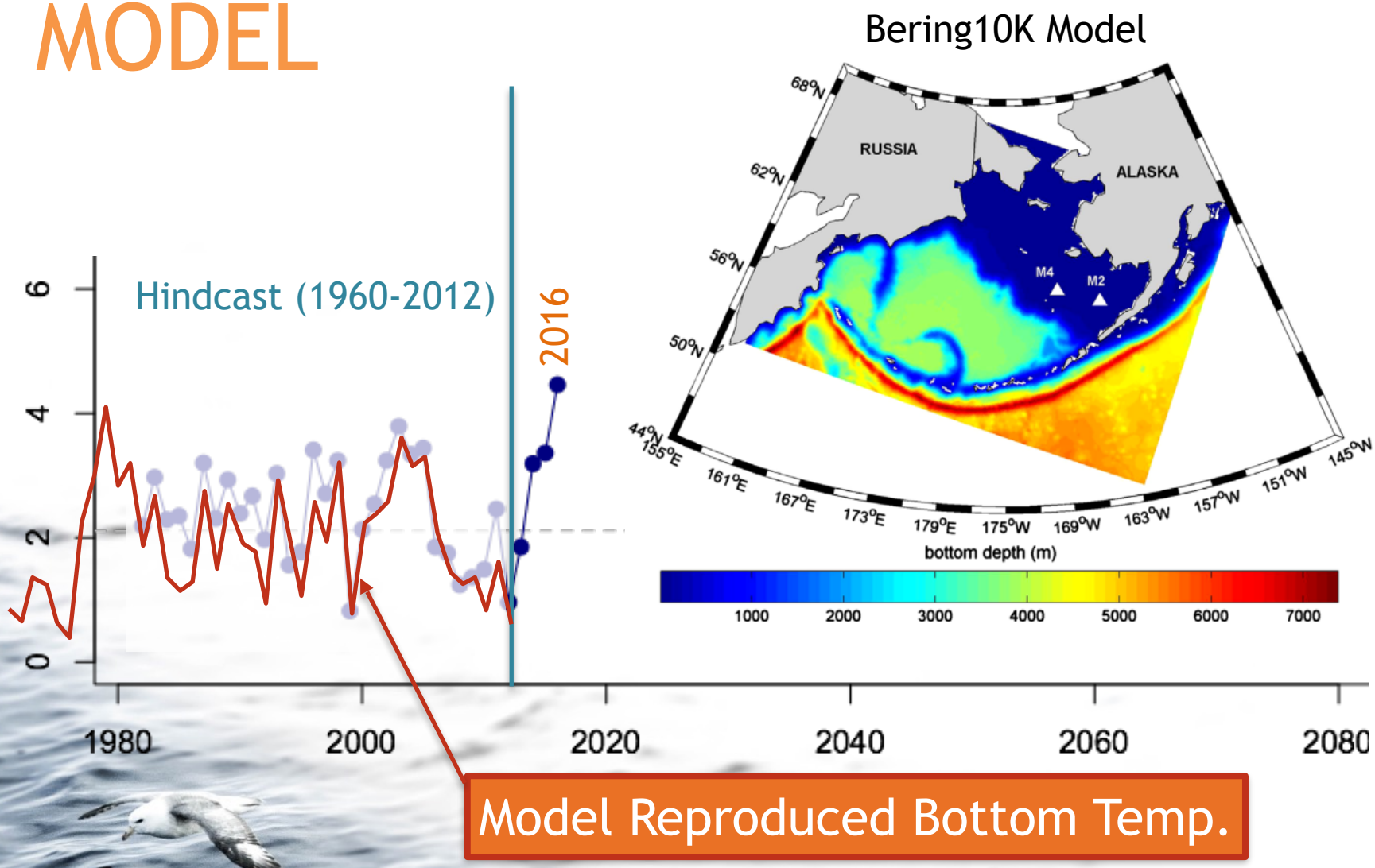
Photo: Mark Holsman

Summer Bottom Temperature (ºC)

OBSERVED



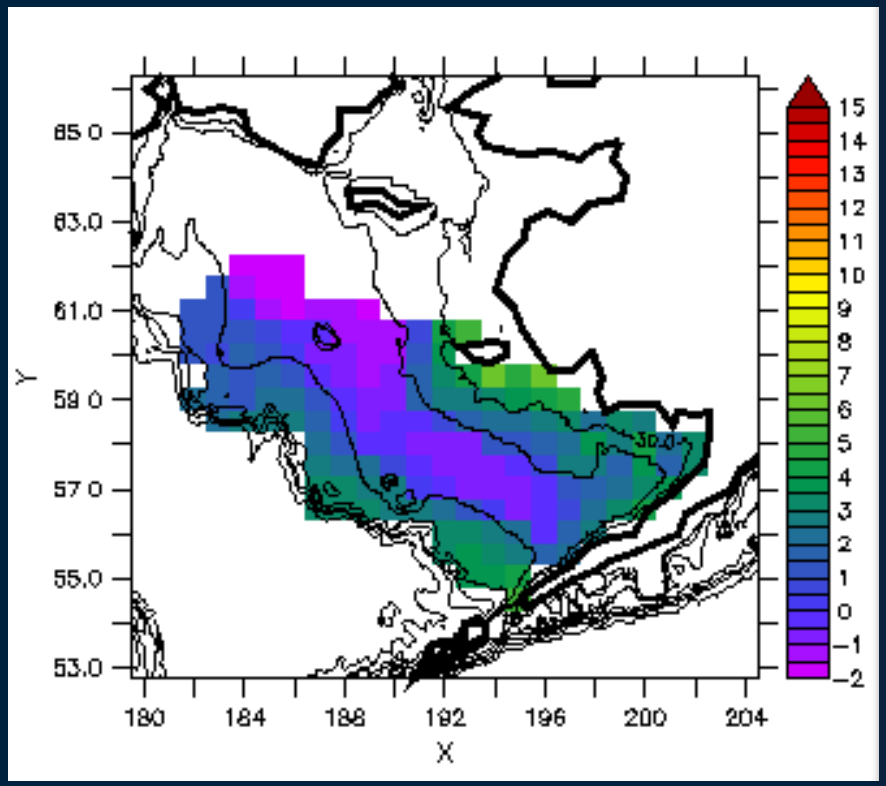
Summer Bottom Temperature (ºC) MODEL



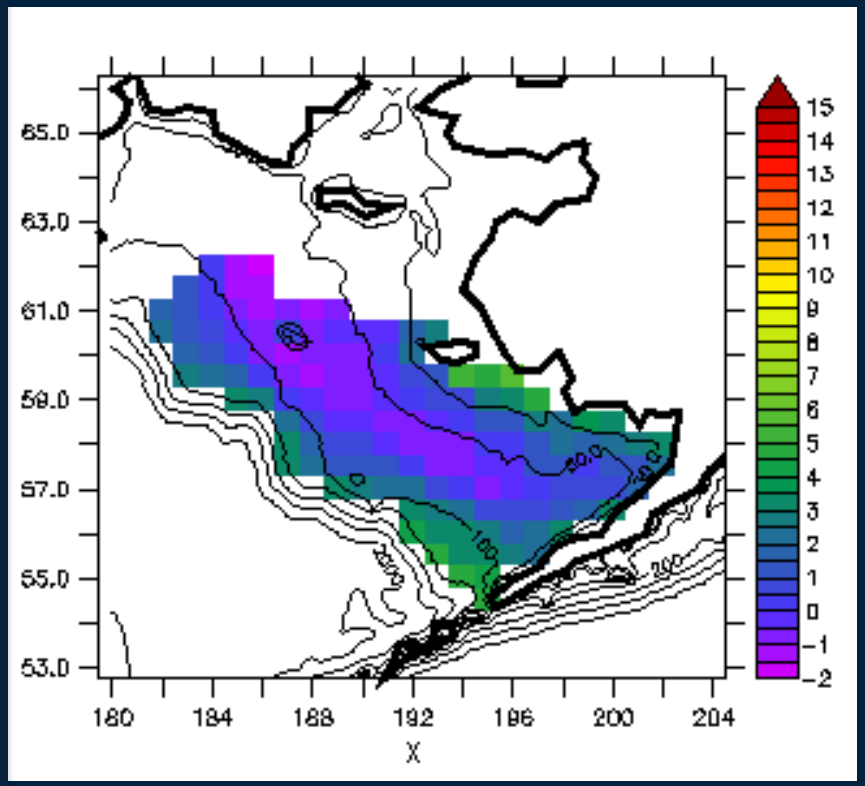
“Bering10K” Regional Oceanography Model

Bottom T. (°C) Summer 2009

DATA



MODEL



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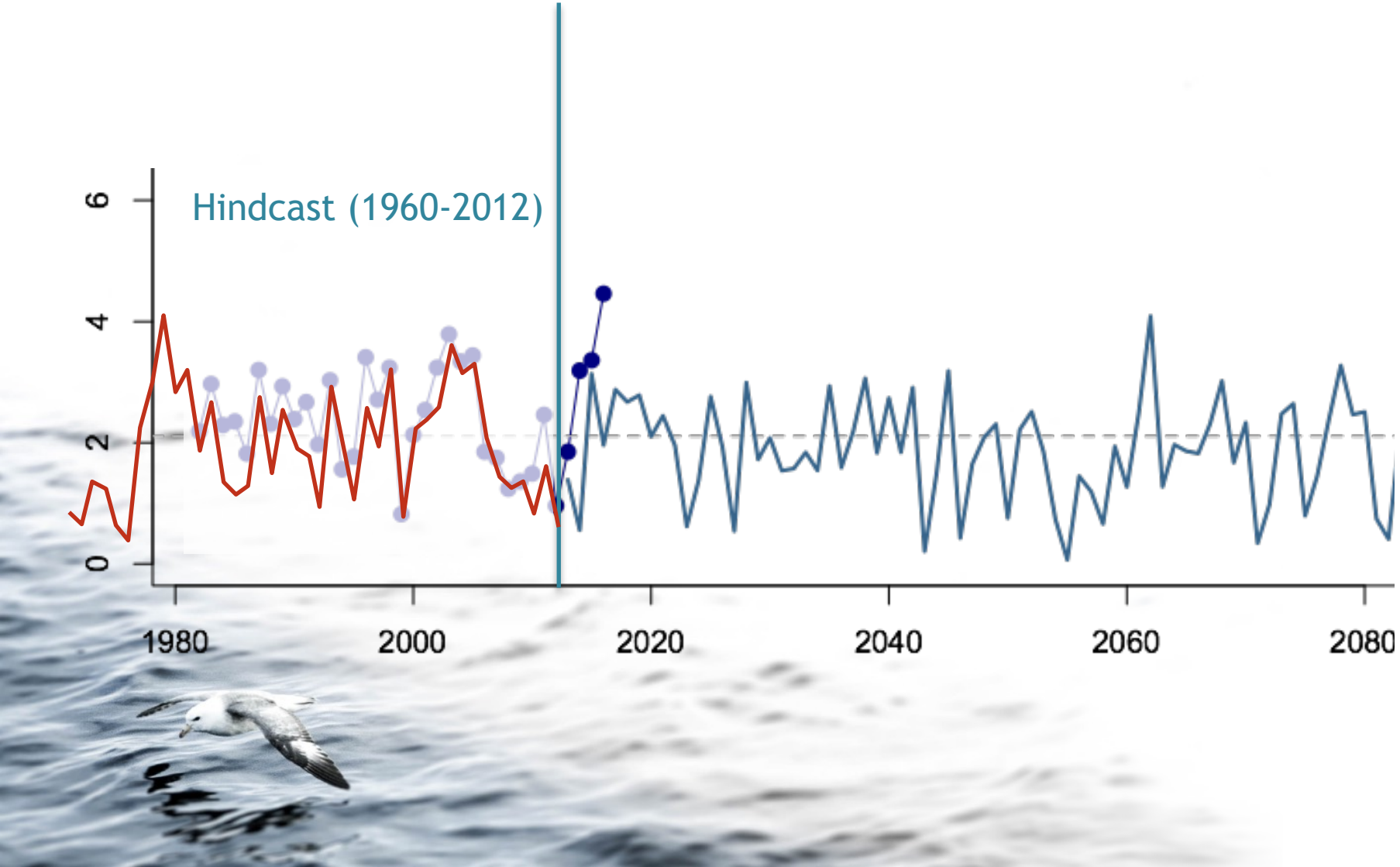
Slide courtesy of A. Hermann

