Photo: Mark Holsman

Suboptimal thermal conditions and spatial mismatch between predators and prey and may limit walleye pollock growth under climate change

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PICES 2016

NOAA FISHERIES

The ACLIM team


Anne Hollowed

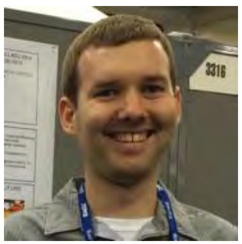

Kirstin Holsman


Alan Haynie


Albert Hermann


Wei Cheng


Andre Punt


Darren Pilcher


Kerim Aydin


Jim Ianelli


Ingrid Spies


Stephen Kasperski


Cody Szuwalski


Amanda Faig


Jonathan Reum

Michael Dalton


Paul Spencer

Tom Wilderbuer

William Stockhausen

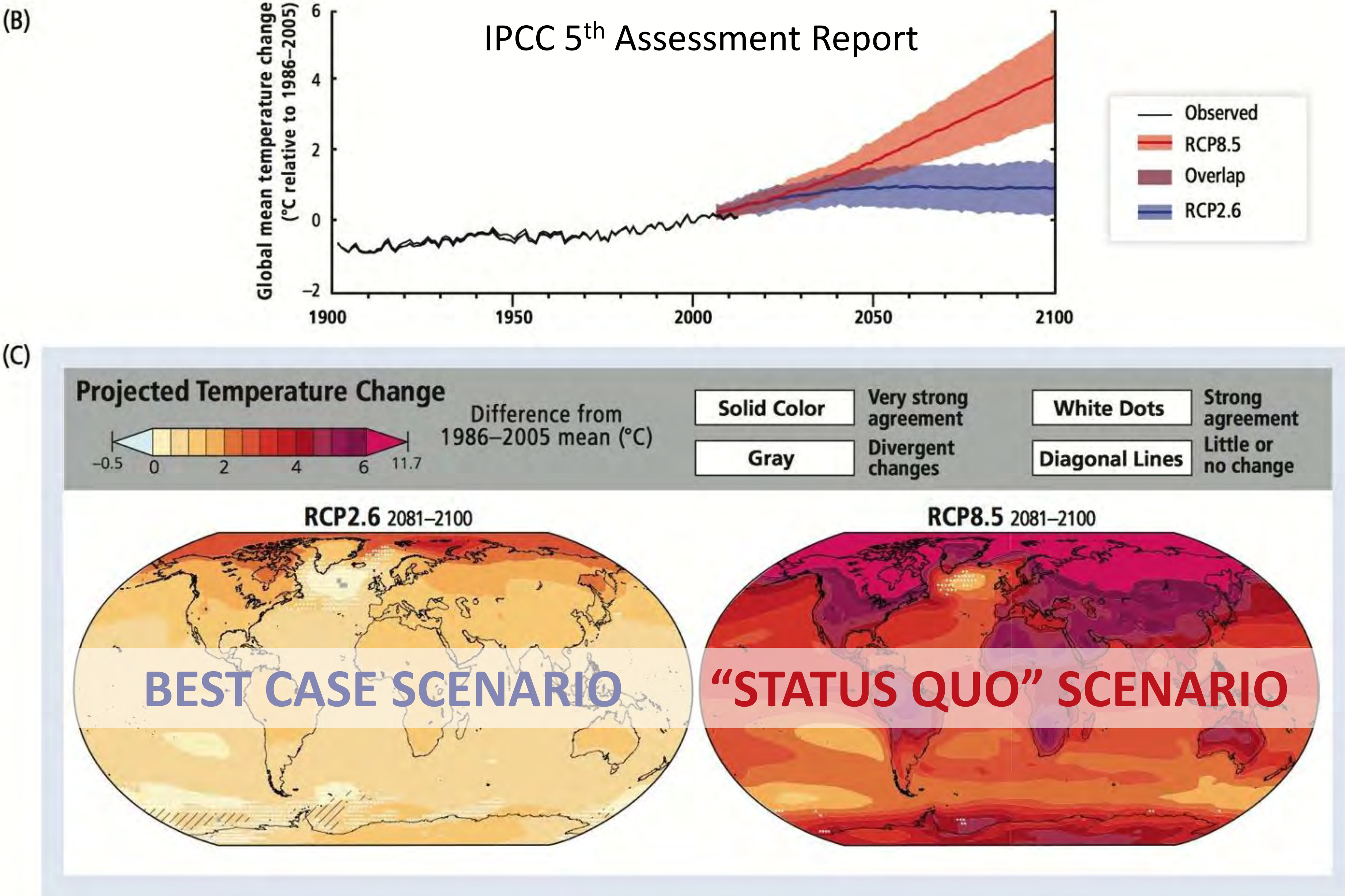
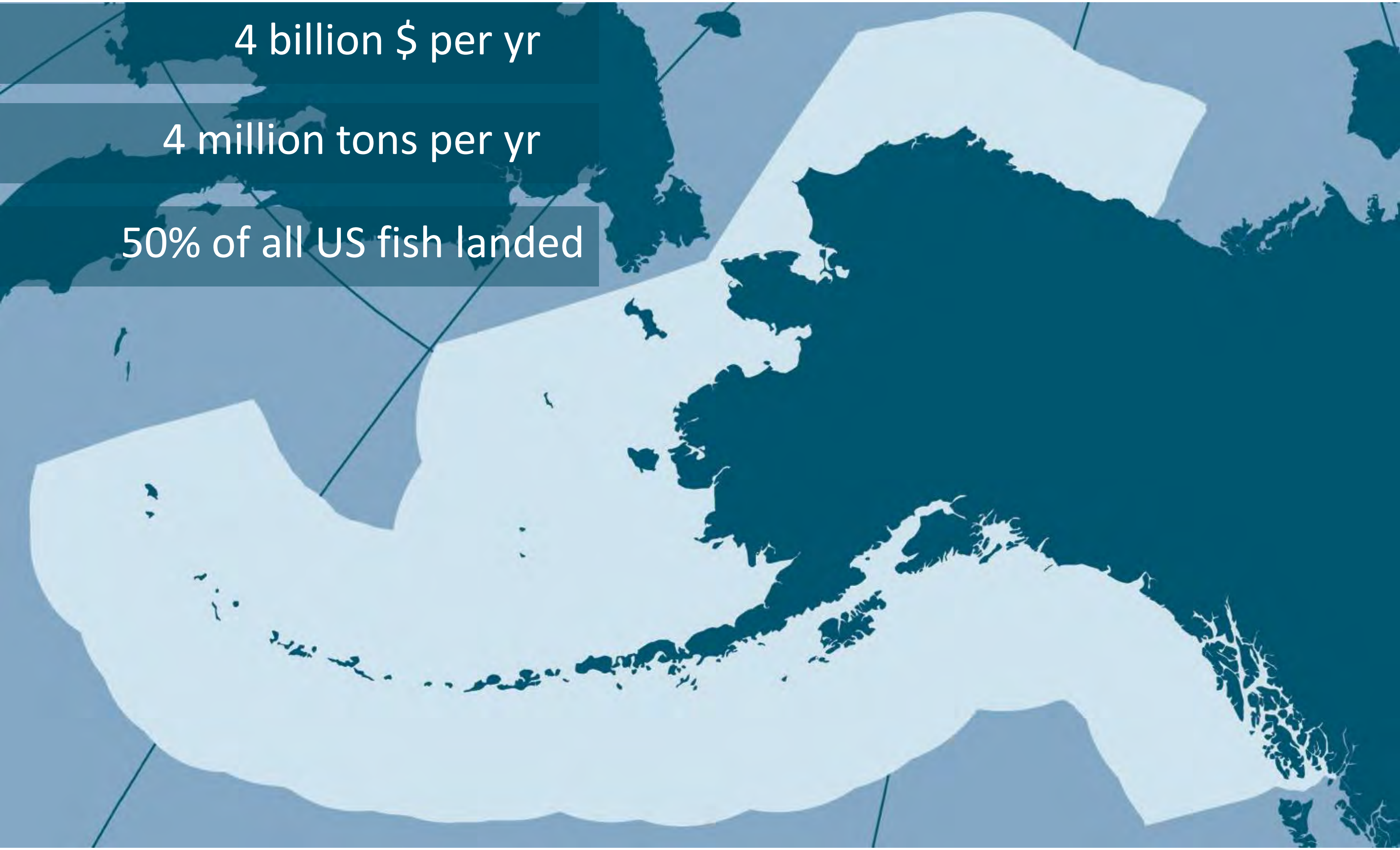


Figure SPM.4 | Observed and projected changes in annual average surface temperature. This figure informs understanding of climate-related risks in the WGII AR5. It illustrates temperature change observed to date and projected warming under continued high emissions and under ambitious mitigation.