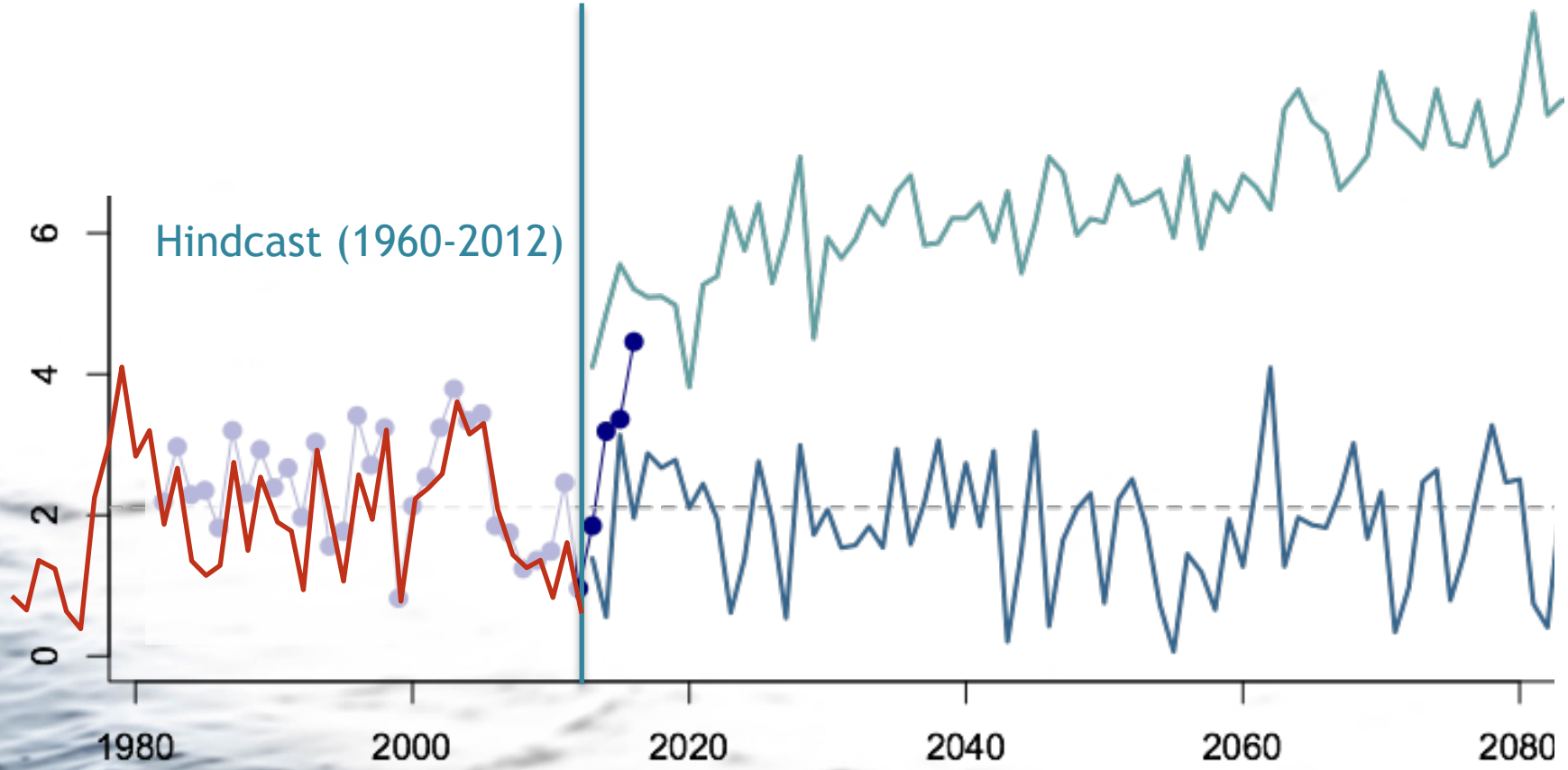
Summer Bottom Temperature (ºC) MODEL

Draft results; please do not reproduce



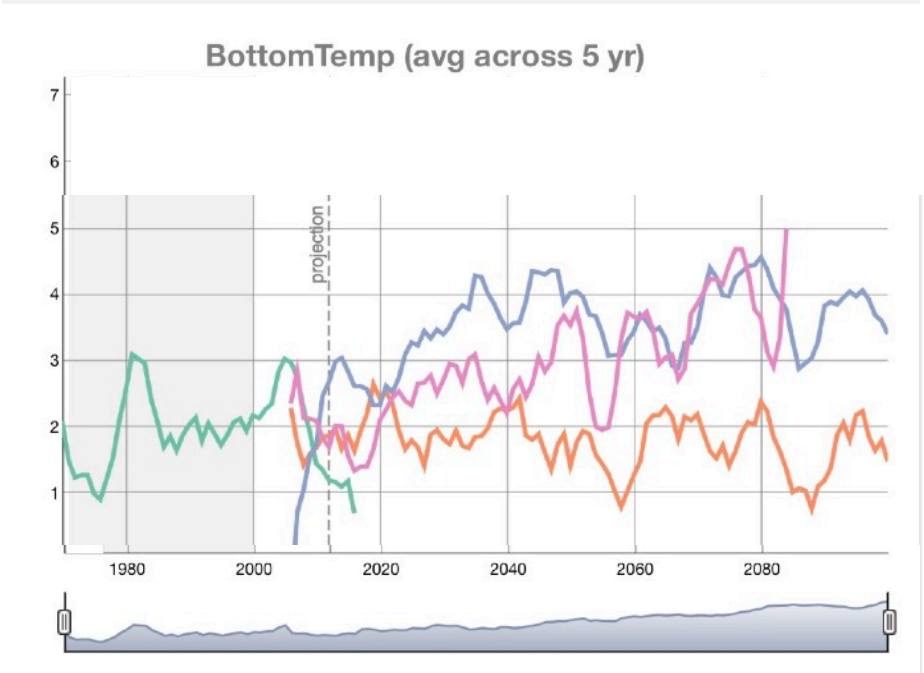
Summer Bottom Temperature (ºC) MODEL

Draft results; please do not reproduce

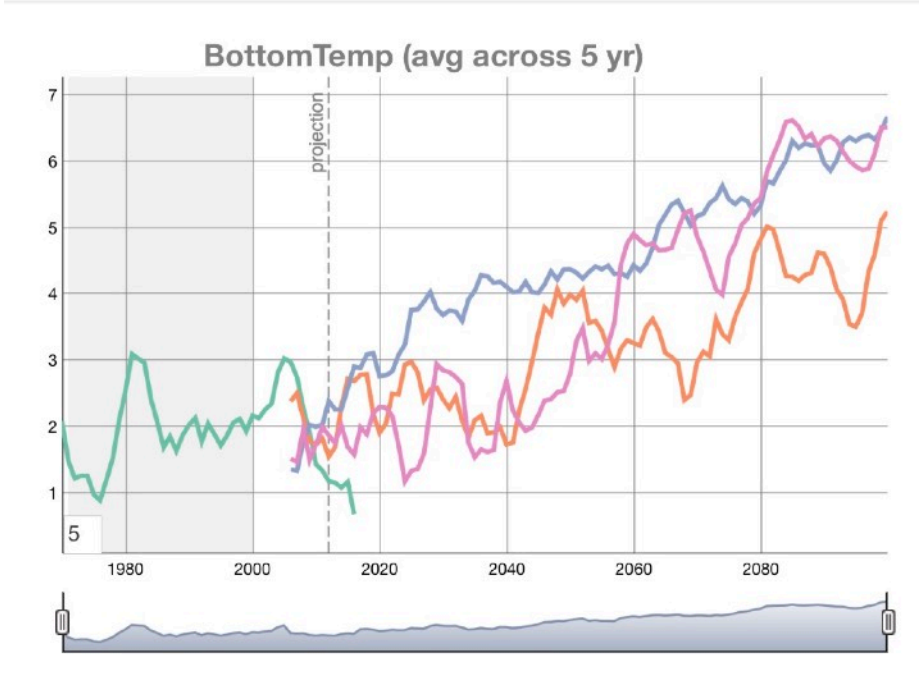


Bottom Temperature (ºC)

Low CO_2 Scenario (RCP 4.5)



High CO_2 Scenario (RCP 8.5)



Holsman et al. in prep; draft results, please do not cite or copy

Bottom Temperature (ºC)