Alaska-wide Fisheries

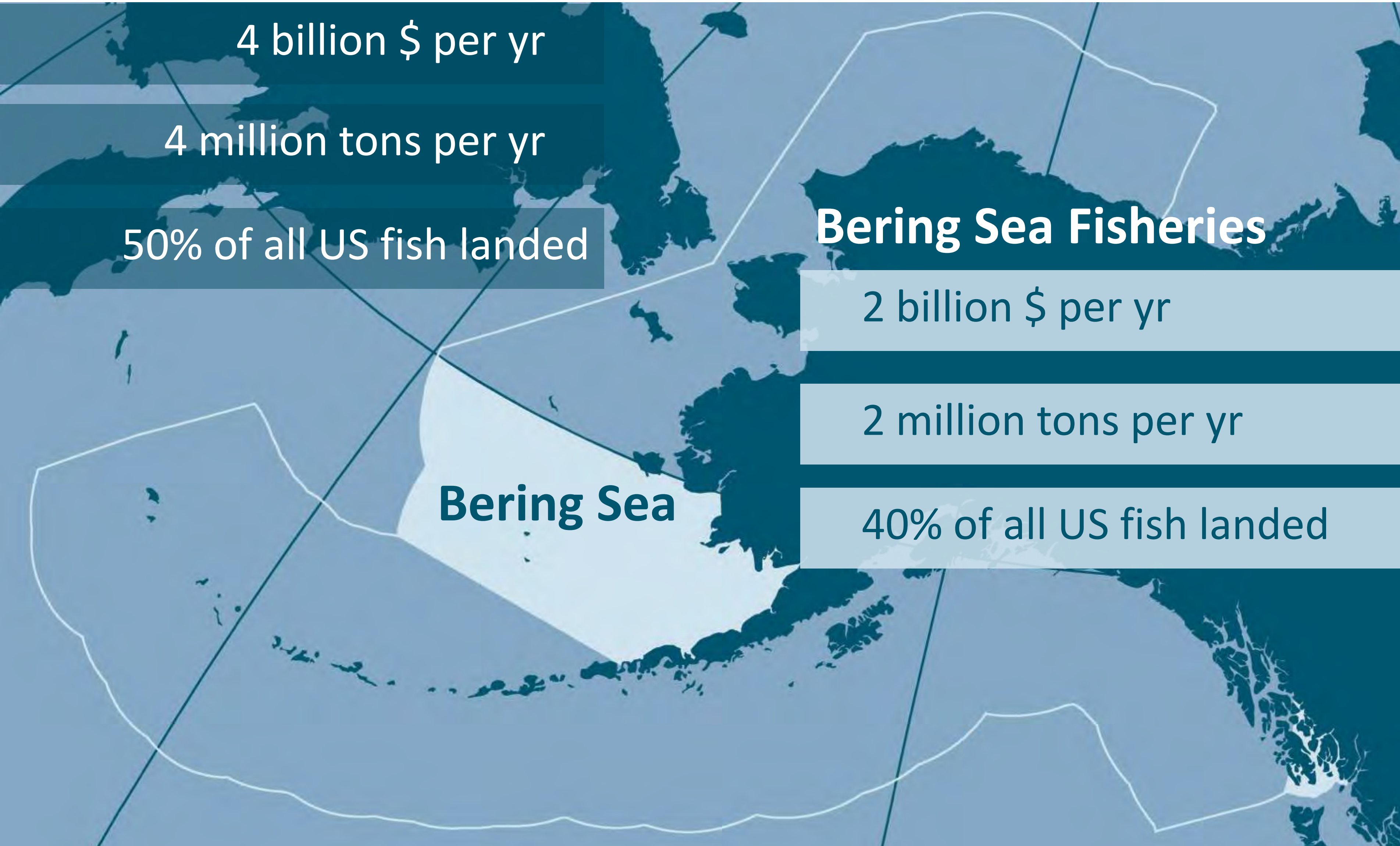


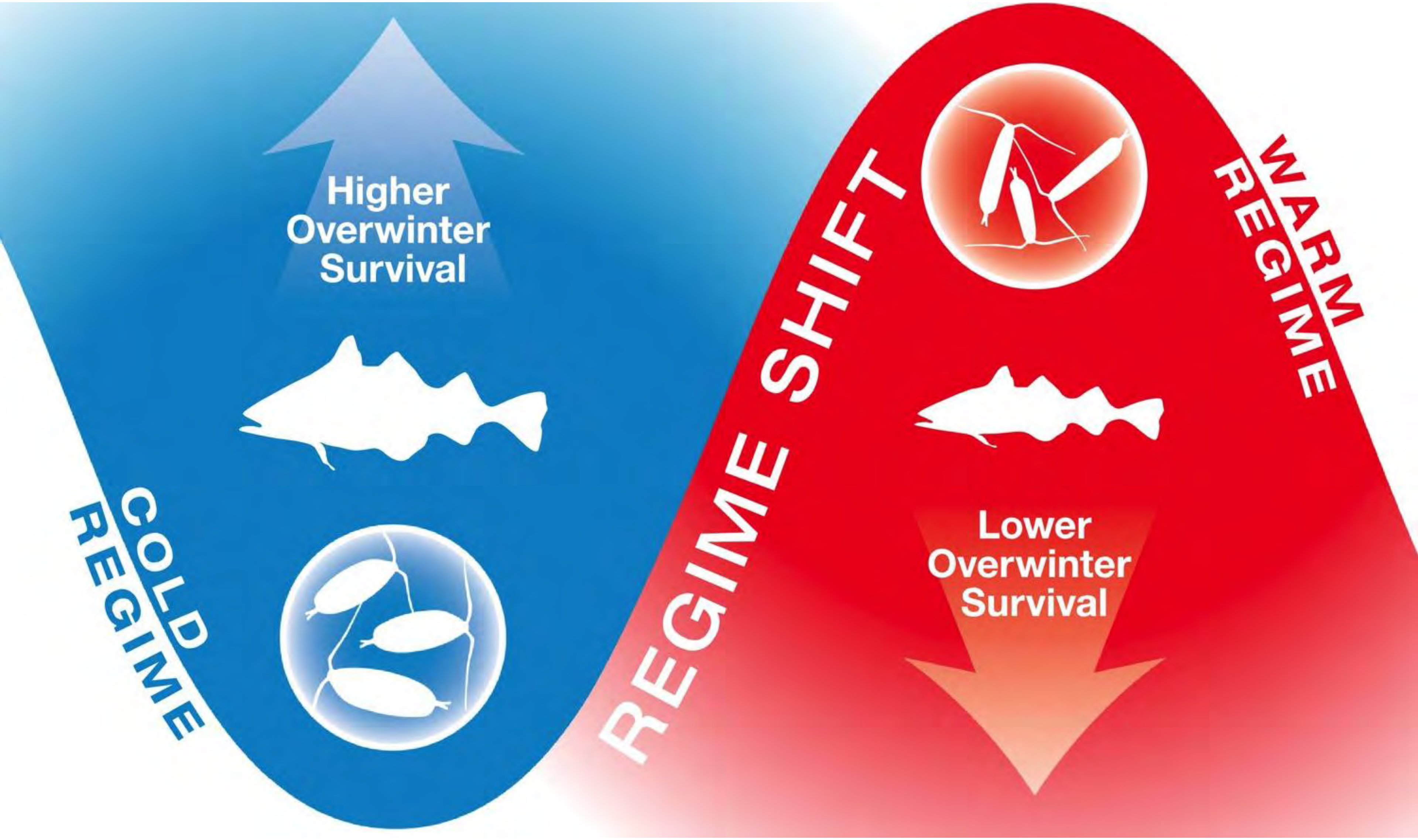
Alaska-wide Fisheries

- 4 billion $ per yr
- 4 million tons per yr
- 50% of all US fish landed

Bering Sea Fisheries

- 2 billion $ per yr
- 2 million tons per yr
- 40% of all US fish landed





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Slide courtesy of J. Duffy-Anderson

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PLOS | ONE

Spatial Match-Mismatch between Juvenile Fish and Prey Provides a Mechanism for Recruitment Variability across Contrasting Climate Conditions in the Eastern Bering Sea

Elizabeth Calvert Siddon[1]*, Trond Kristiansen[2], Franz J. Mueter[1], Kirstin K. Holsman[3], Ron A. Heintz[4], Edward V. Farley[4]

1 School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, Alaska, United States of America, **2** Institute of Marine Research, Bergen, Norway, **3** Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington, United States of America, **4** Ted Stevens Marine Research Institute, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, Alaska, United States of America

Abstract

Understanding mechanisms behind variability in early life survival of marine fishes through modeling efforts can improve predictive capabilities for recruitment success under changing climate conditions. Walleye pollock (*Theragra chalcogramma*) support the largest single-species commercial fishery in the United States and represent an ecologically important component of the Bering Sea ecosystem. Variability in walleye pollock growth and survival is structured in part by climate-driven bottom-up control of zooplankton composition. We used two modeling approaches, informed by observations, to understand the roles of prey quality, prey composition, and water temperature on juvenile walleye pollock growth: (1) a bioenergetics model that included local predator and prey energy densities, and (2) an individual-based model that included a mechanistic feeding component dependent on larval development and behavior, local prey densities and size, and physical oceanographic conditions. Prey composition in late-summer shifted from predominantly smaller copepod

Siddon et al. (2013) PLOS ONE 8(12): Article #: e84526.

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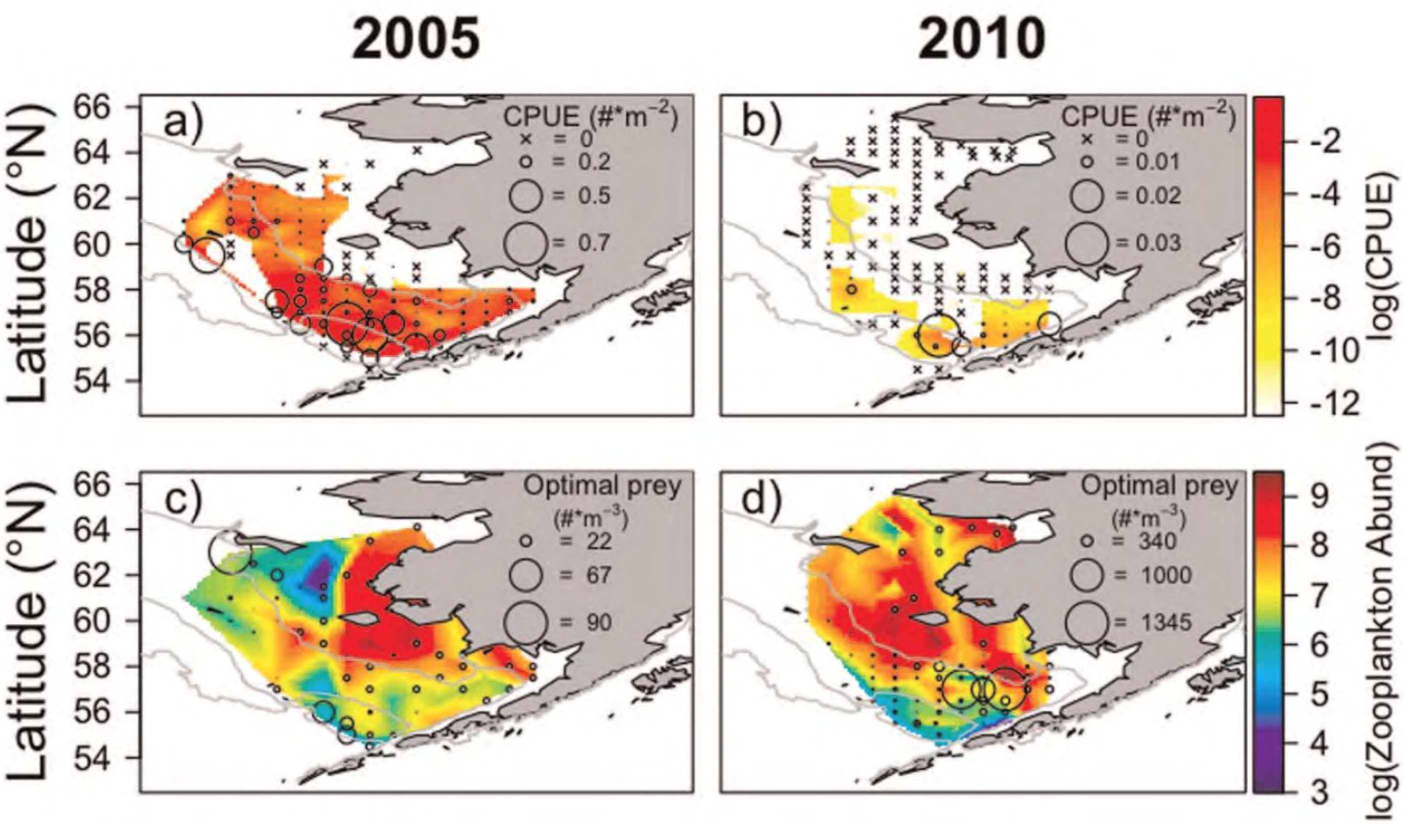
Warm

Cool



Siddon et al. (2013) [PLOS ONE](#) 8(12): Article #: e84526.

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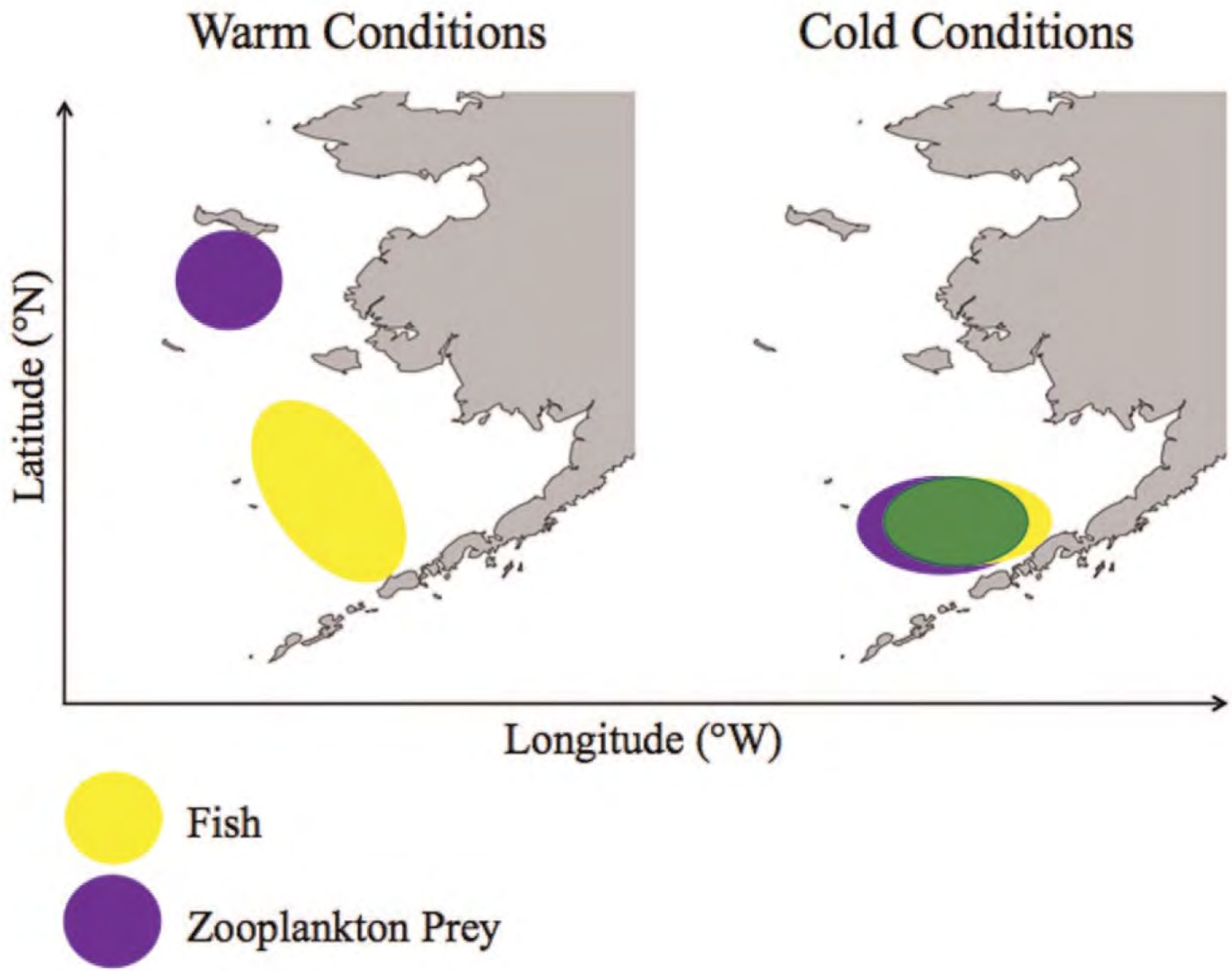