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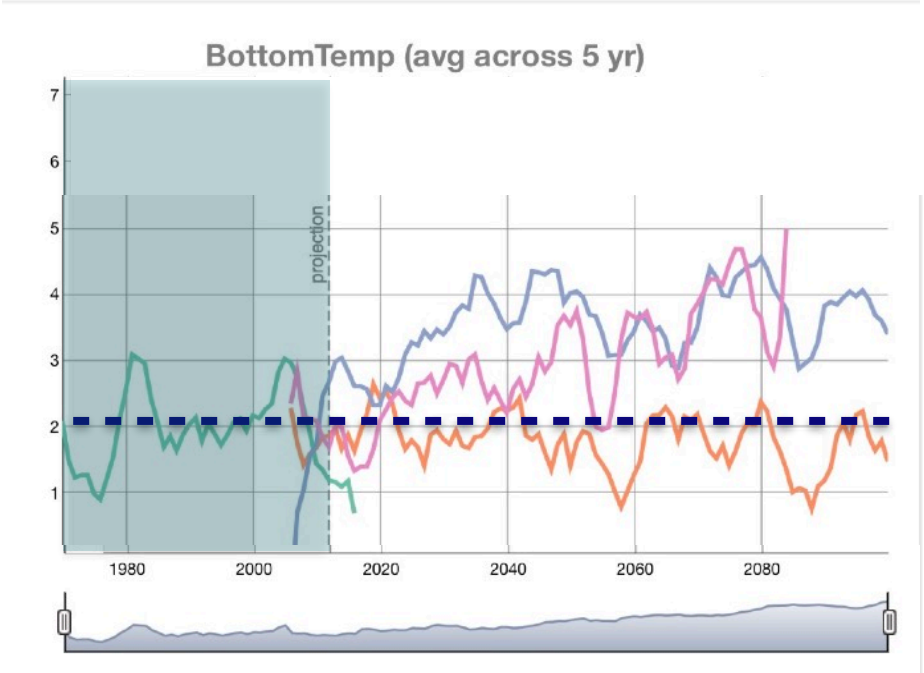

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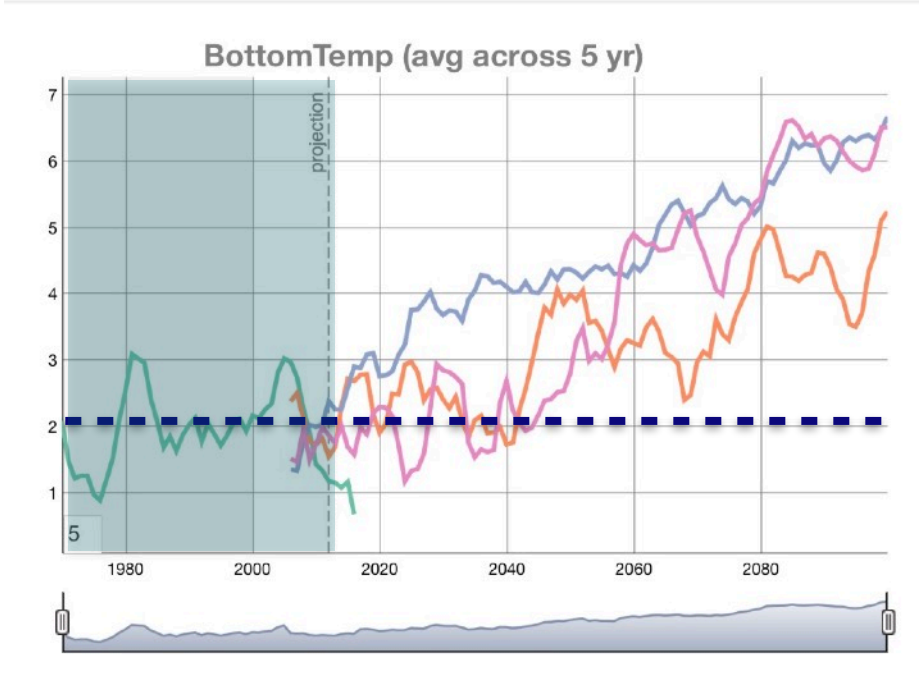

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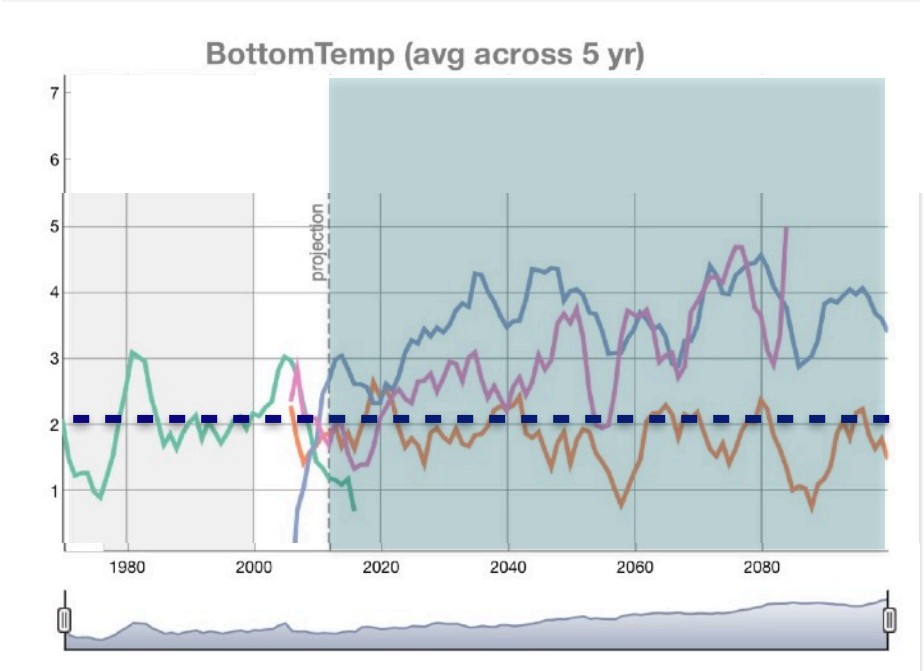
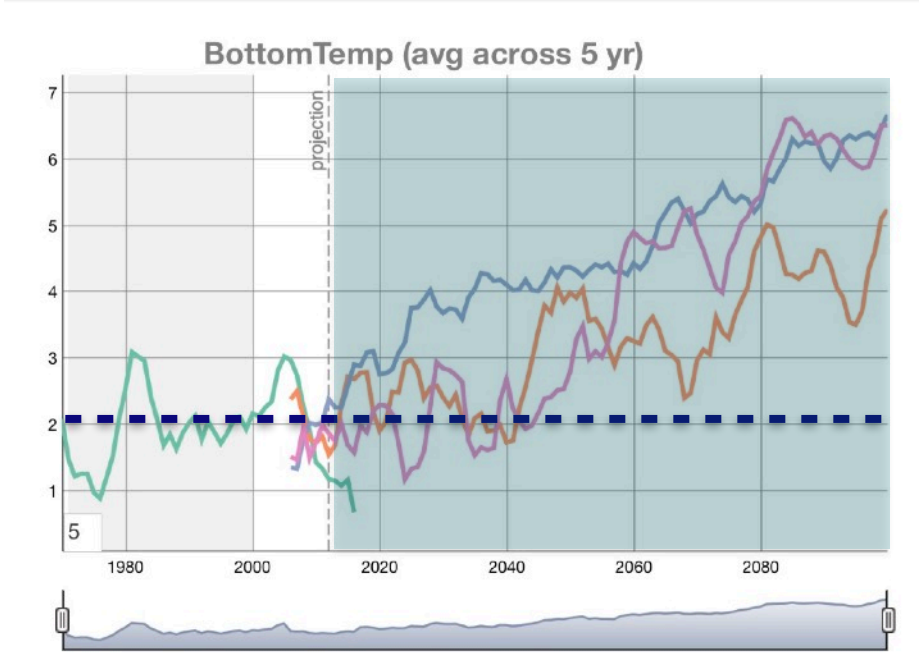


High CO_2 Scenario (RCP 8.5)



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Bottom Temperature (ºC)

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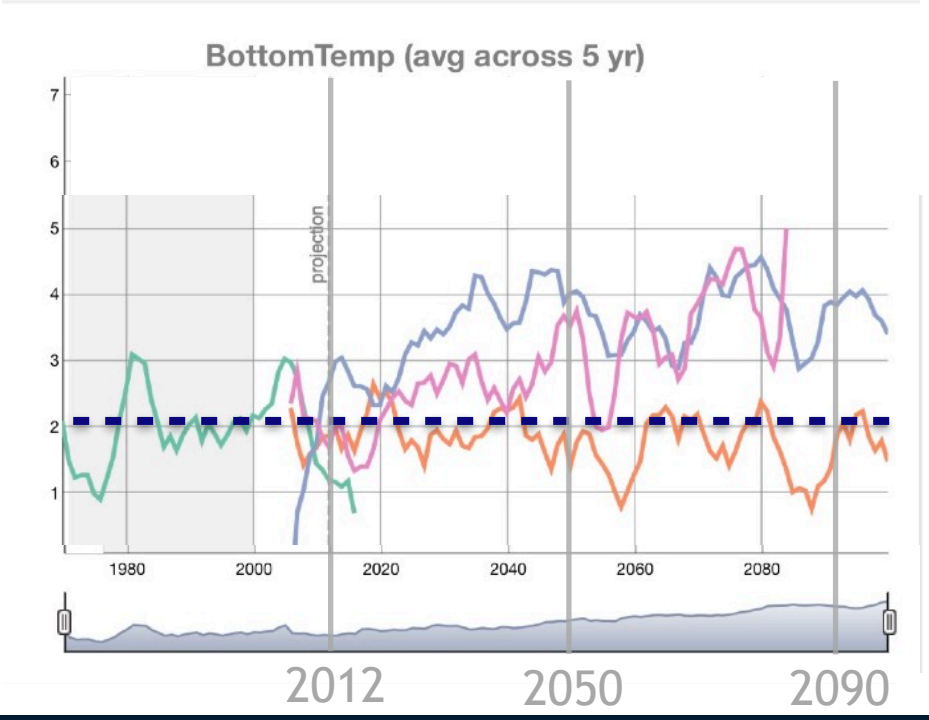
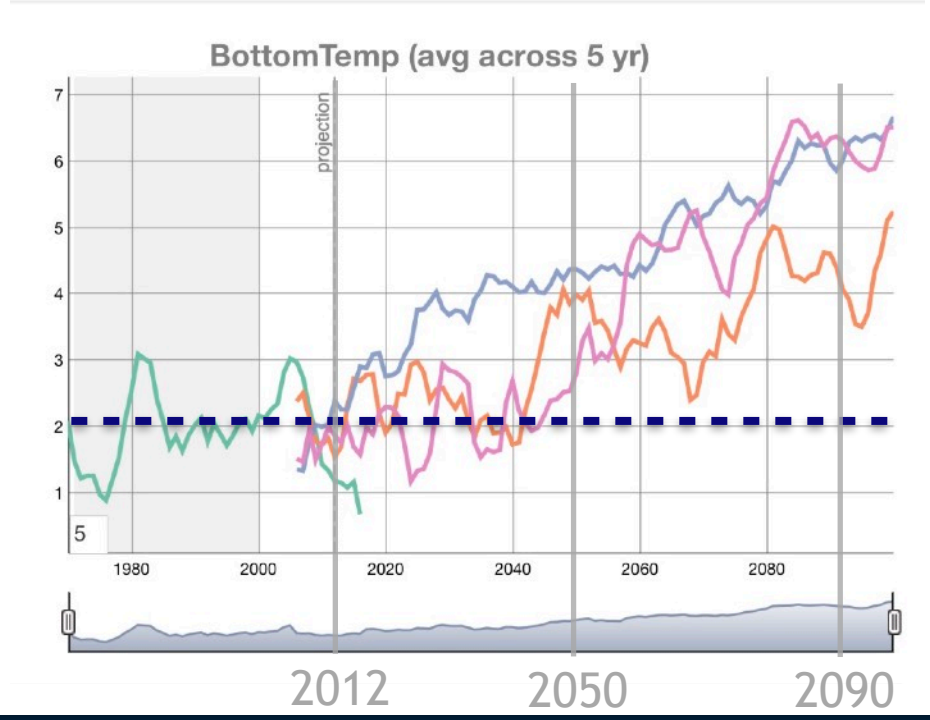


High CO_2 Scenario (RCP 8.5)



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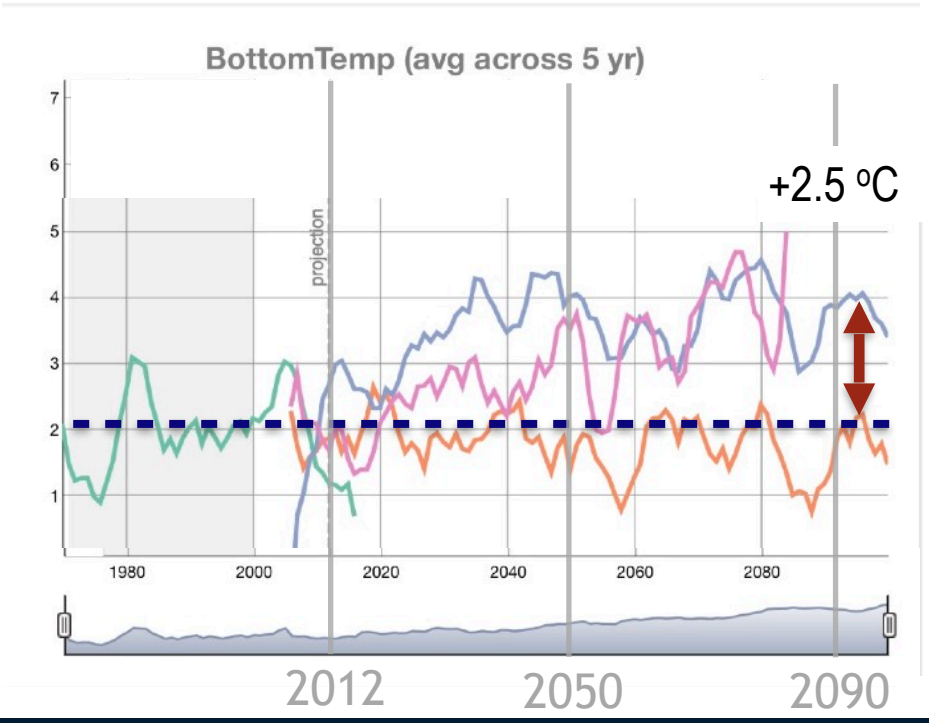

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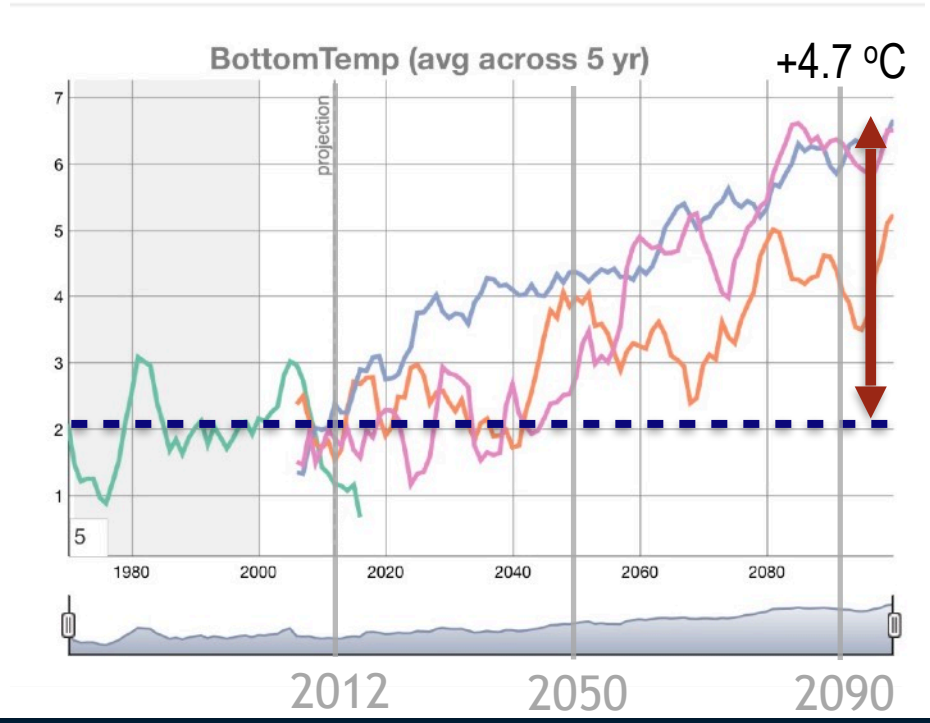

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Average of all “warm” scenarios (ESM RCP 8.5)

B2 ACLIM
October 2017

Bottom Temp (C) | SST (C) | Neocalanus

Temp °C

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2

5 4.8 4.6 4.4 4.2 4 3.8 3.6 3.4 3.2 3 2.8 2.6 2.4 2.2 2 1.8 1.6 1.4 1.2 1 0.8 0.6 0.4 0.2 0 -20

2006-2016 | 2006-2016 | 2006-2016

2040-2050 | 2040-2050 | 2040-2050

2080-2090 | 2080-2090 | 2080-2090

Average of all “warm” scenarios (ESM RCP 8.5)

B2 ACLIM
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Temp °C

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2

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2006-2016

NOW

2040-2050

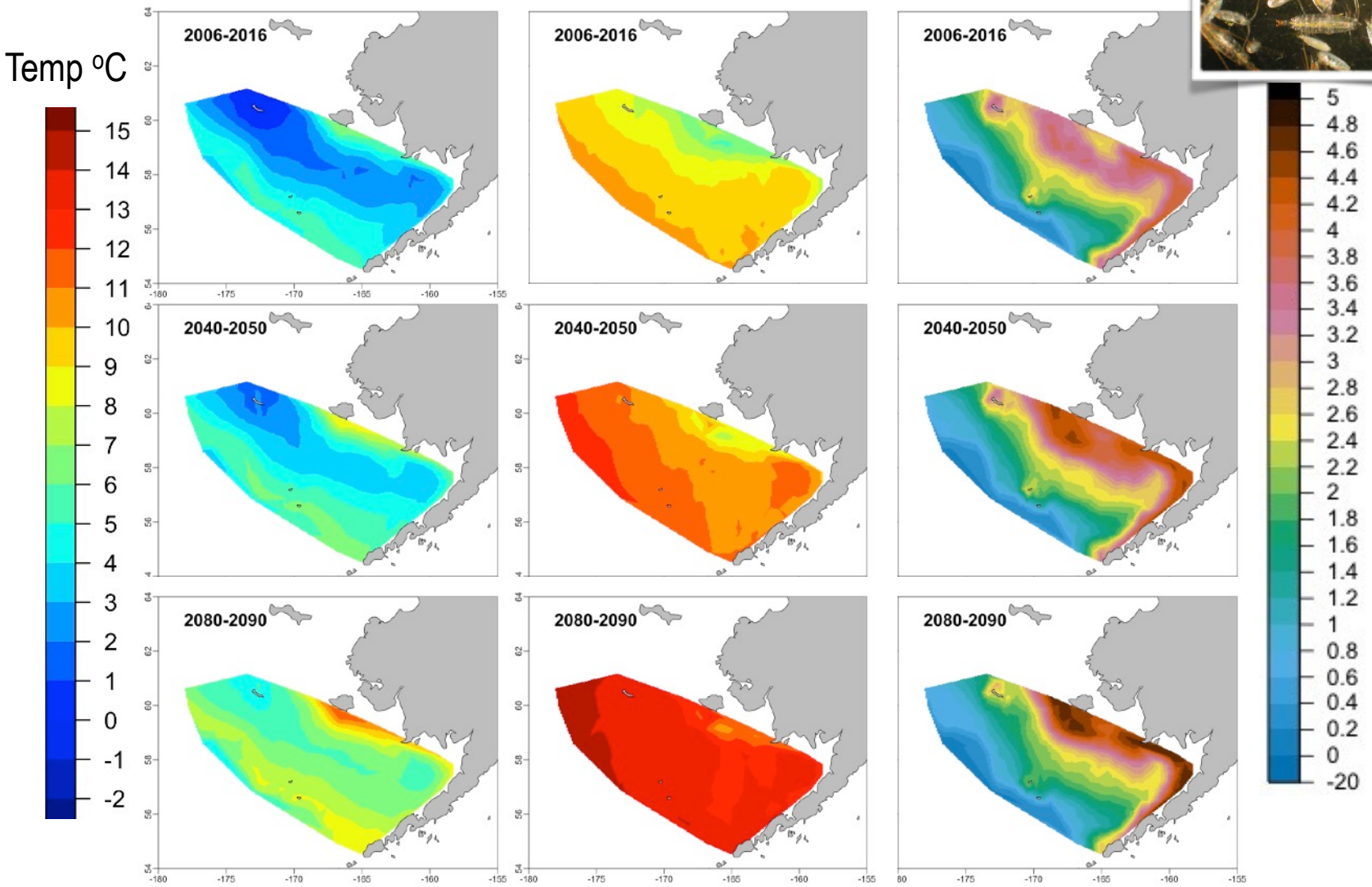
Mid-century

2080-2090

End of century

Average of all “warm” scenarios (ESM RCP 8.5)

B2 ACLIM
October 2017



Average of all “warm” scenarios (ESM RCP 8.5)

B2 ACLIM
October 2017

Bottom Temp (C)

SST (C)

FALL Zoop.