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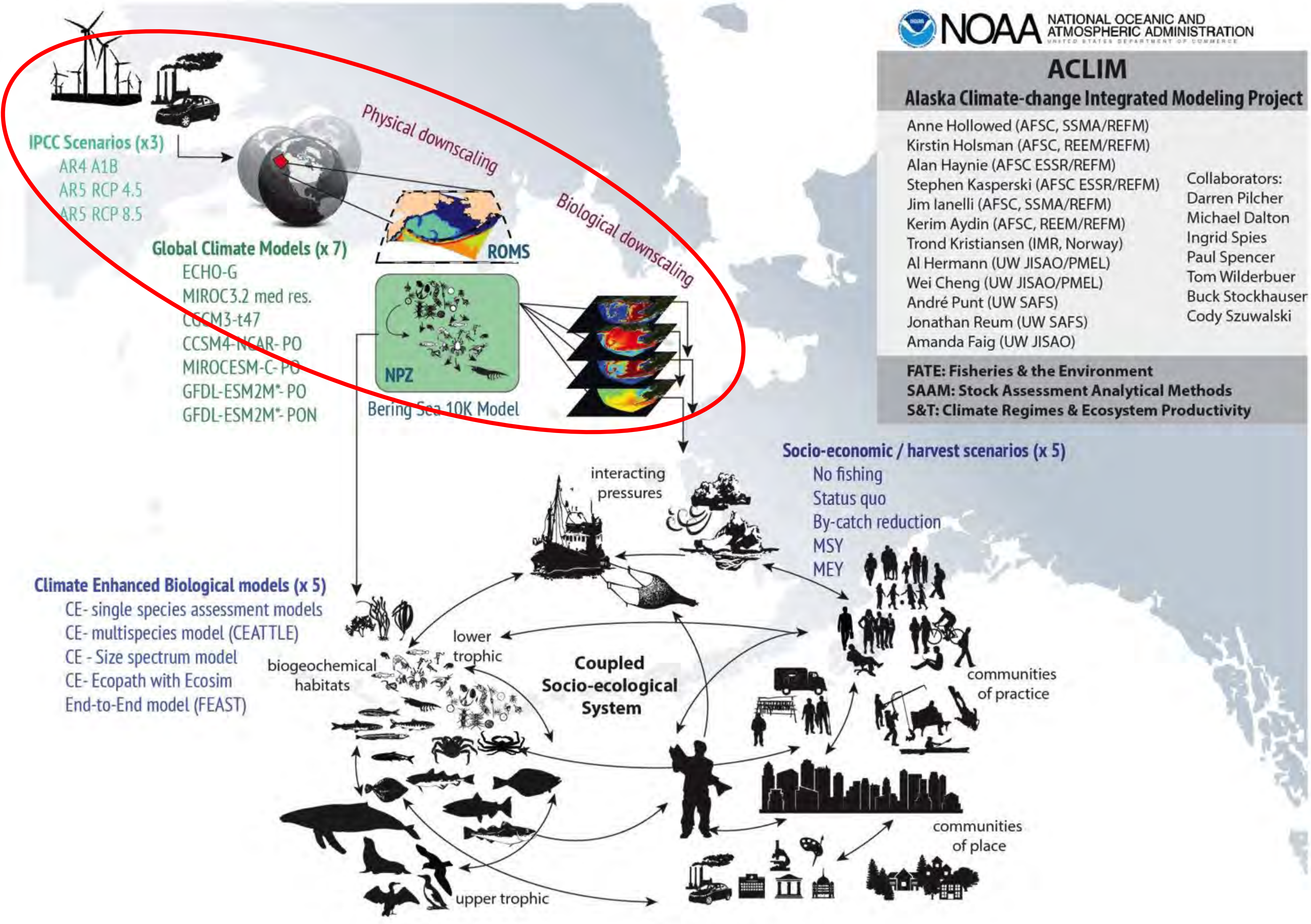
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE
ACLIM
Alaska Climate-change Integrated Modeling Project
Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holsman (AFSC, REEM/REFM)
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Trond Kristiansen (IMR, Norway)
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Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)
Jonathan Reum (UW SAFS)
Amanda Faig (UW JISAO)
Collaborators:
Darren Pilcher
Michael Dalton
Ingrid Spies
Paul Spencer
Tom Wilderbuer
Buck Stockhauser
Cody Szuwalski
FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity
IPCC Scenarios (x3)
AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5
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
Physical downscaling
ROMS
Biological downscaling
NPZ
Bering Sea 10K Model
Socio-economic / harvest scenarios (x 5)
No fishing
Status quo
By-catch reduction
MSY
MEY
interacting pressures
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)
lower trophic
biogeochemical habitats
Coupled Socio-ecological System
communities of practice
communities of place
upper trophic

Physical & NPZ modeling

Dr. Al Hermann

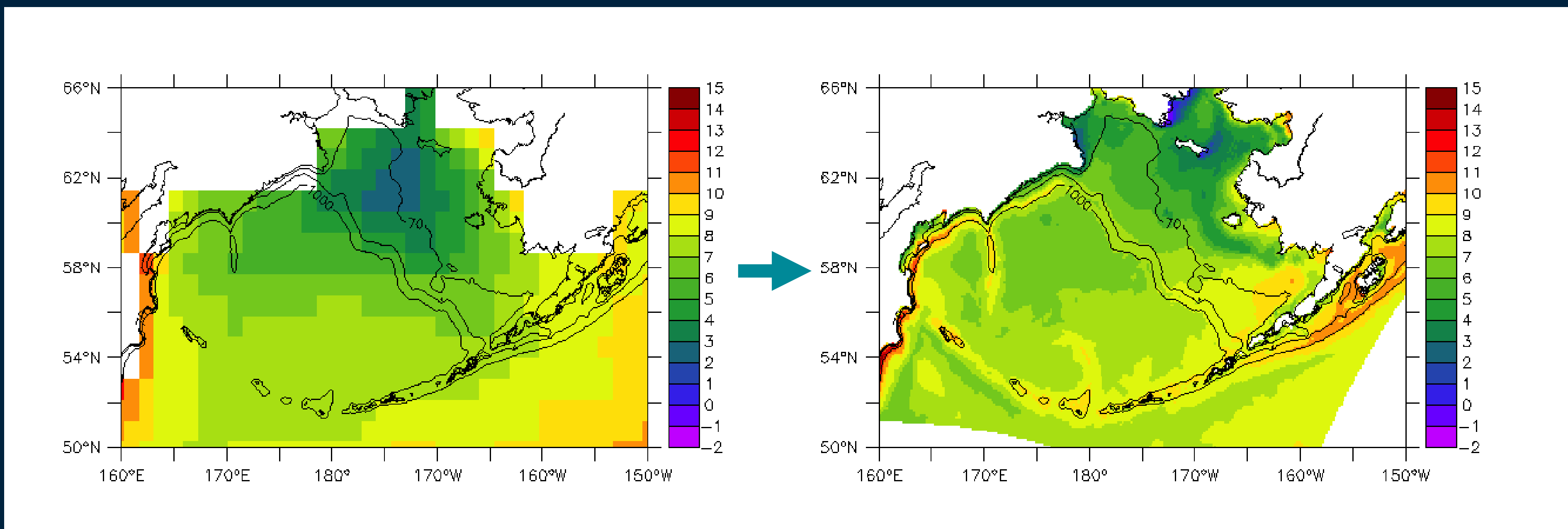
Dr. Wei Cheng

JISAO/UW and NOAA/PMEL

Photo: Mark Holsman

IPCC global projections drive regional model (*dynamical downscaling*)

IPCC model (MIROC) Regional model (Bering10K)



IPCC global atmosphere provides *surface forcing*

IPCC global ocean provides *boundary conditions*

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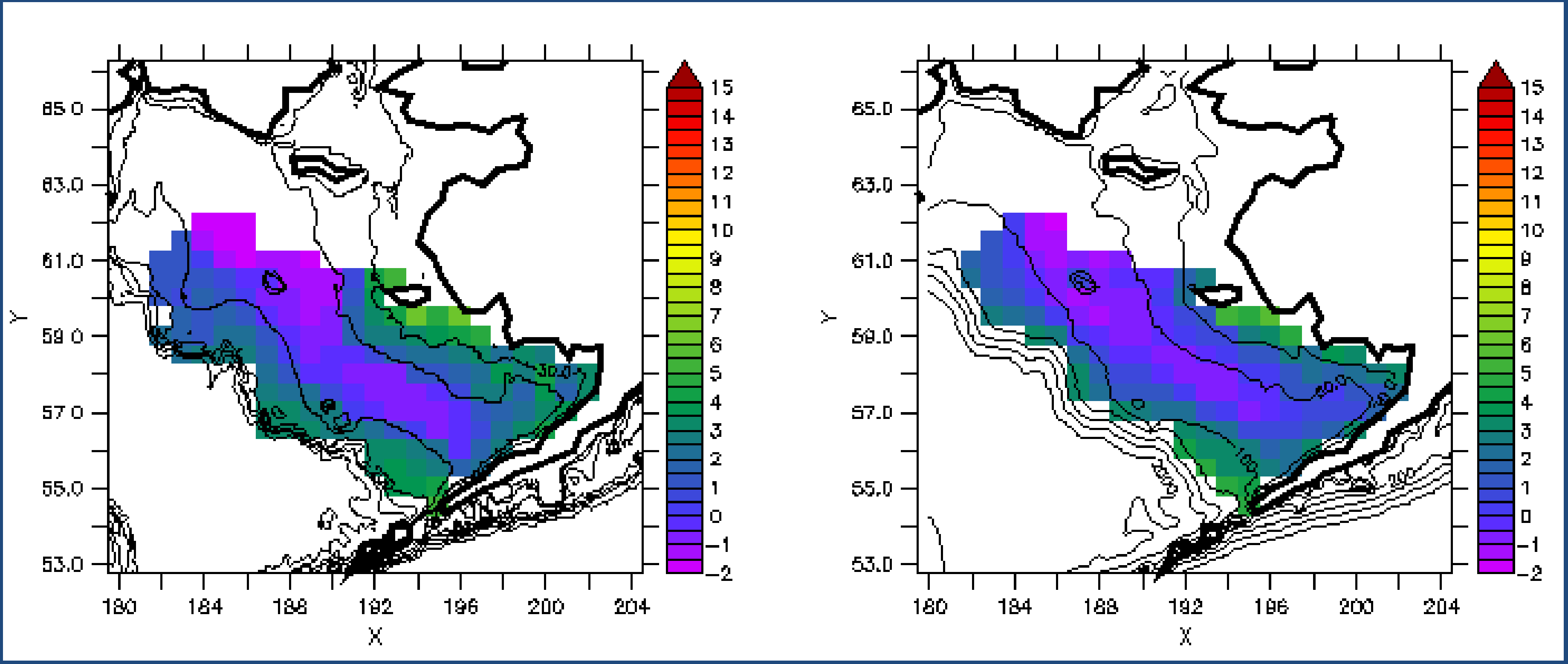
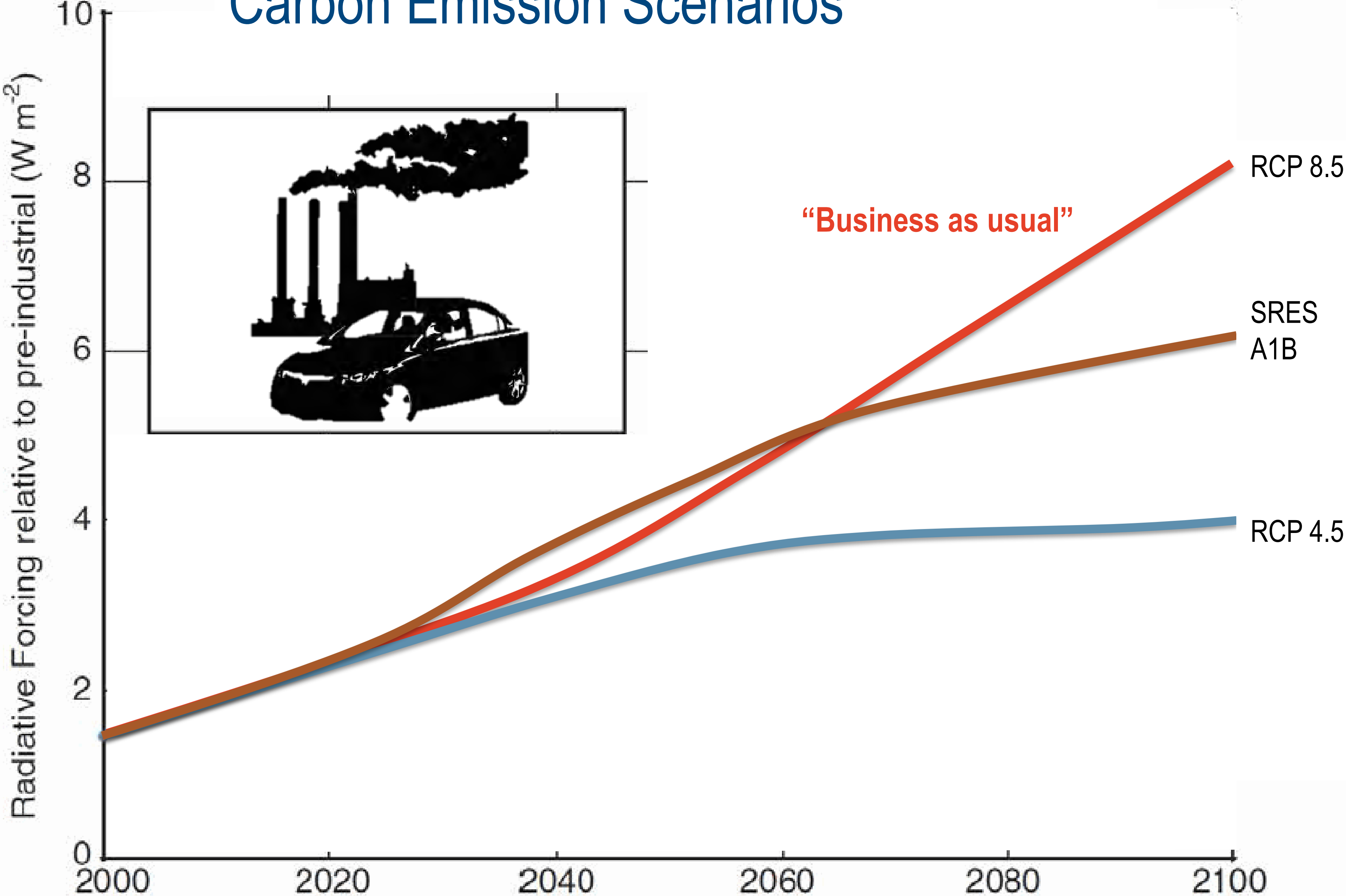
Bering10K validation:
Bottom Temp (deg C) summer 2009