Temp °C

15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2

2006-2016

2040-2050

2080-2090

density

10
9
8
7
6
5
4
3
2
1
0

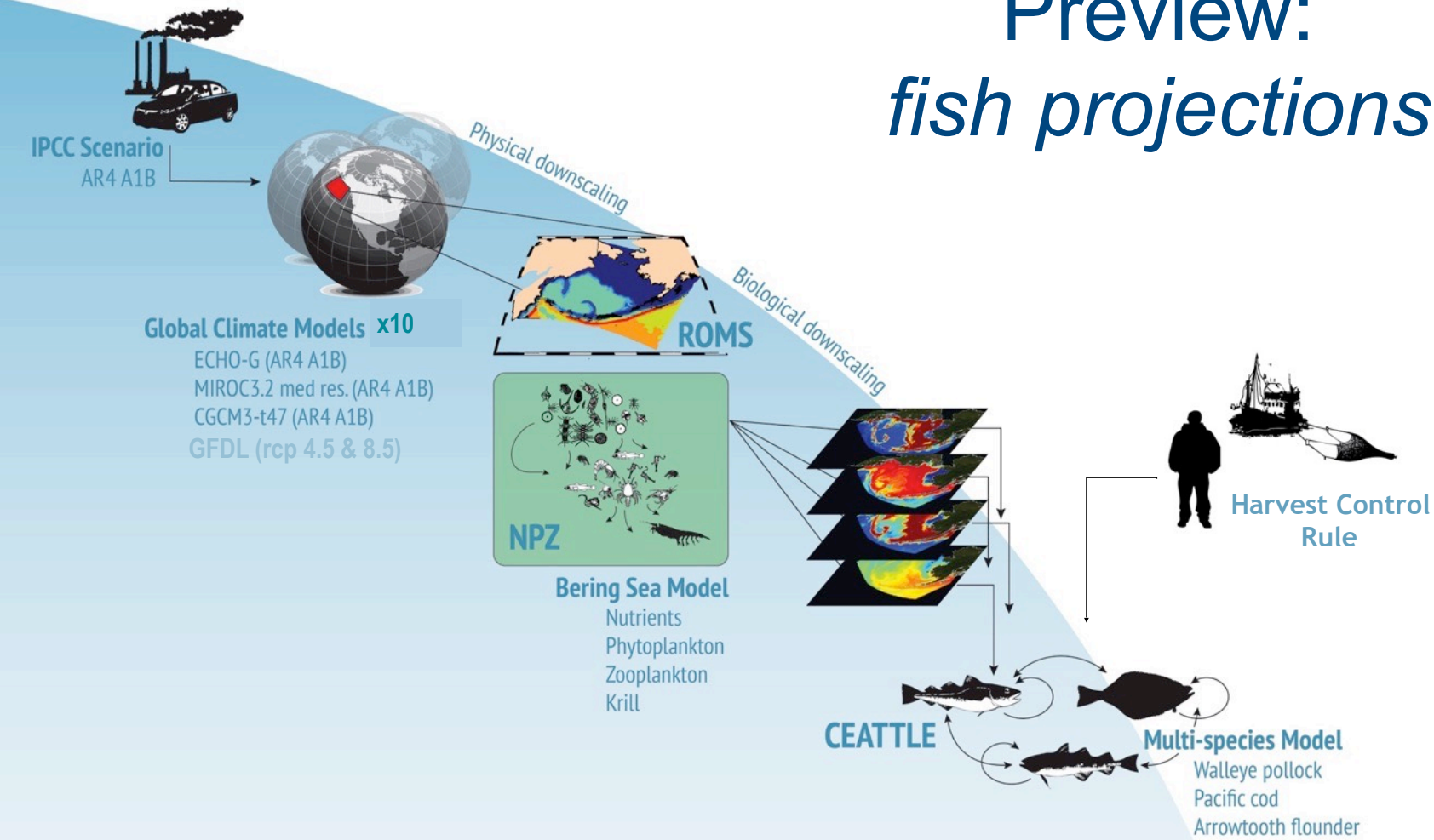
Preliminary Results

(fish projections)

No fishing & "Status quo"
assuming we don't adjust our management but the climate changes

Photo: Mark Holsman

Preview:
fish projections

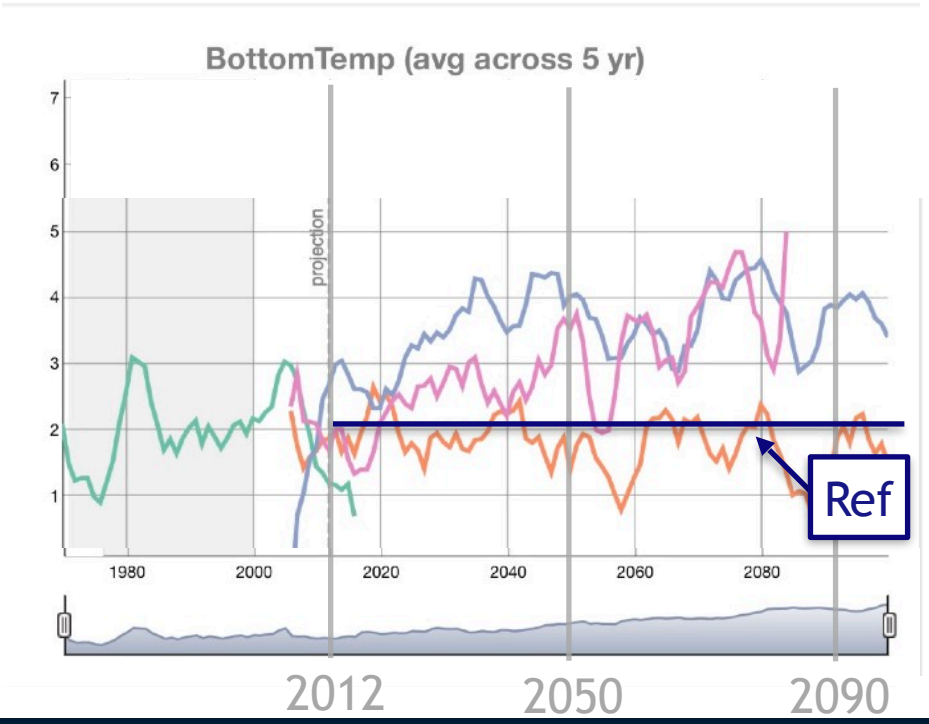


Holsman et al. in prep

Climate-specific Harvest & Population Projections

Bottom Temperature (ºC)

Low CO_2 Scenario (RCP 4.5)



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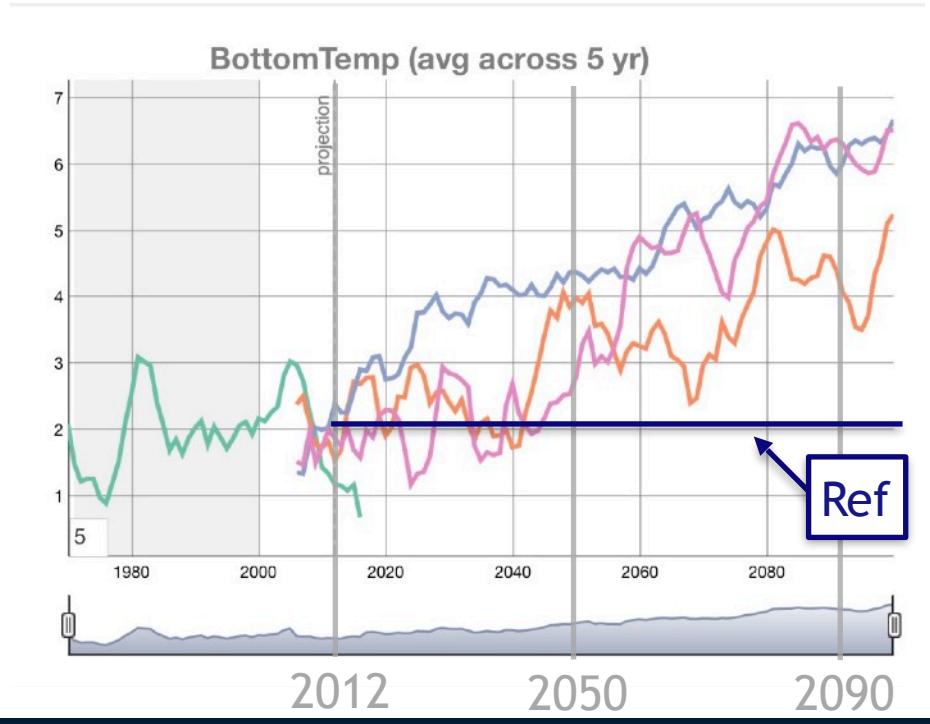

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NOAA FISHERIES

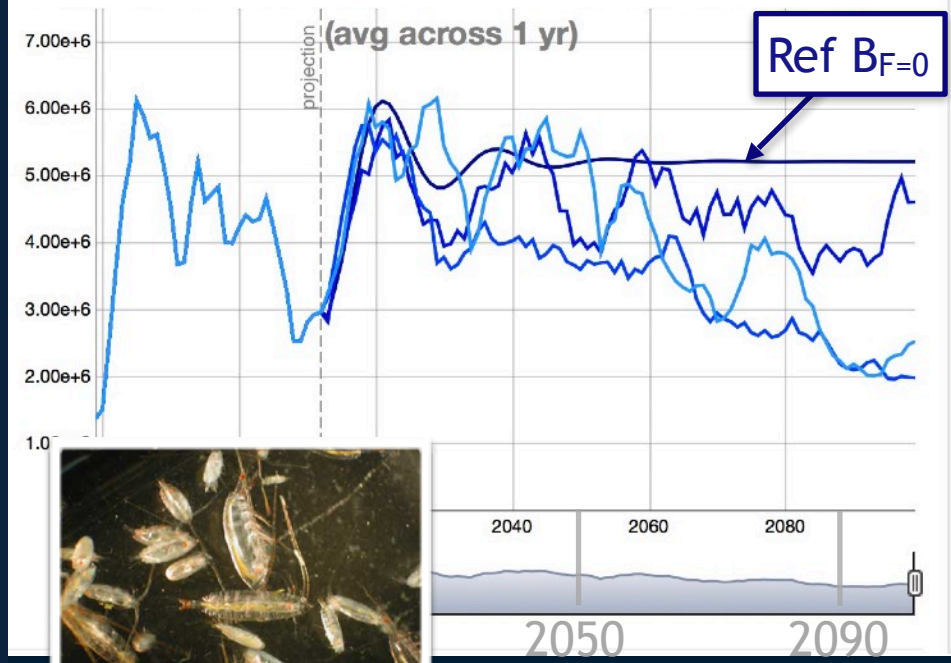
Unfished Spawning Biomass (F=0)

Low CO_2 Scenario (RCP 4.5)

Single-species model: Pollock

High CO_2 Scenario (RCP 8.5)