DATA MODEL

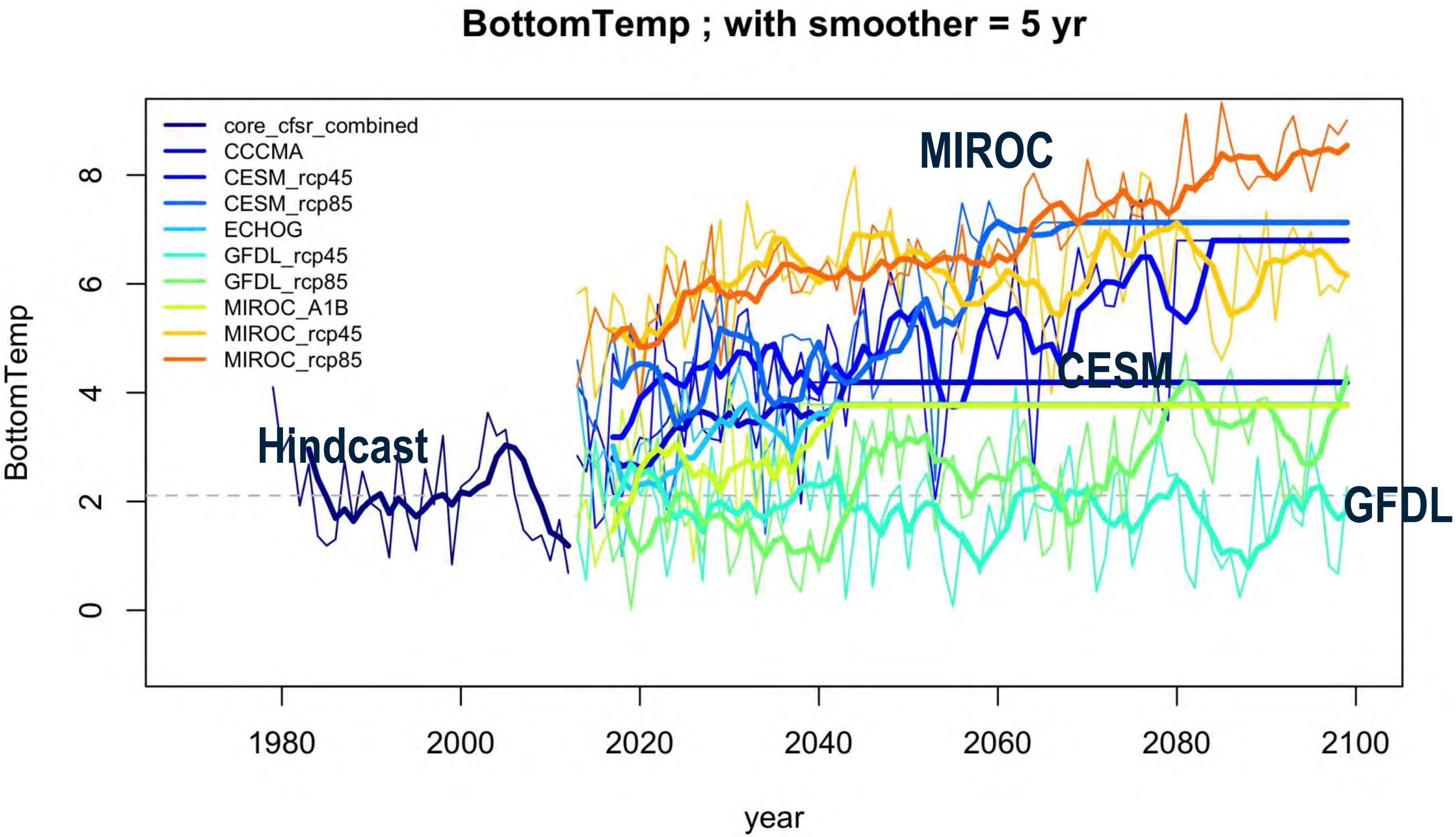


Carbon Emission Scenarios



Part 1 Overview Presenter: Anne Hollowed

Bering10K output: Bottom Temperature



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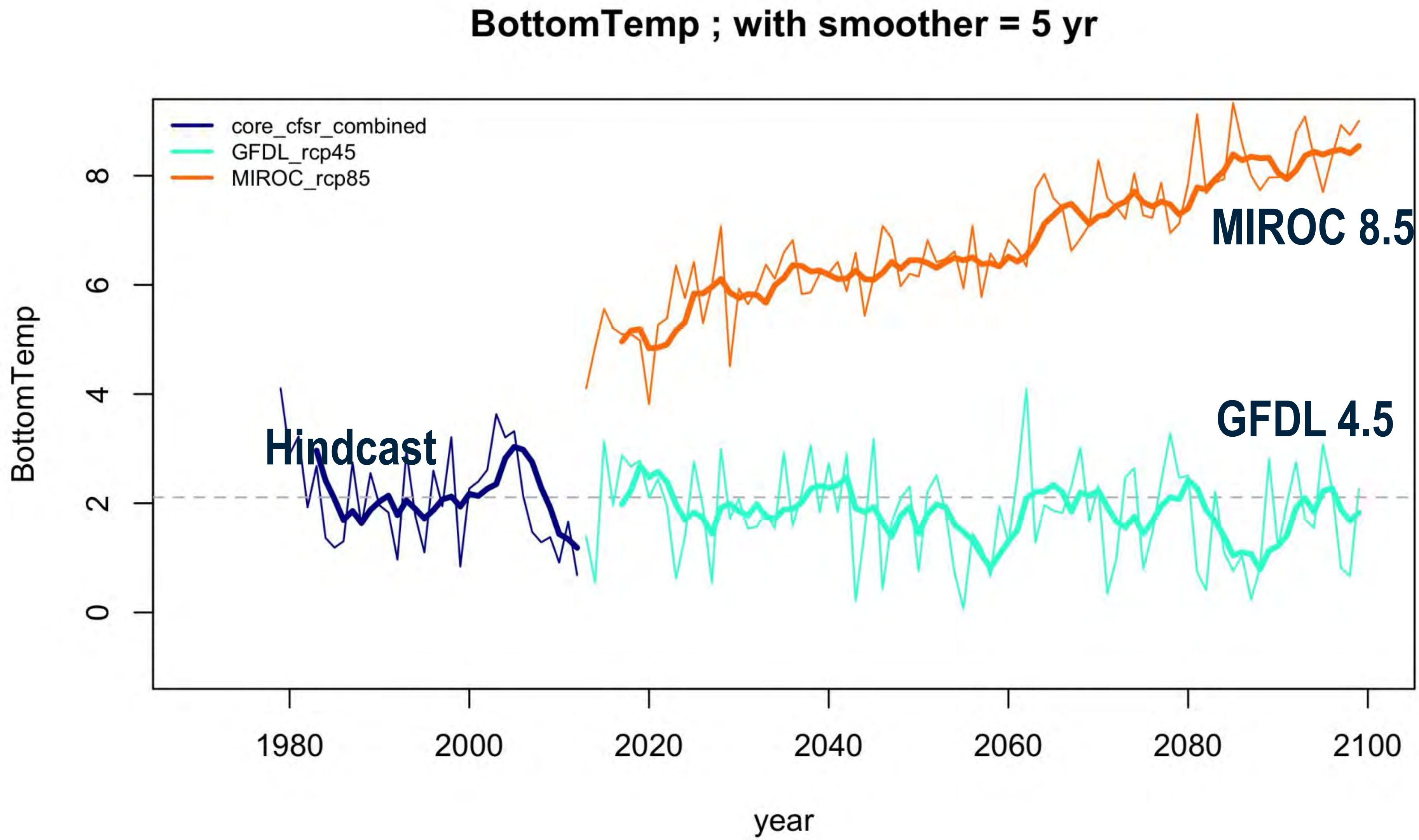
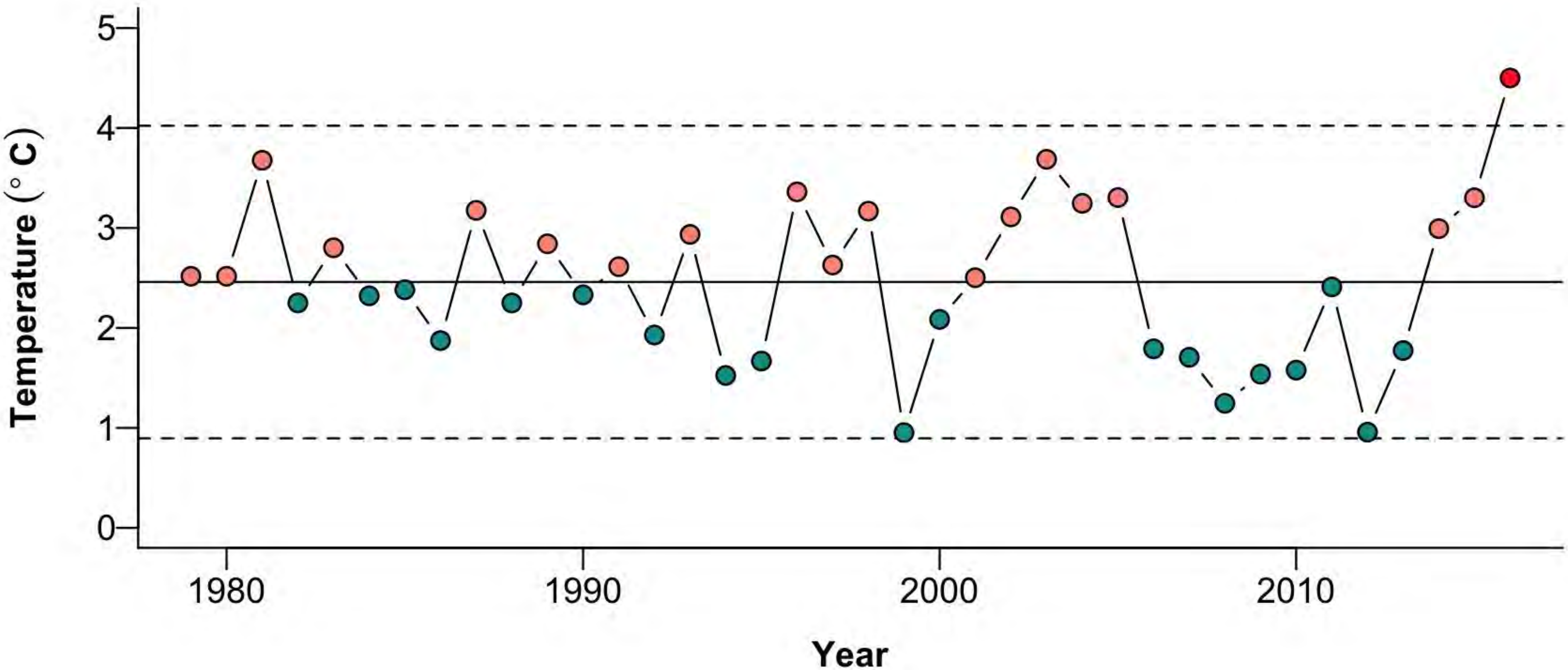
Bering10K output: Bottom Temperature



Survey Observations: Bottom Temperature



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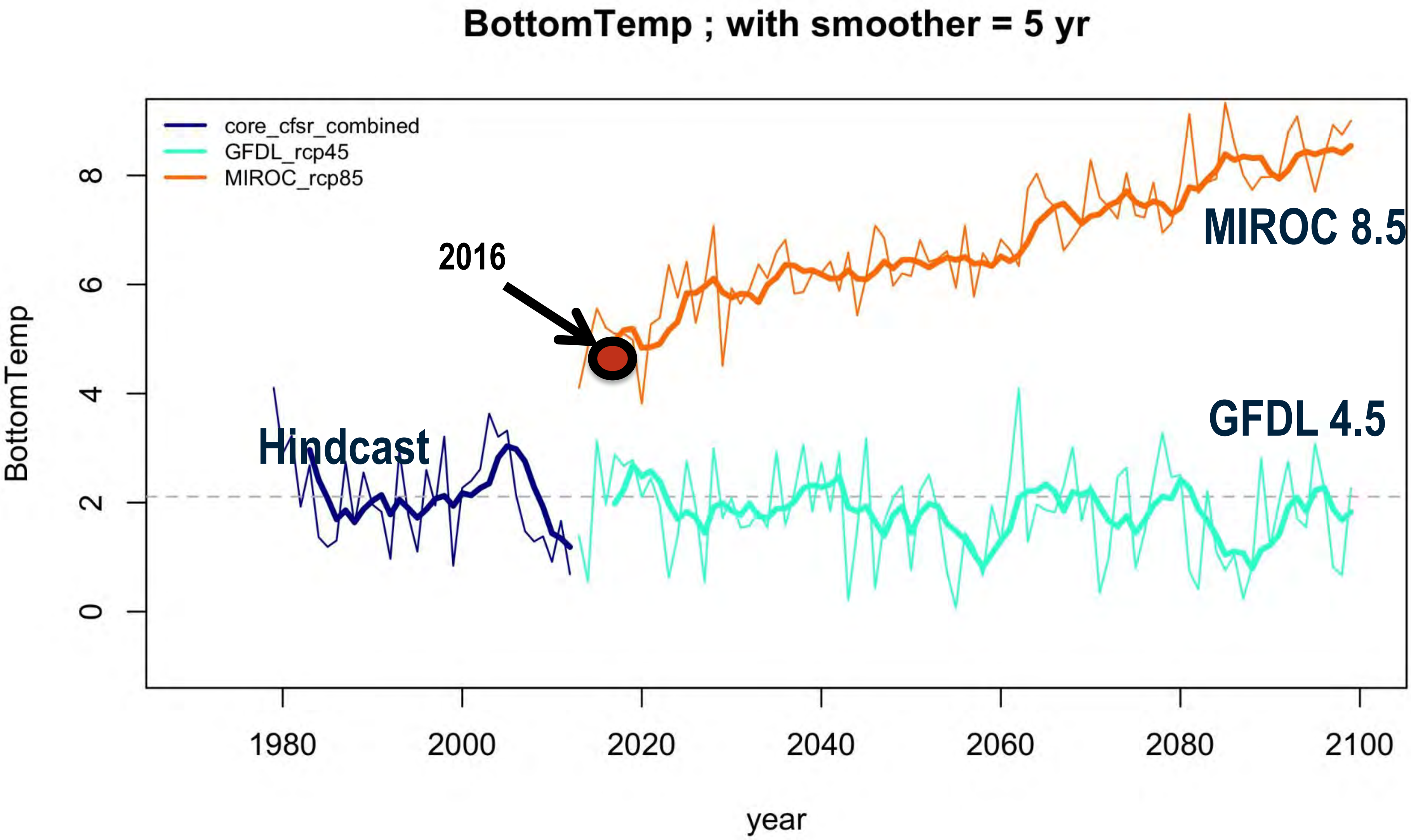
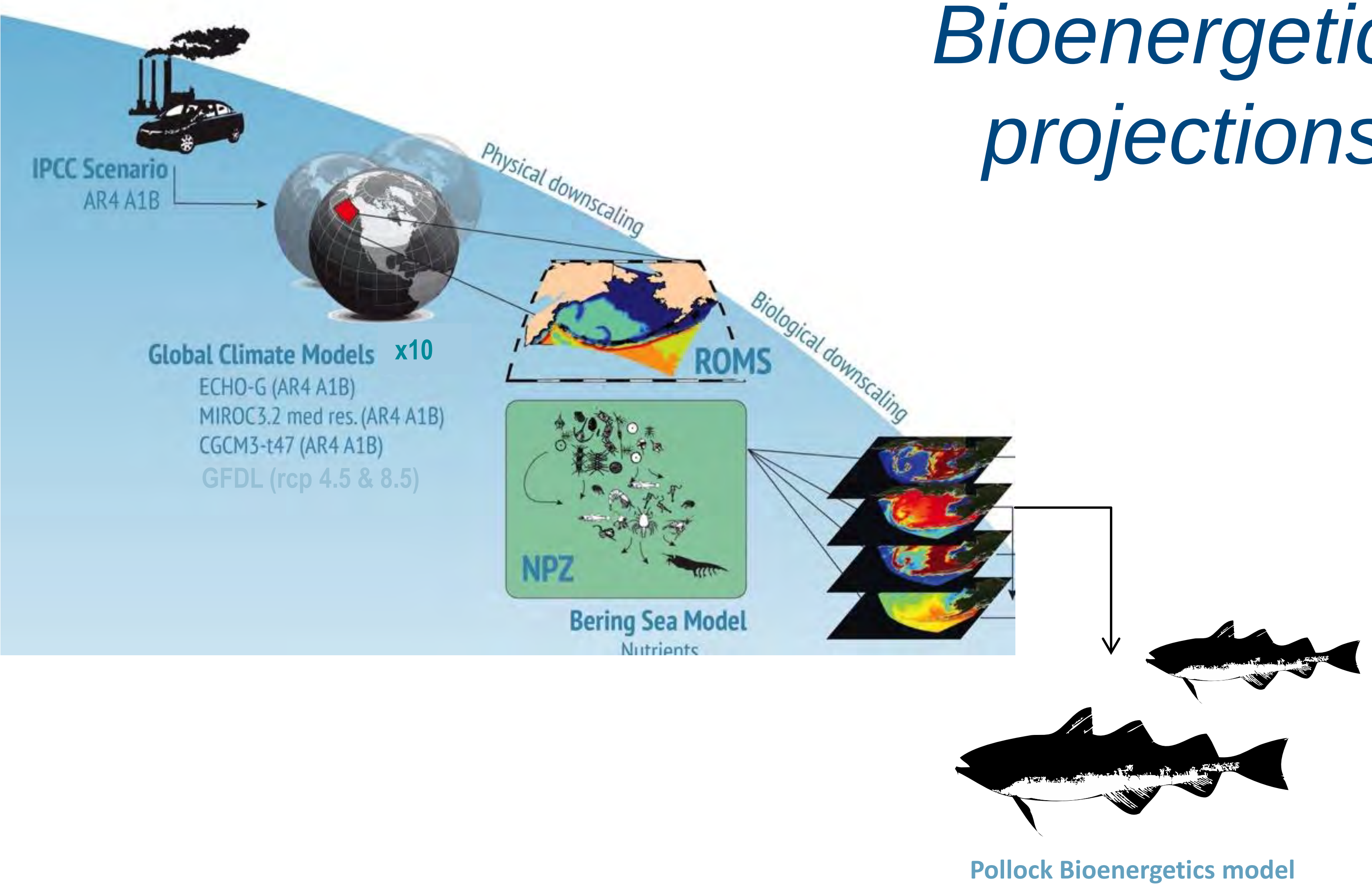
Bering10K output: Bottom Temperature