Single-species model: Pollock



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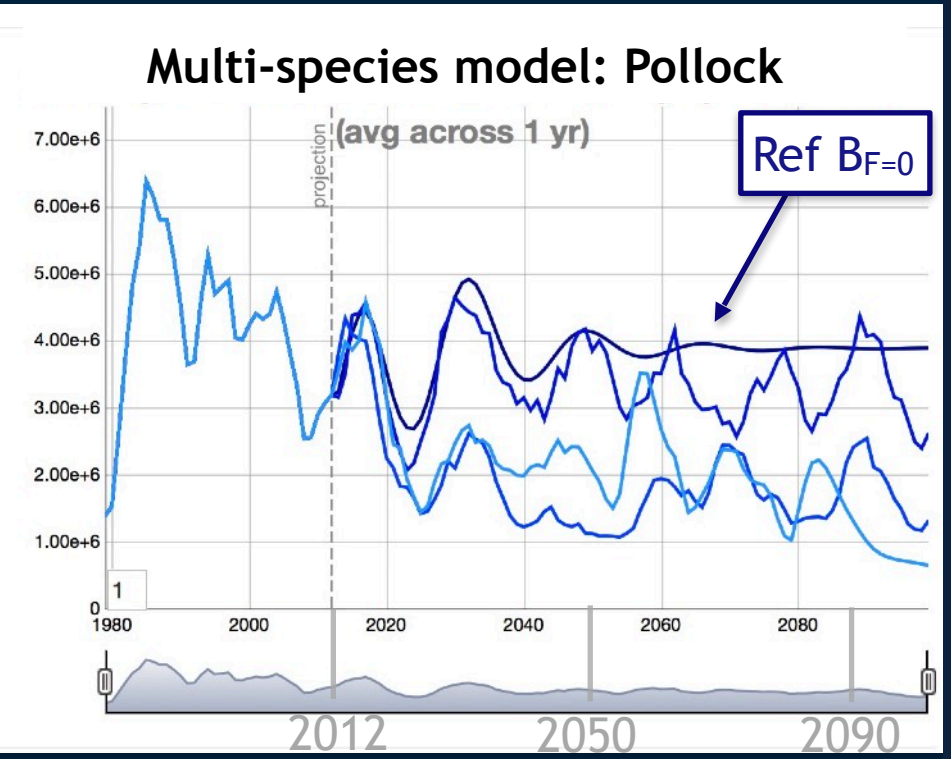
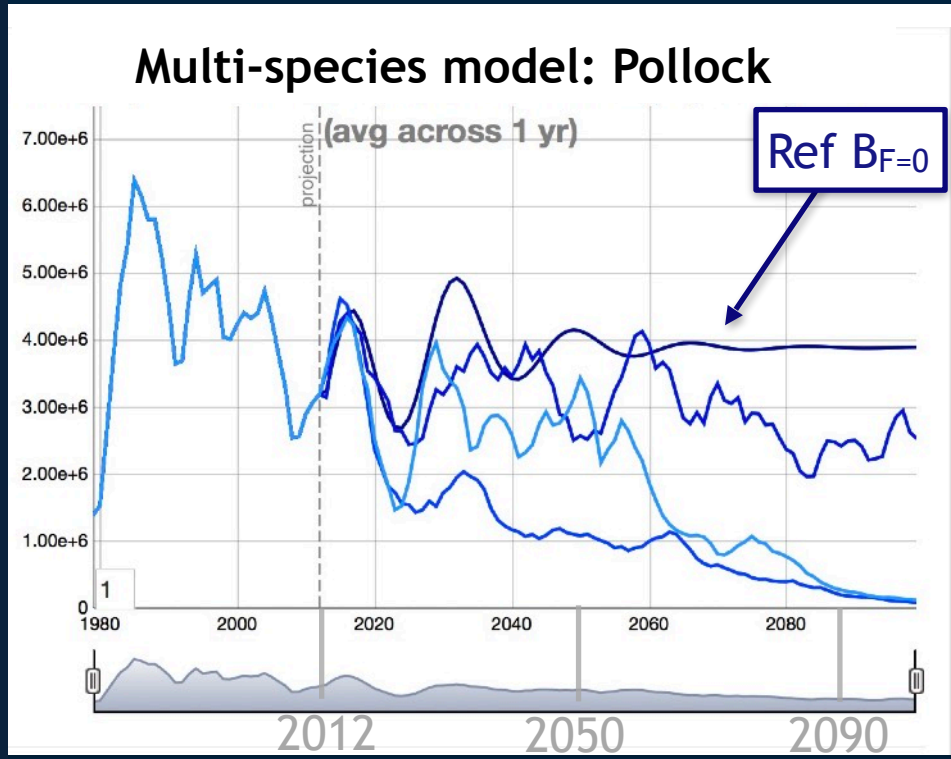


High CO_2 Scenario (RCP 8.5)



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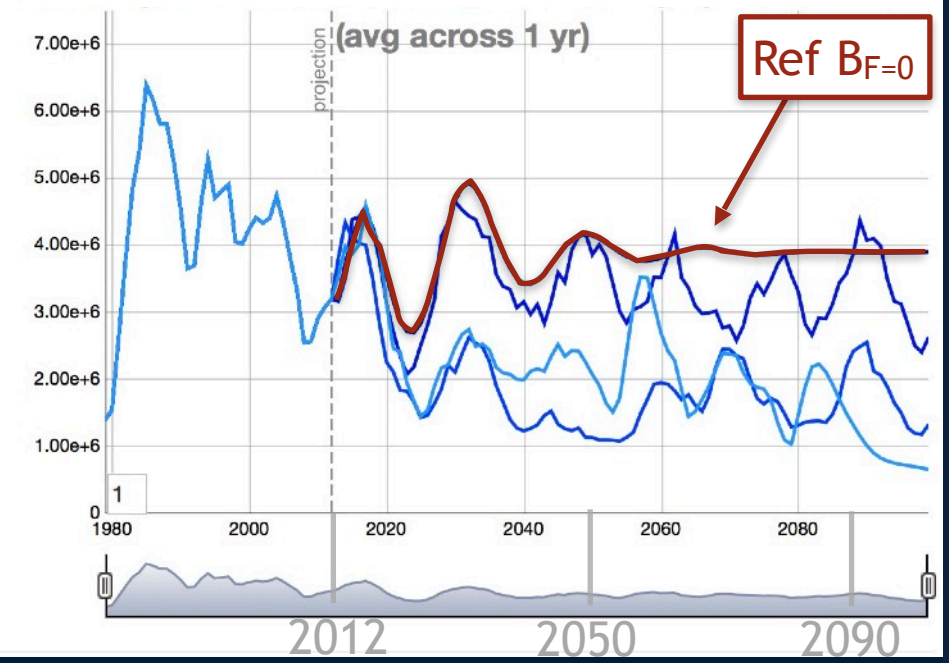
Multi-species model: Pollock



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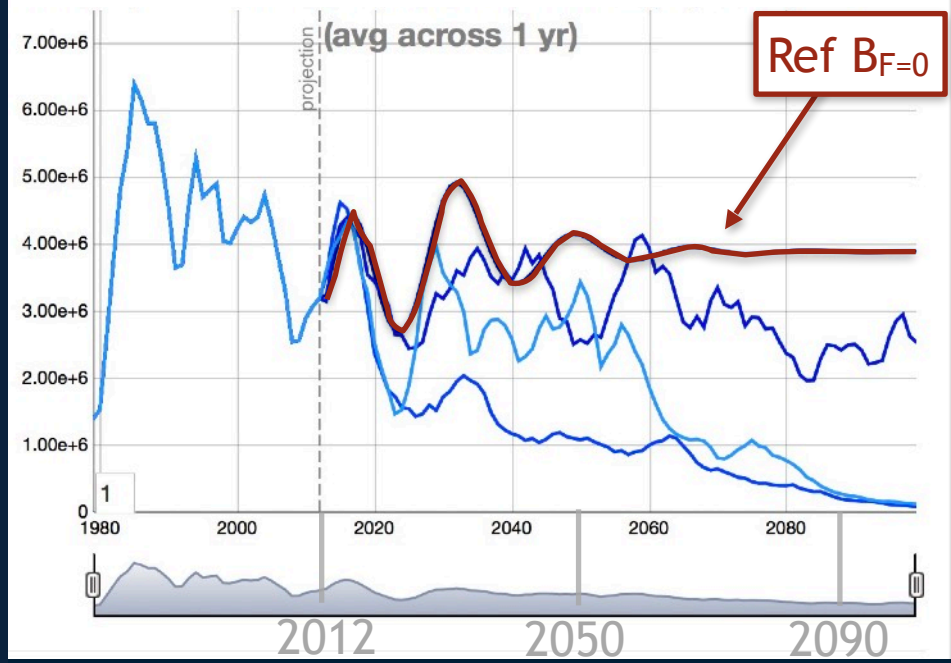

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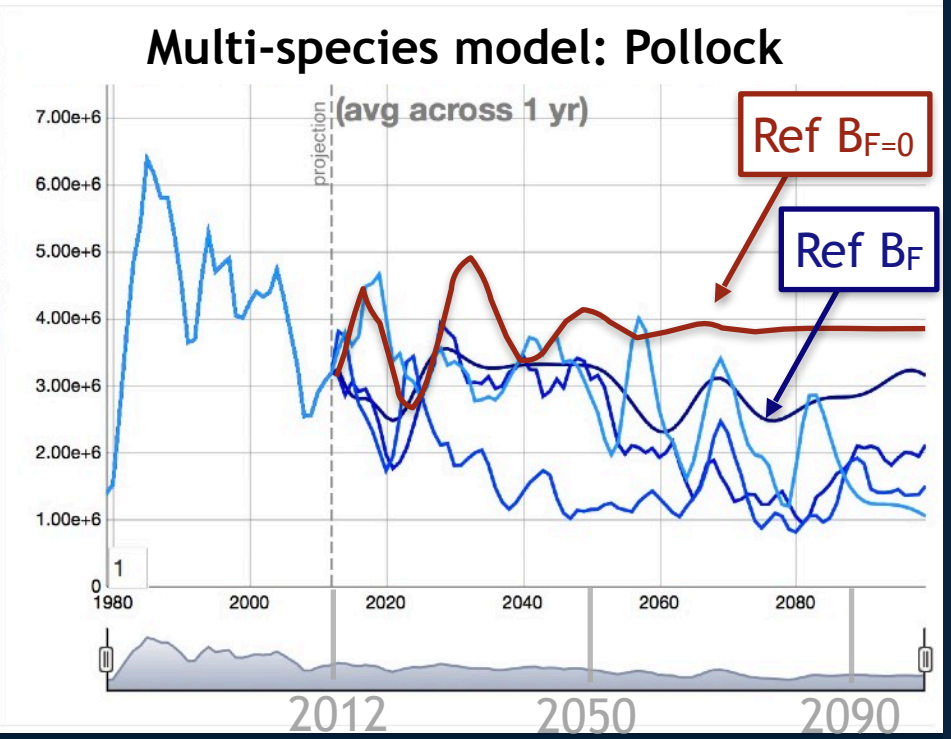
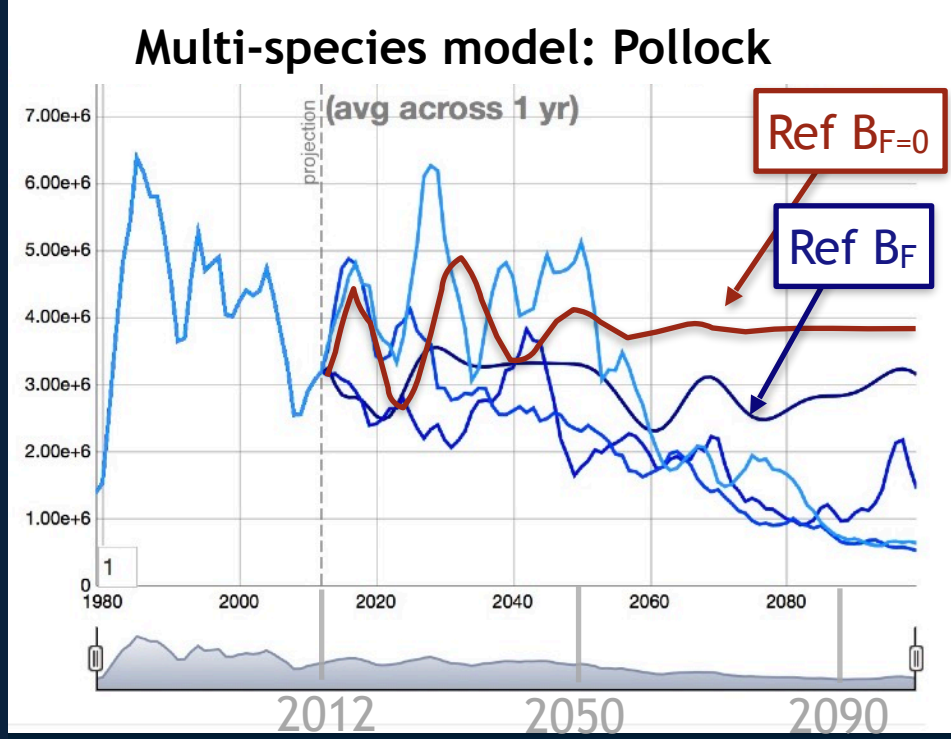
NOAA FISHERIES