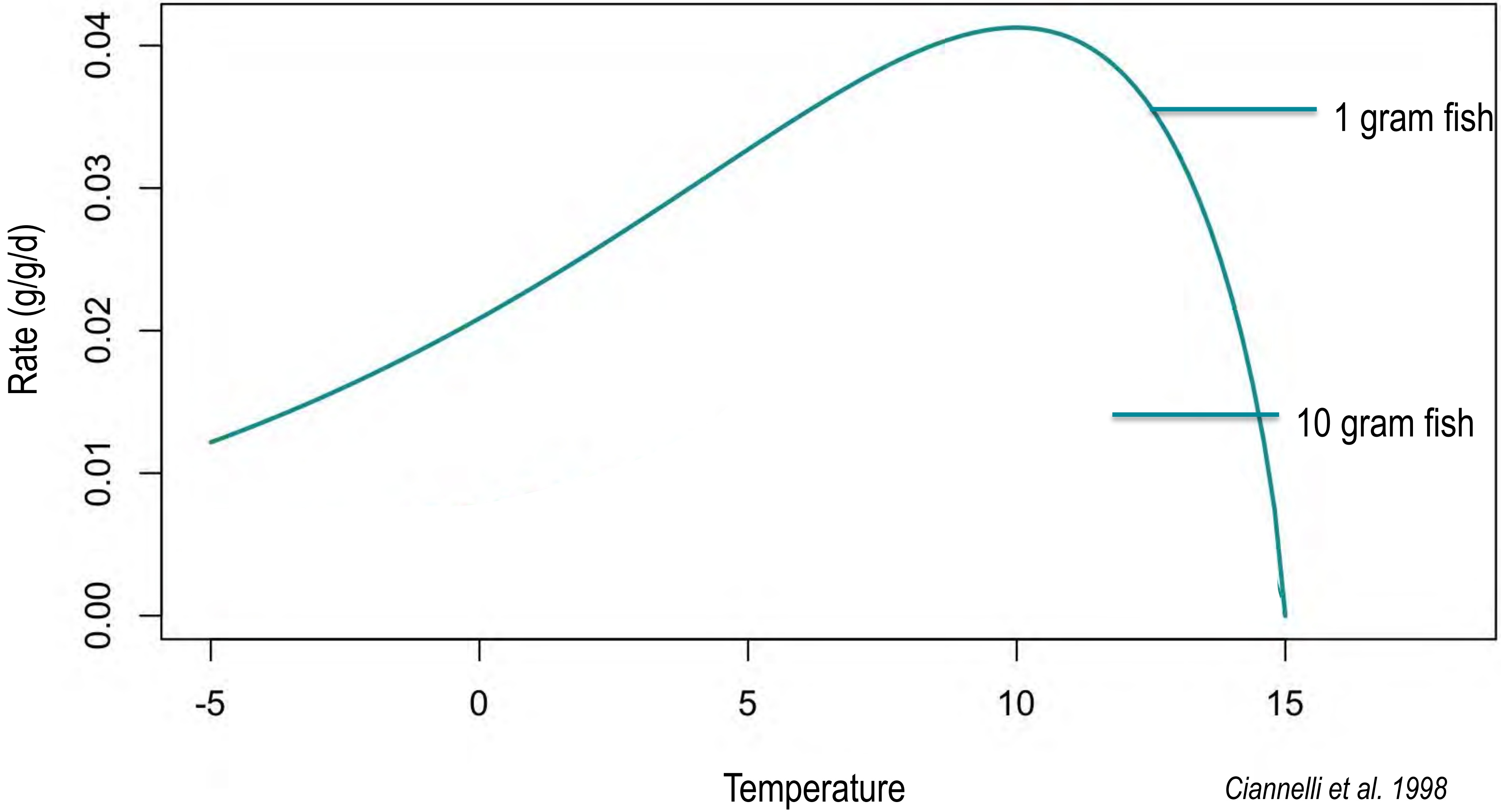
Bioenergetics projections



Holsman et al. in prep

Pollock Bioenergetics

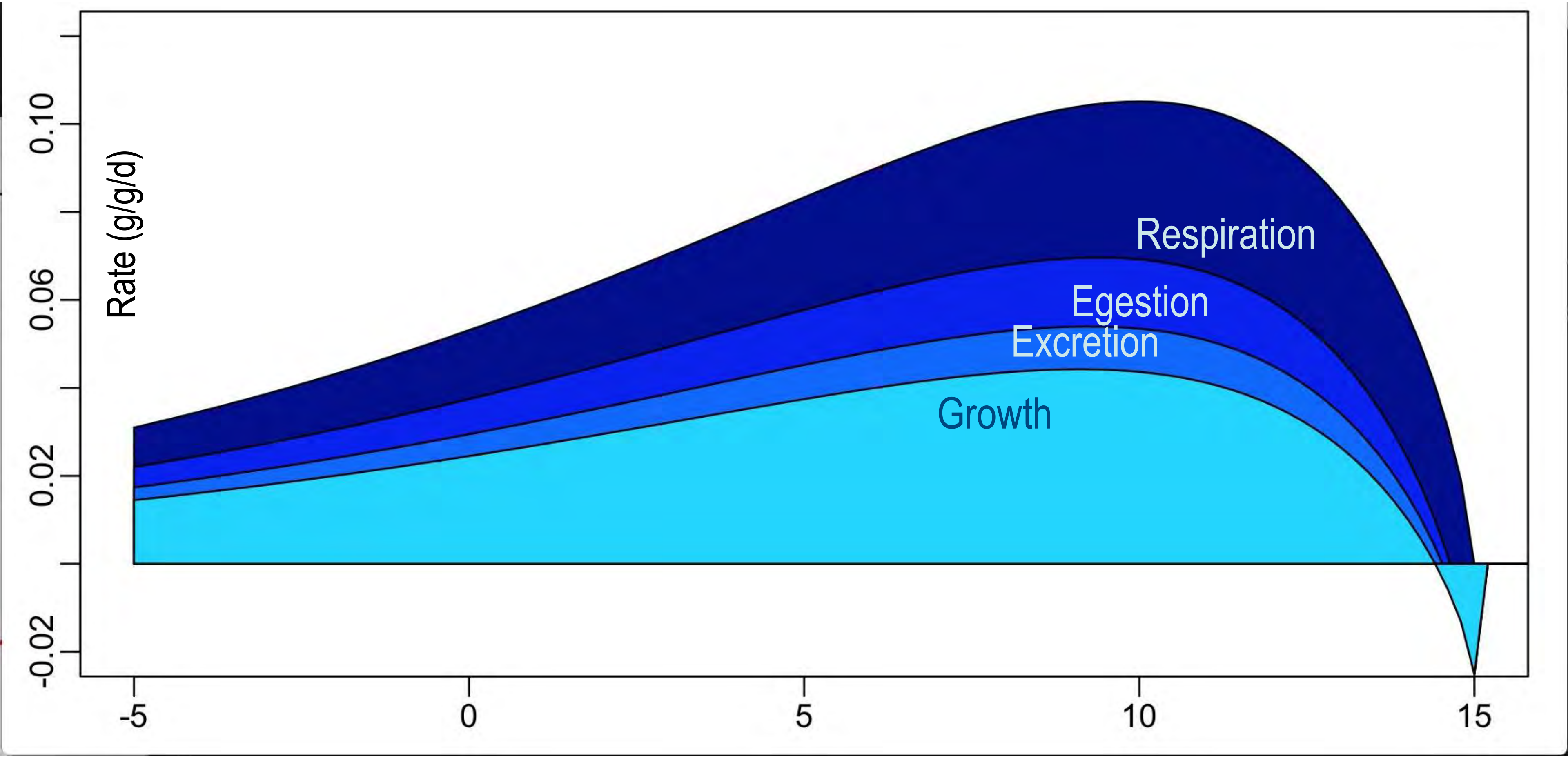
$$G = C-(R+F+U)$$



Ciannelli et al. 1998

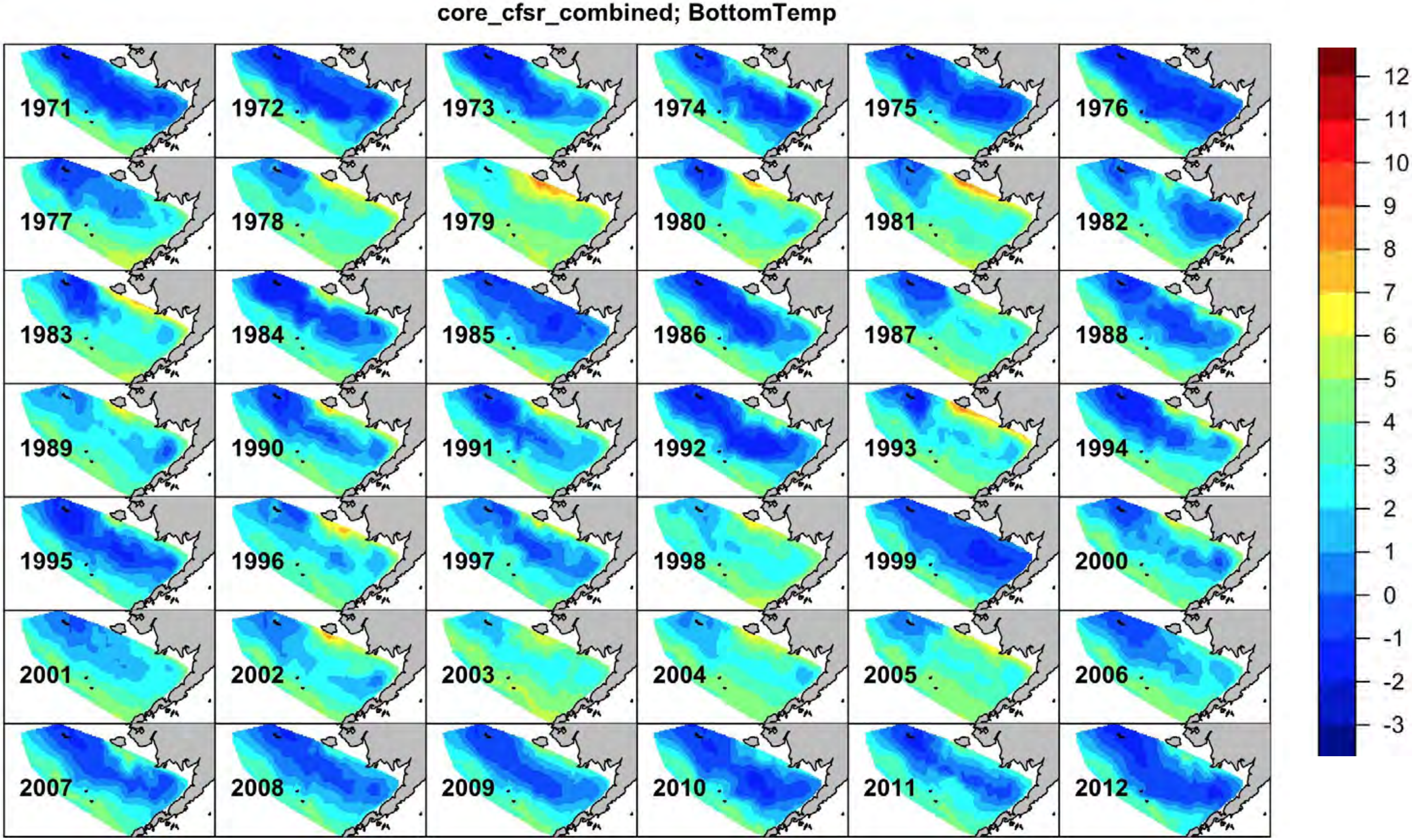
Pollock Bioenergetics

$$G = C-(R+F+U)$$

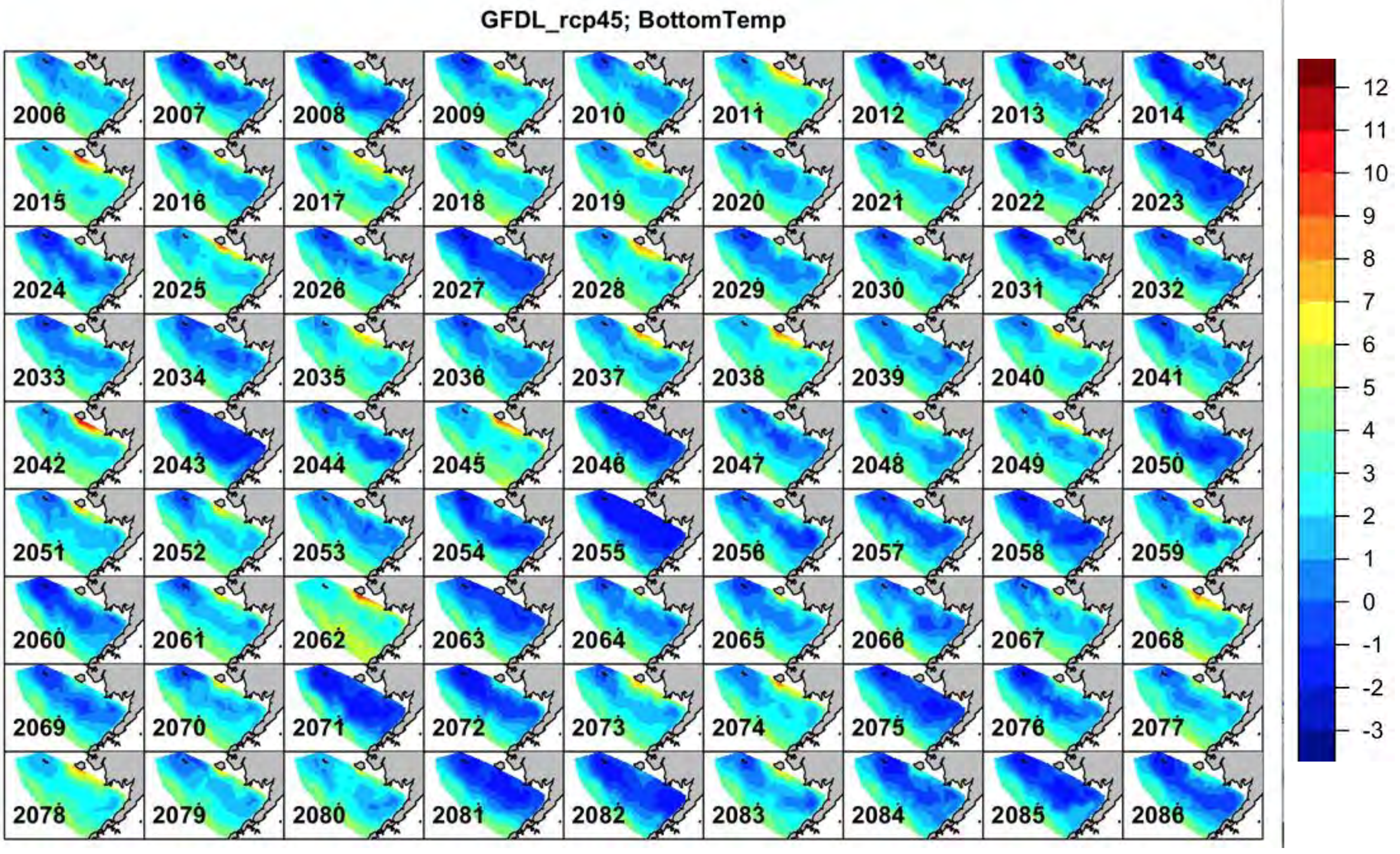


Ciannelli et al. 1998

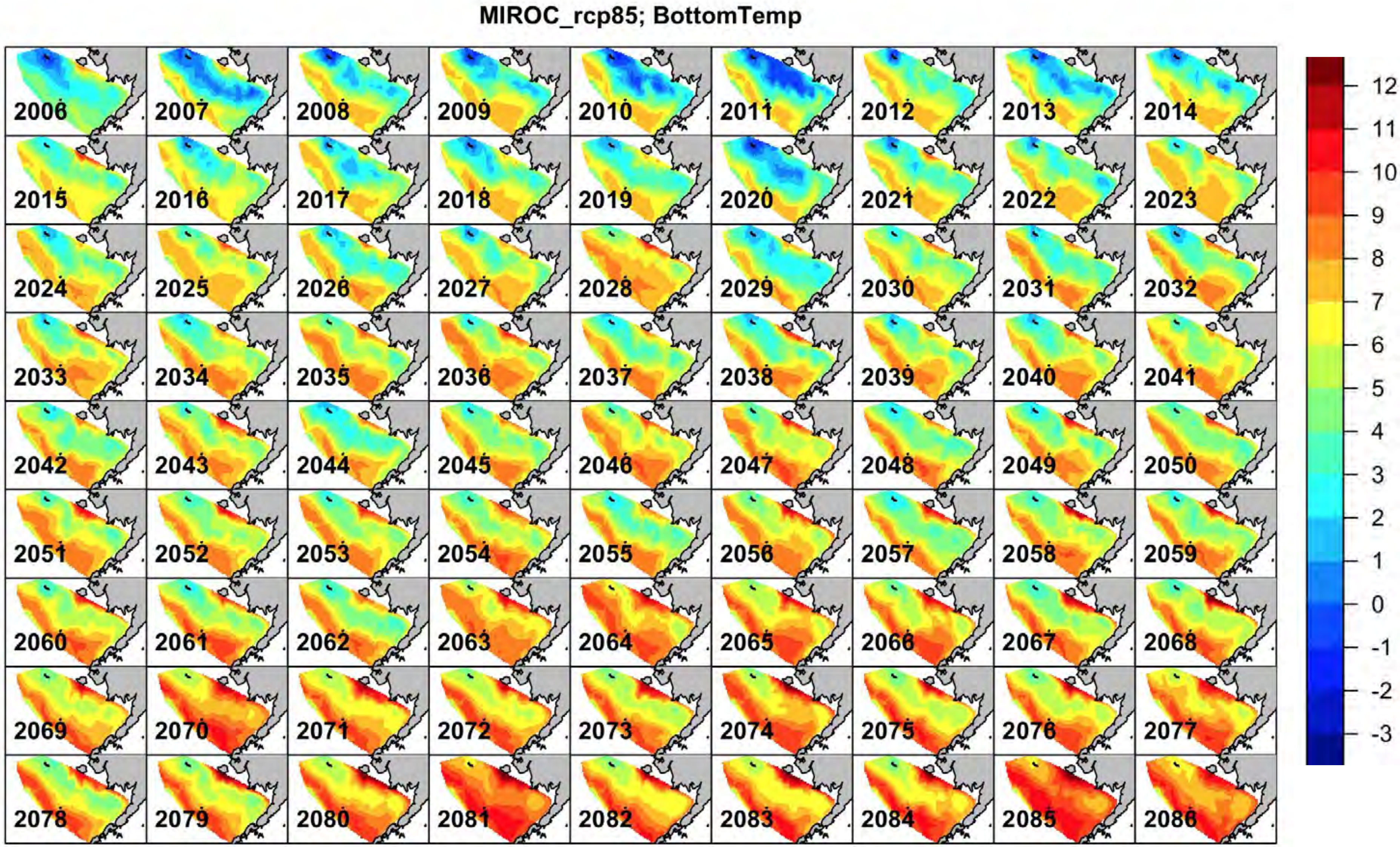
Bottom Temp hindcast (1971→2012)



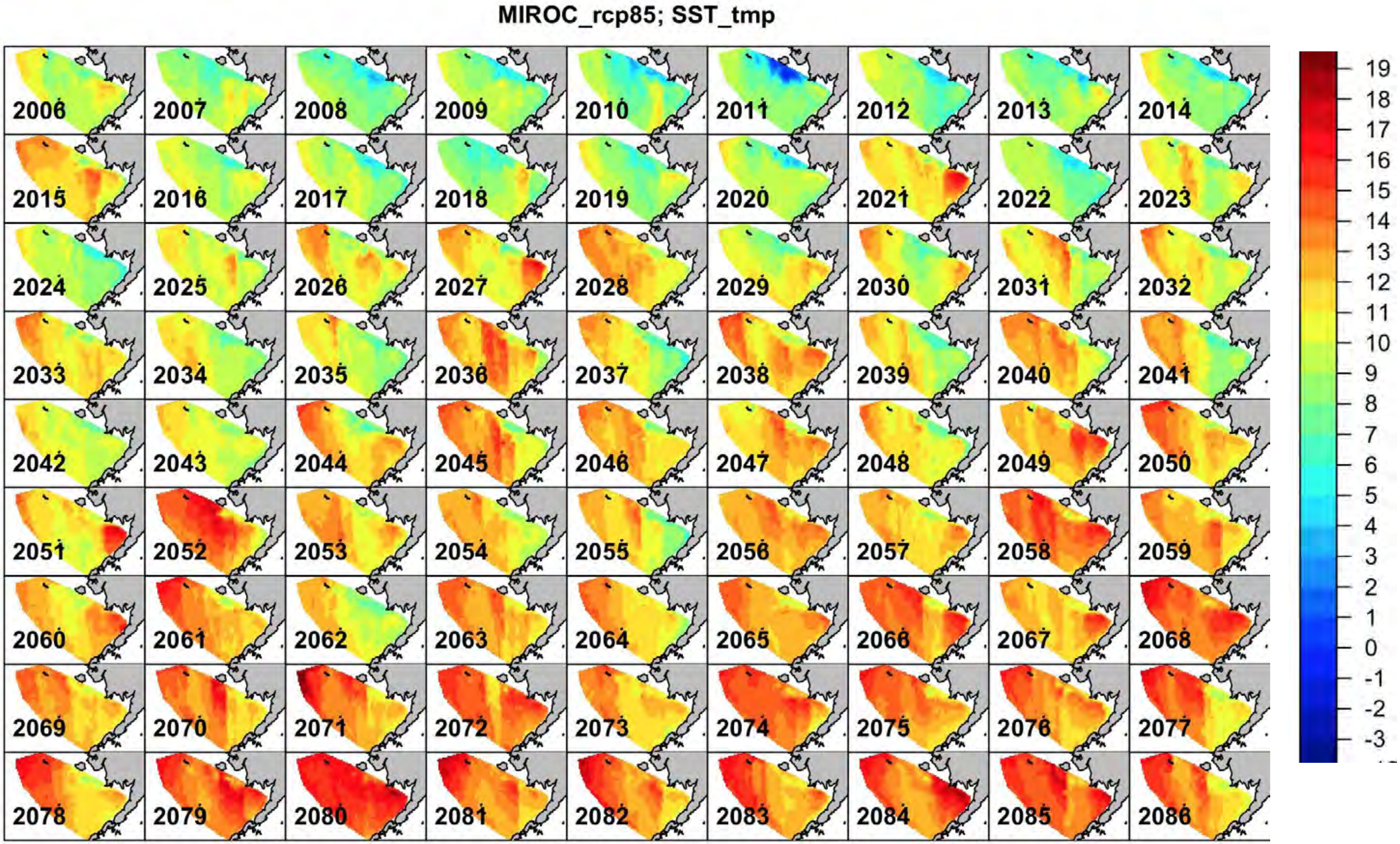
Bottom Temp Projections (2006→2086)



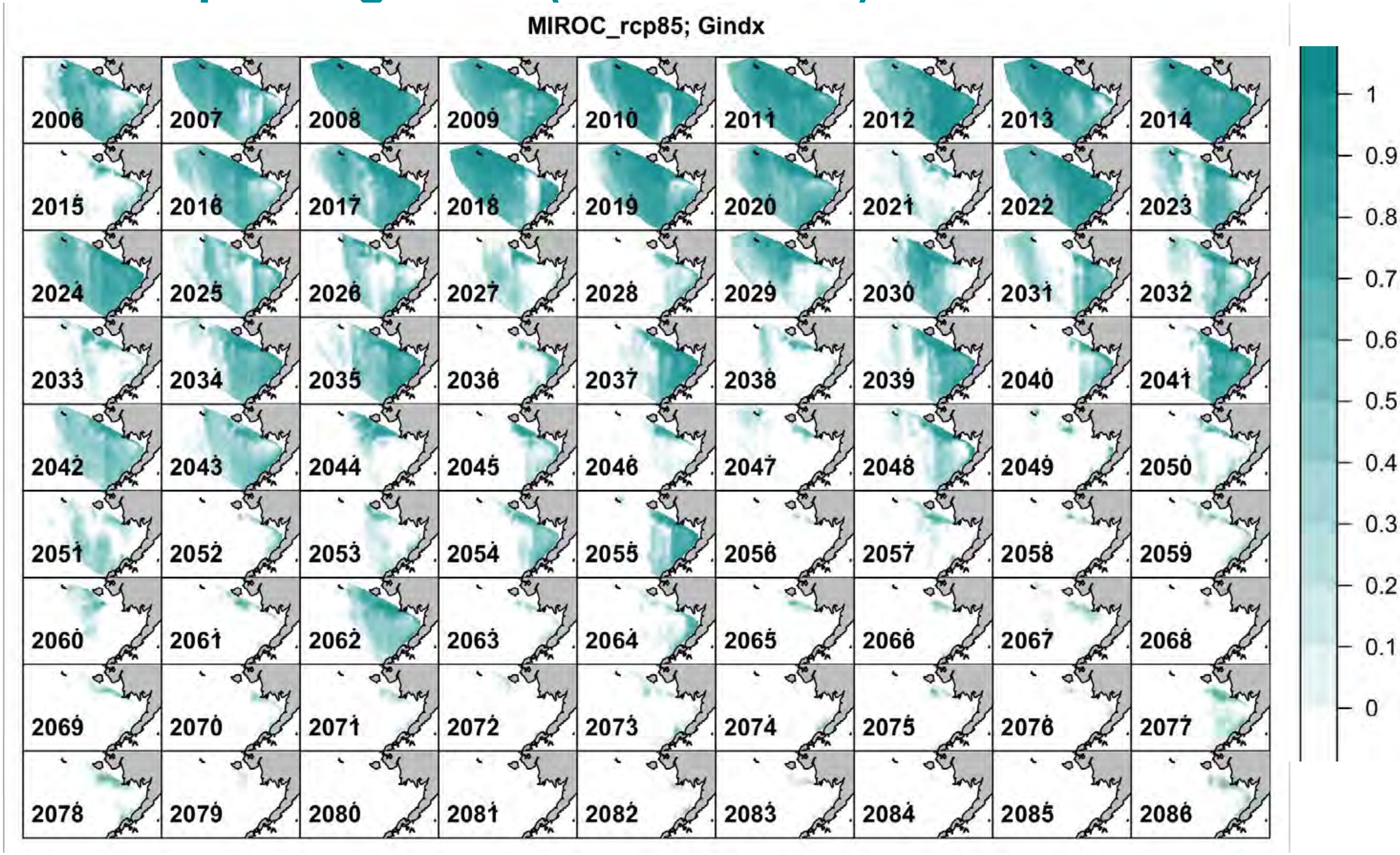
Bottom Temp Projections (2006→2086)



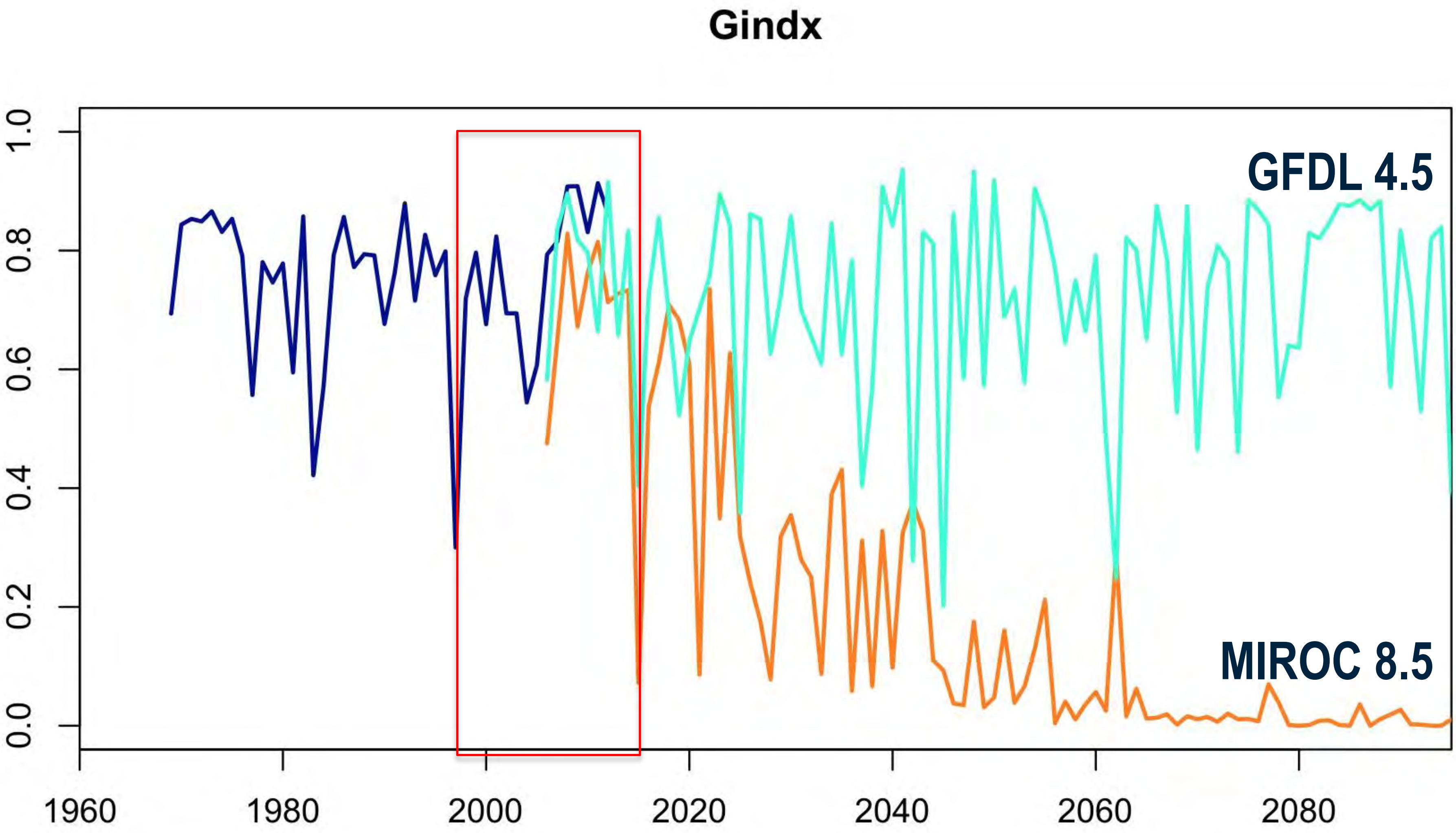
SST Projections (2006→2086)



Scope for growth (2006→2086)



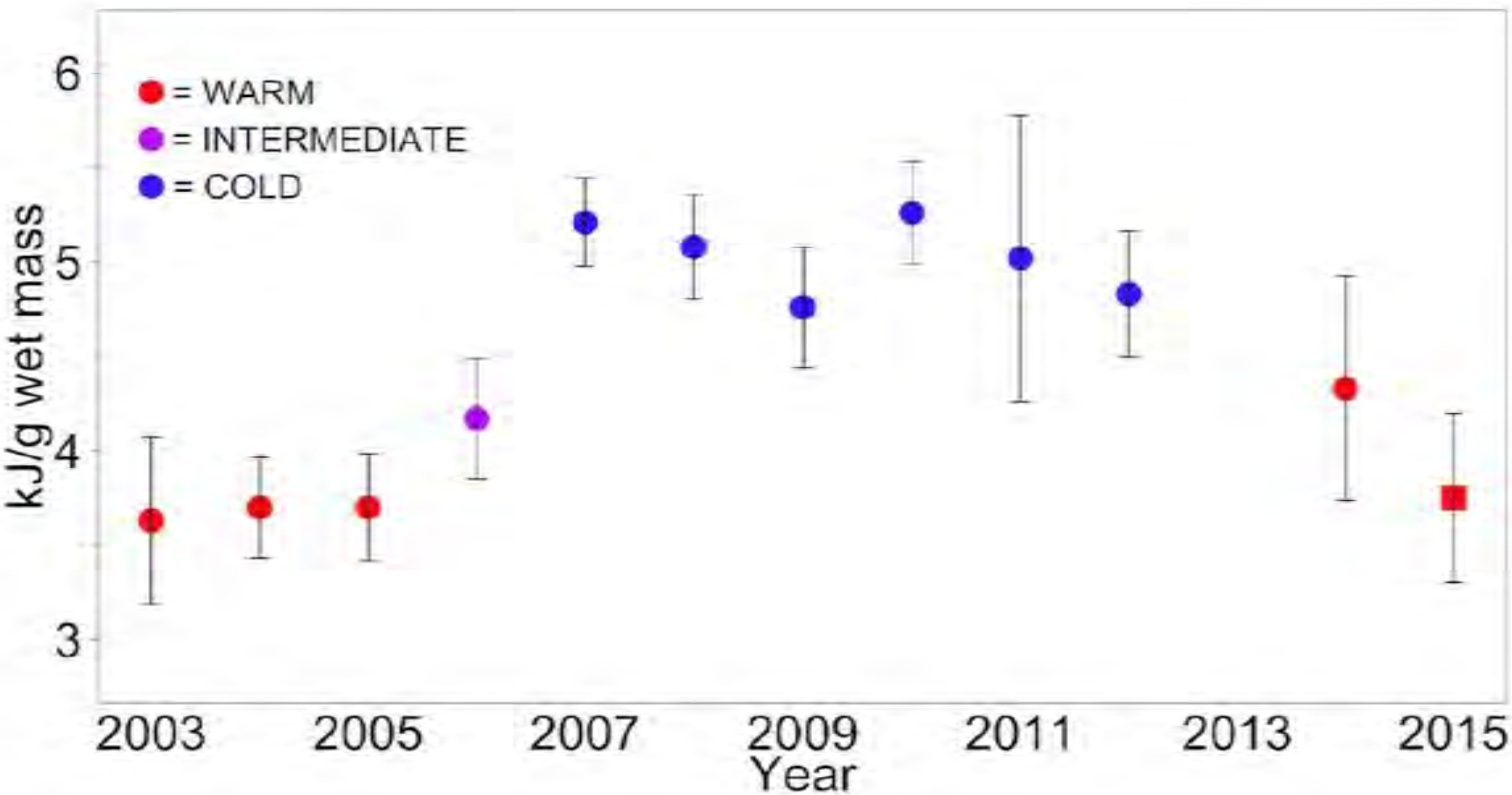
Mean annual growth index



Fall Energetic Condition of Age-0 Walleye Pollock Predicts Survival and Recruitment Success