Fished Spawning Biomass

Low CO_2 Scenario (RCP 4.5)



High CO_2 Scenario (RCP 8.5)



Holsman et al. in prep; draft results, please do not cite or copy

NOAA FISHERIES

Single-species model

	Low CO_2	High CO_2
$B_{F=0}$	-33%	-42%
B_F	-30%	-35%

Multi-species model

	Low CO_2	High CO_2
$B_{F=0}$	-64%	-76%
B_F	-54%	-72%

Preliminary Results

"Status quo"
*assuming **we don't adjust our management** but the climate changes*

Photo: Mark Holsman

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ACLIM
Alaska Climate Integrated Modeling Project

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Amanda Faig (UW SAFS)

FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

Global Climate Models (x 7)
- ECHO-G
- MIROC3.2 med res.
- CGCM3-t47
- CCSM4-NCAR- PO
- MIROCESM-C- PO
- GFDL-ESM2M*- PO
- GFDL-ESM2M*- PON

Projection Scenarios (x3)
- AR4 A1B
- AR5 RCP 4.5
- AR5 RCP 8.5

Physical downscaling

ROMS

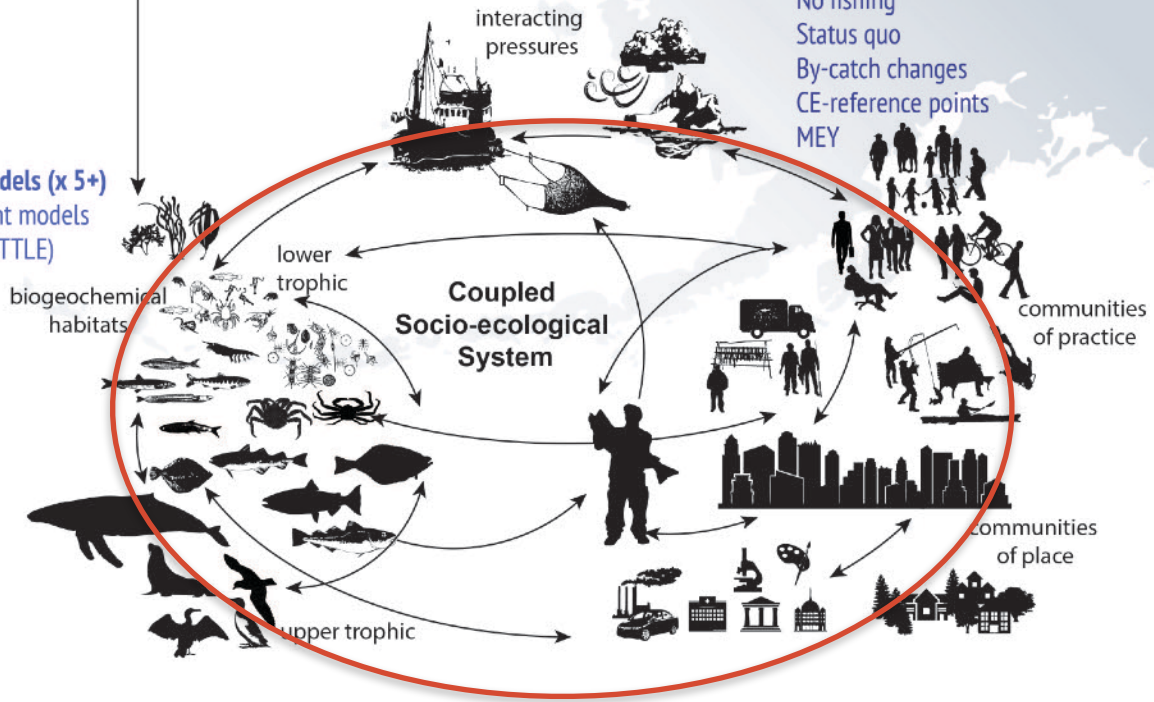
Biological downscaling

NPZ

Bering Sea 10K Model

Socio-economic / harvest scenarios (x 5+)
- No fishing
- Status quo
- By-catch changes
- CE-reference points
- MEY

Climate Enhanced Biological models (x 5+)
- CE- single species assessment models
- CE- multispecies model (CEATTLE)
- CE - Size spectrum model
- CE- Ecopath with Ecosim
- End-to-End model (FEAST)



The Human Connection

Improving Management Foresight

Improving Management Foresight

- We need to be ready for **feasible** outcomes as well as the most likely scenarios.

- We will use the ACLIM tools to consider a wide range of possibilities to help anticipate future challenges.

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Overview – "Socioecon-ACLIM"

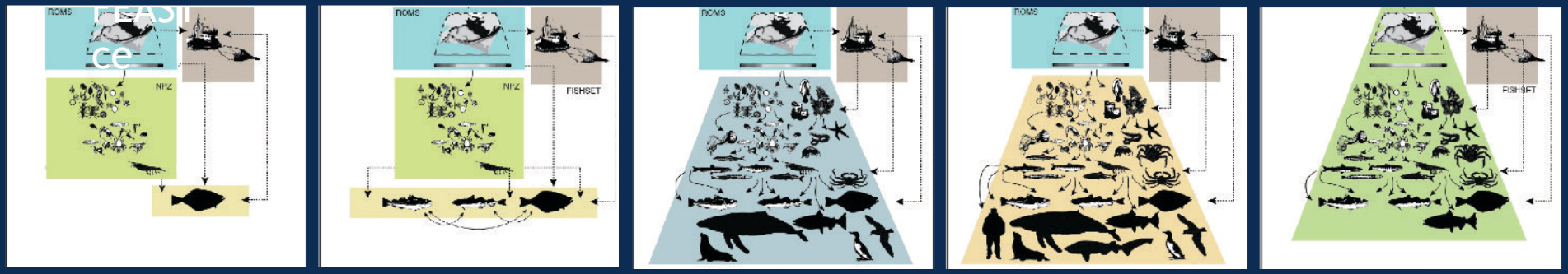
- Coupling biological and economic models
- Fishery mechanisms
- Management tools

Overview – "Socioecon-ACLIM"

- Coupling biological and economic models
- Fishery mechanisms
- Management tools
- **Help! We need your input!**

Coupling Biophysical / Biological
&
Economic Models & Policies

CE-SSM | CE-MSM | CE-EwE | CE-MIZER



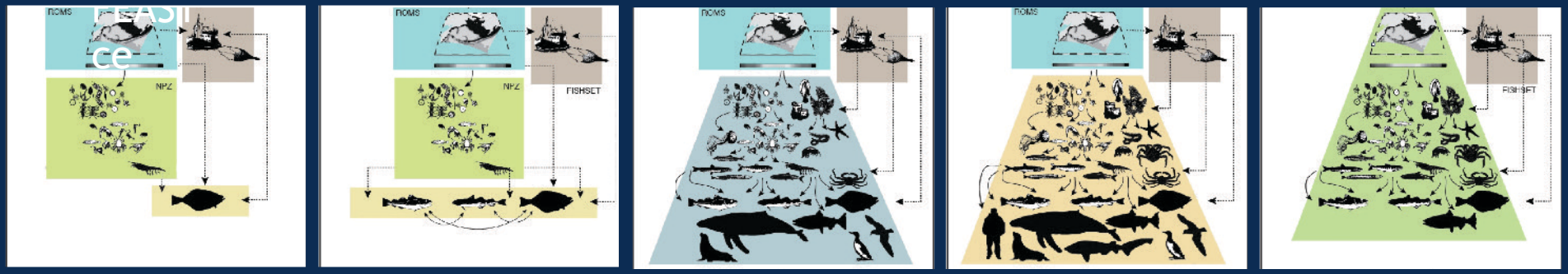
Fast, mcmc
Statistical
Implicit ecosystem "noise"

Slow, high resolution
Mechanistic
Explicit ecosystem interactions

ACLIM utilizes economic models of different complexity

- Effort response to abundance
- Spatial models of fleets responding to shifts in fish distributions.
- Maximum economic yield (MEY)
- Community impact analyses

CE-SSM | CE-MSM | CE-EwE | CE-MIZER



Fast, mcmc
Statistical
Implicit ecosystem "noise"

Slow, high resolution
Mechanistic
Explicit ecosystem interactions

ACLIM considers 6 general scenarios (and many variations)

- Status quo
- No fishing
- MSY (no 2 MMT cap)
- Max. Economic Yield (MEY)
- Bycatch changes
- Price & cost changes

Status Quo Management under the Ecosystem Cap

- For each species, TAC <= ABC
- The sum of all TACs <= 2 MMT
- In 2017, Sum(ABCs) = ~ 4 MMT