Contributed by Ron Heintz, Elizabeth Siddon, and Ed Farley

EBS Ecosystem Considerations Report 2016



Fall Energetic Condition of Age-0 Walleye Pollock Predicts Survival and Recruitment Success
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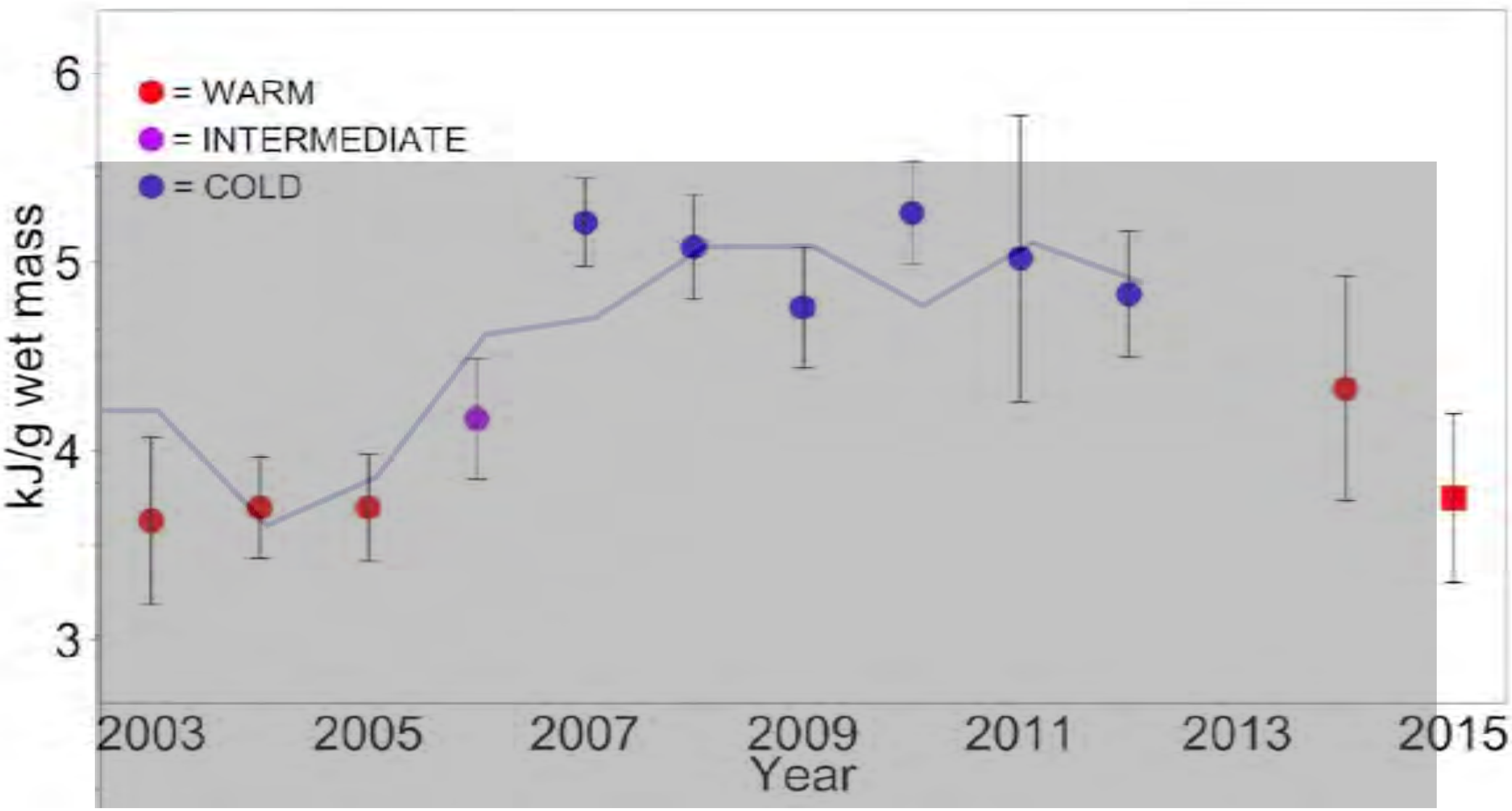
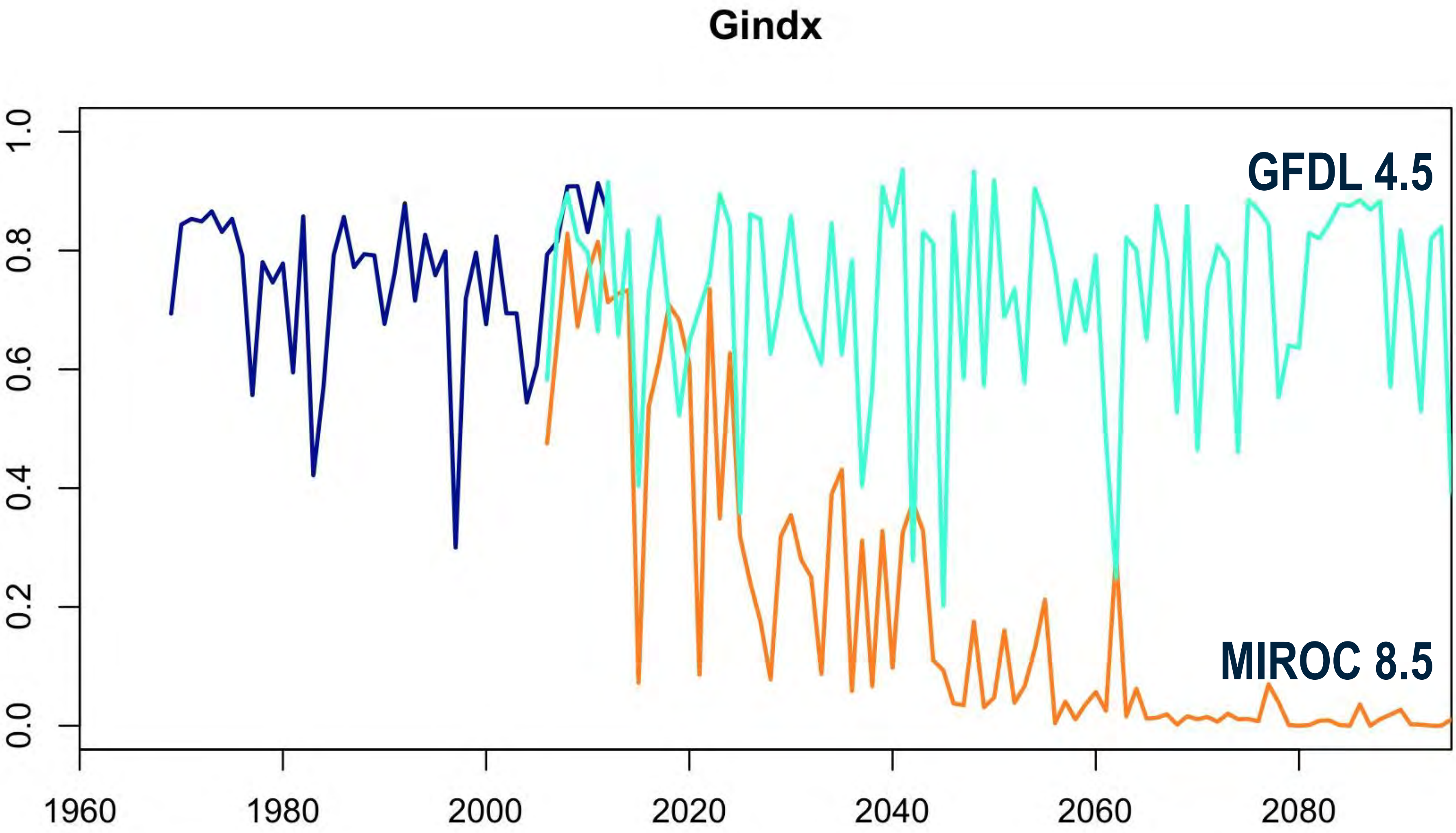
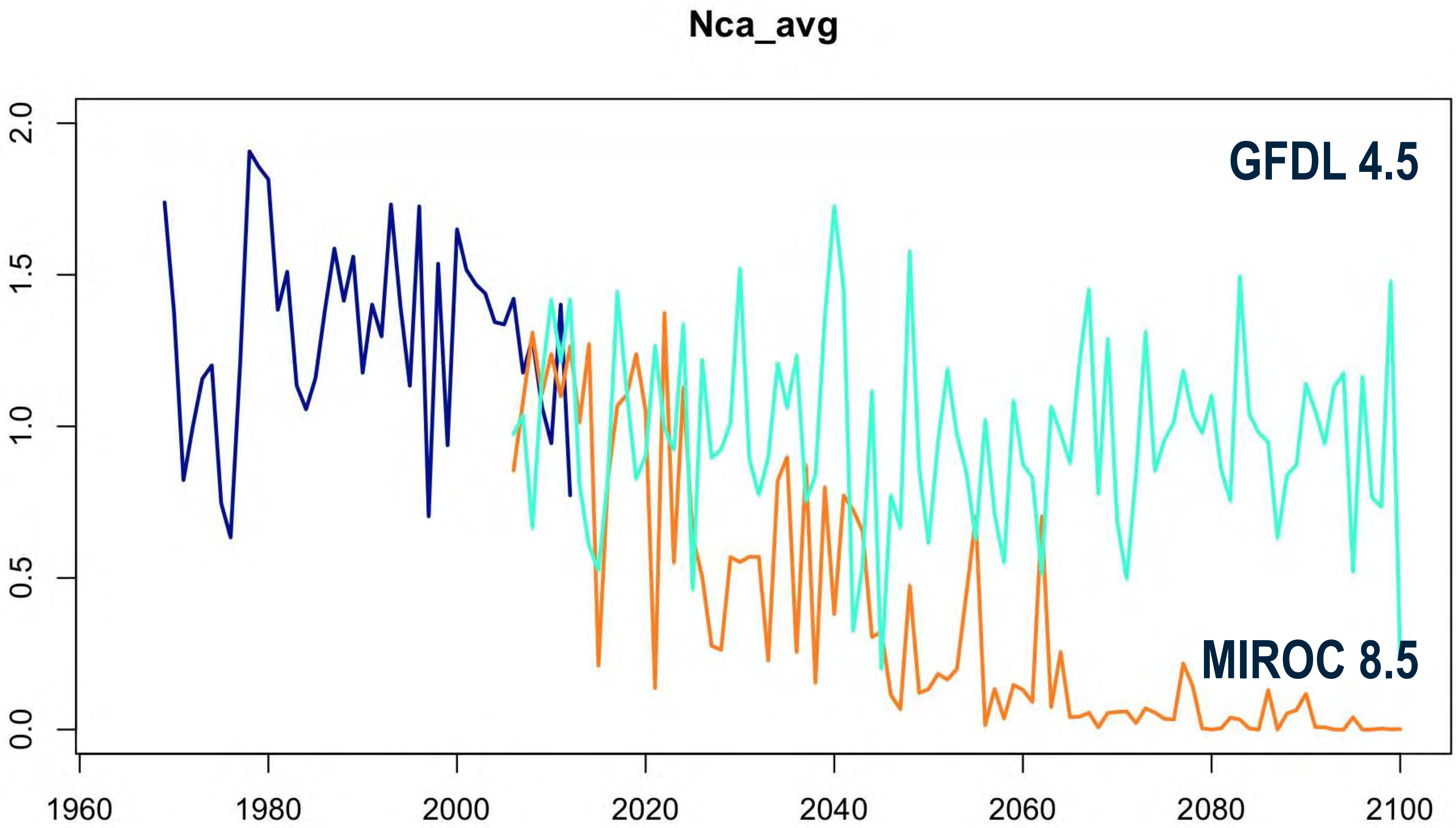


Mean annual growth index



Mean annual available food



Summary

- Projected declines in growth potential (8.5)
- Projected declines in available food (8.5)
- Spatial mismatch & thermal conditions may drive fish N and near-shore

Photo: Mark Holsman

Thanks!

Photo: Mark Holsman

NPRB & BSIERP Team
ACLIM Team
NOAA IEA Program

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

...and of people!

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