The Council chooses TAC reduction for each species below its ABC so the BSAI TAC < 2 million MT

Biomass – TAC - Catch Model for Projections

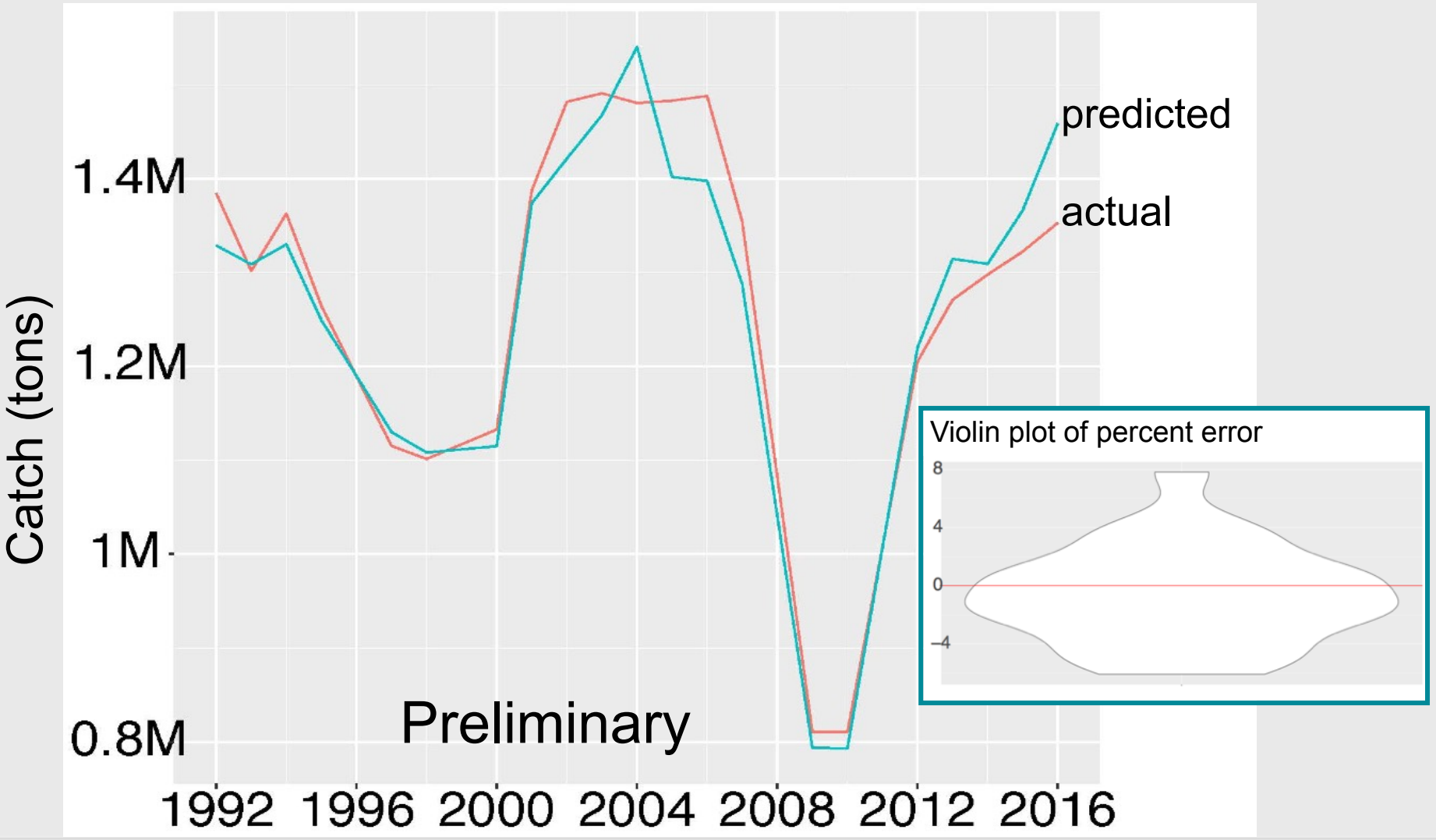
1. Use ABC to predict TAC
   - Observe past Council decisions
   - Model relationship between Council & ABC
   - Impose 2 Million metric ton cap

Amanda Faig

2. Use TAC prediction to predict Catch
   - Model catch based on past fishery outcomes, weighted to recent behavior.
   - Limit catch to not exceed ABC

Bering Sea Pollock, historical evaluation

BS Pollock catch, predicted from ABC



Shared Socioeconomic Pathways (SSPs)
&
Fishery Mechanisms

Shared Socioeconomic Pathways (SSPs)

- SSPs capture important elements of changing world economy and global cooperation
- These will have an important impact on whether a ‘high’ or ‘low’ carbon world occurs.

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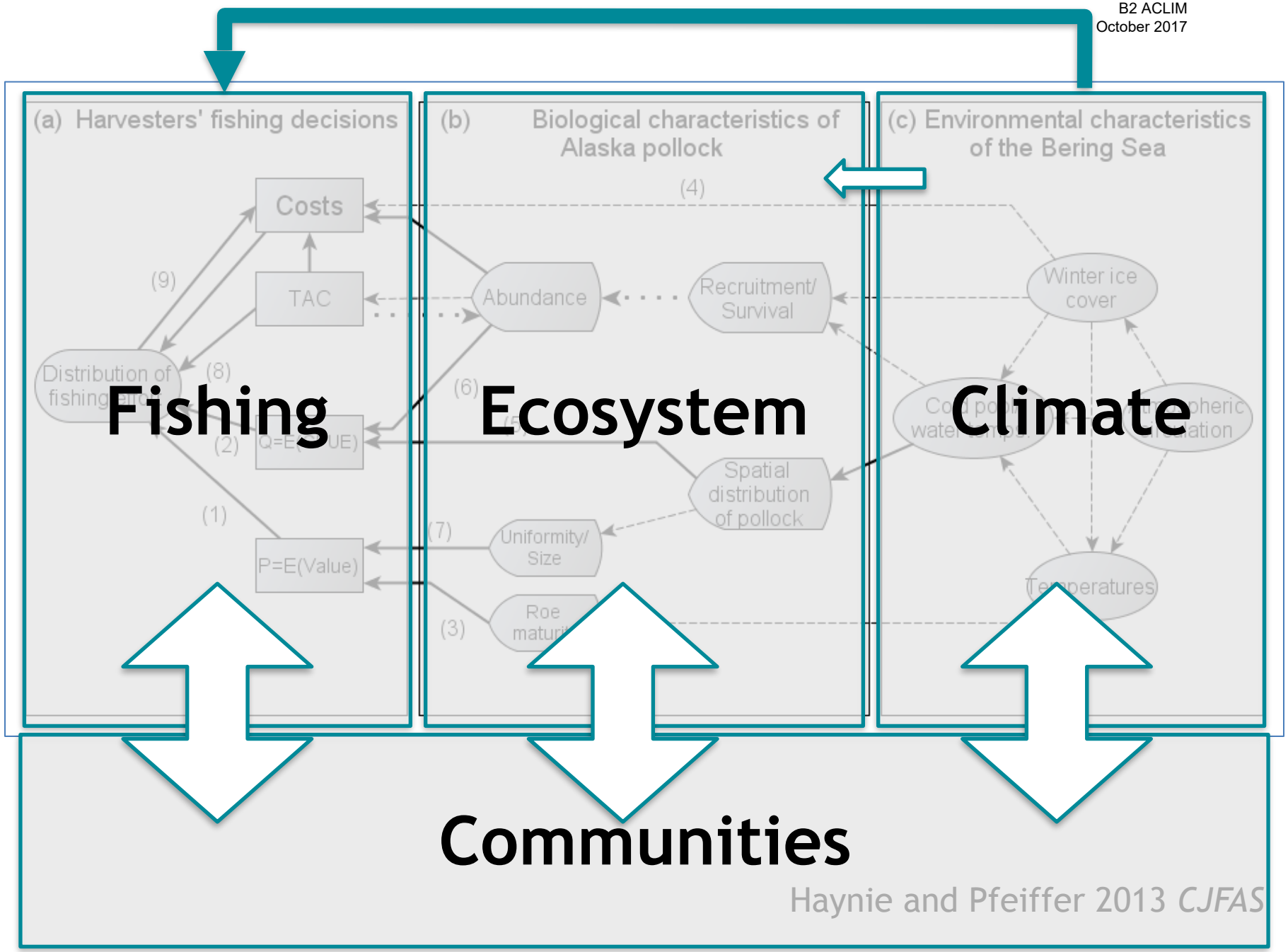
- These will have an important impact on whether a 'high' or 'low' carbon world occurs.

However, these factors will interact with 'Fishery mechanisms' that will more directly impact fishing in the North Pacific.



Haynie and Pfeiffer 2013 *CJFAS*

Fishery Mechanisms

- Fish prices
- Relative price of premium fish
- Number of species fished
- Costs
- Priority on conservation
- Protection of fishing communities

Fishery Mechanisms	Why this might <u>increase</u>	Why this might <u>decrease</u>
Fish prices		
Relative price of premium fish		
Number of species fished		
Costs		
Priority on conservation		
Protection of fishing communities		

Can we simplify these further?

Fishery Mechanisms
Fish prices
Relative price of premium fish
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Can we simplify these further?

Fishery Mechanisms
Fish prices
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Protection of fishing communities

- **Net Trip Revenue**
- **Skill in selective harvesting**
- **Flexibility of fishing opportunities**

Characterize expected impacts & uncertainty

- Catch
- Revenue
  - Average returns
  - Variability
  - Fleet & community distribution

Consider Feasible Management Tools

- New technology
- Catch shares
- Dynamic / fixed area closures
- Bycatch reduction incentives
- Revised harvest control rules
- Other suggestions?
- Tools of the future!

Future process

- Understand possible changes
- Council & stakeholders consider outcomes they most want to avoid or achieve
- Evaluate policies based on Council & stakeholder preferences.

The goal of ACLIM is constant improvement

- These models use the best available knowledge about the ecosystem
- As we learn more, the models and projections will be updated.

Take-home Messages

- The Bering Sea is likely to change
- ACLIM tools will evolve & improve
- Continued excellent and responsive management will be essential.

Our questions for you:

- What are we missing?
- How can we best share results with the Council & other stakeholders?

Thanks!

NPRB & BSIERP Team
ACLIM Team
AFSC

"Behind these numbers lies, of course, an infinity of movements and of destinies."
– von Bertalanffy 1938

…and of people!

Funding:
- Fisheries & the Environment (FATE)
- Stock Assessment Analytical Methods (SAAM)
- Climate Regimes & Ecosystem Productivity (CREP)
- Economics and Human Dimensions Program
- NOAA Integrated Ecosystem Assessment Program (IEA)
- NOAA Research Transition Acceleration Program (RTAP)

NOAA FISHERIES

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