AK Climate-change Integrated Modeling project (ACLIM)

Photo: Mark Holsman

Identifying impacts and management solutions for Eastern Bering Sea fisheries.

Kirstin Holsman[1]

kirstin.holsman@noaa.gov

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2. NOAA Office of Oceanic and Atmospheric Research, Pacific Marine Environmental Laboratory
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NOAA FISHERIES

The ACLIM team


Anne Hollowed

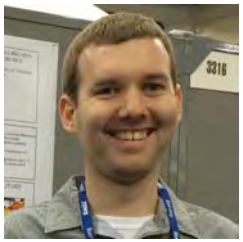

Kirstin Holsman


Alan Haynie


Albert Hermann


Wei Cheng


Andre Punt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Jonathan Reum

Michael Dalton


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Tom Wilderbuer

William Stockhausen

IPCC 5th Assessment Report

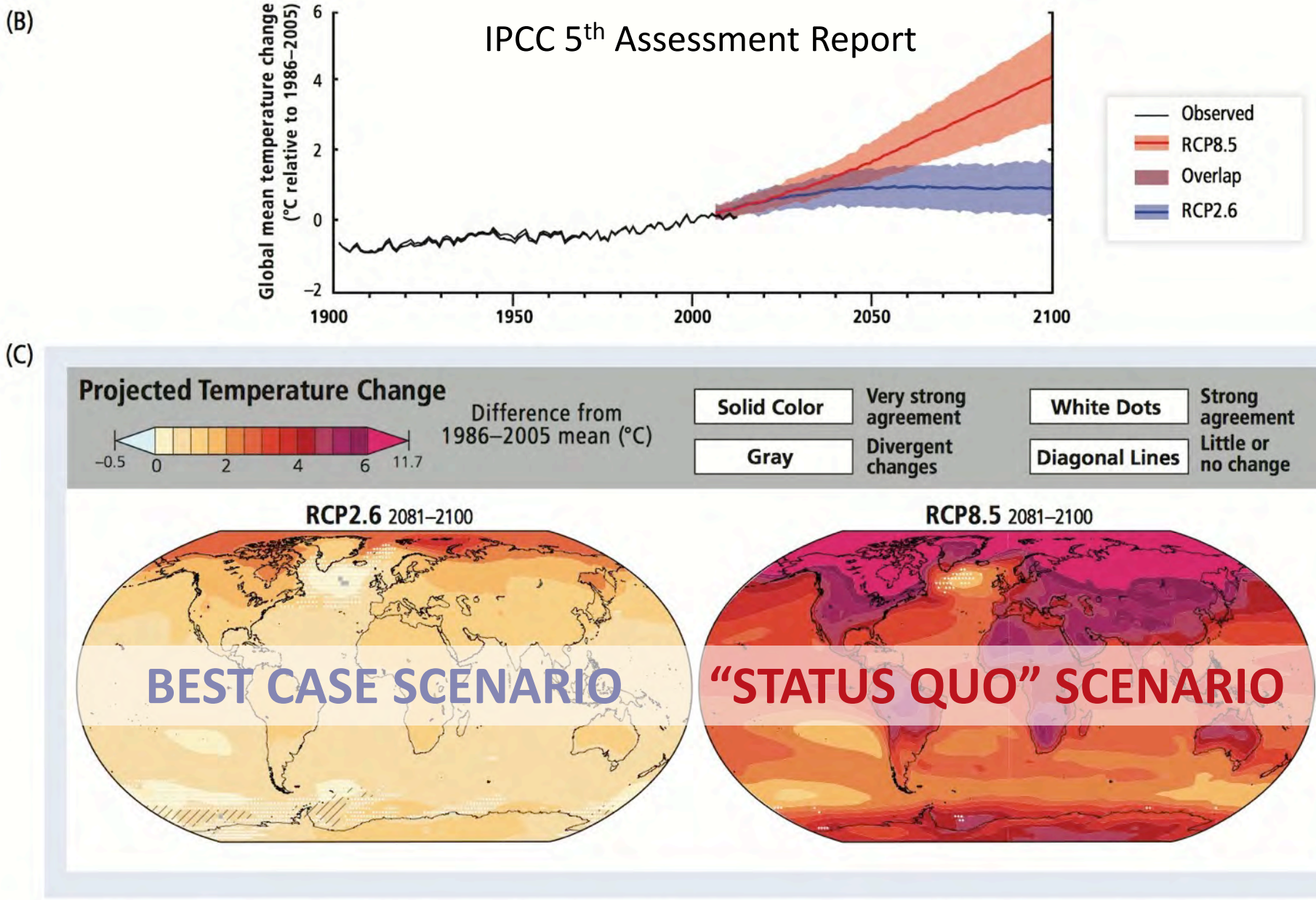
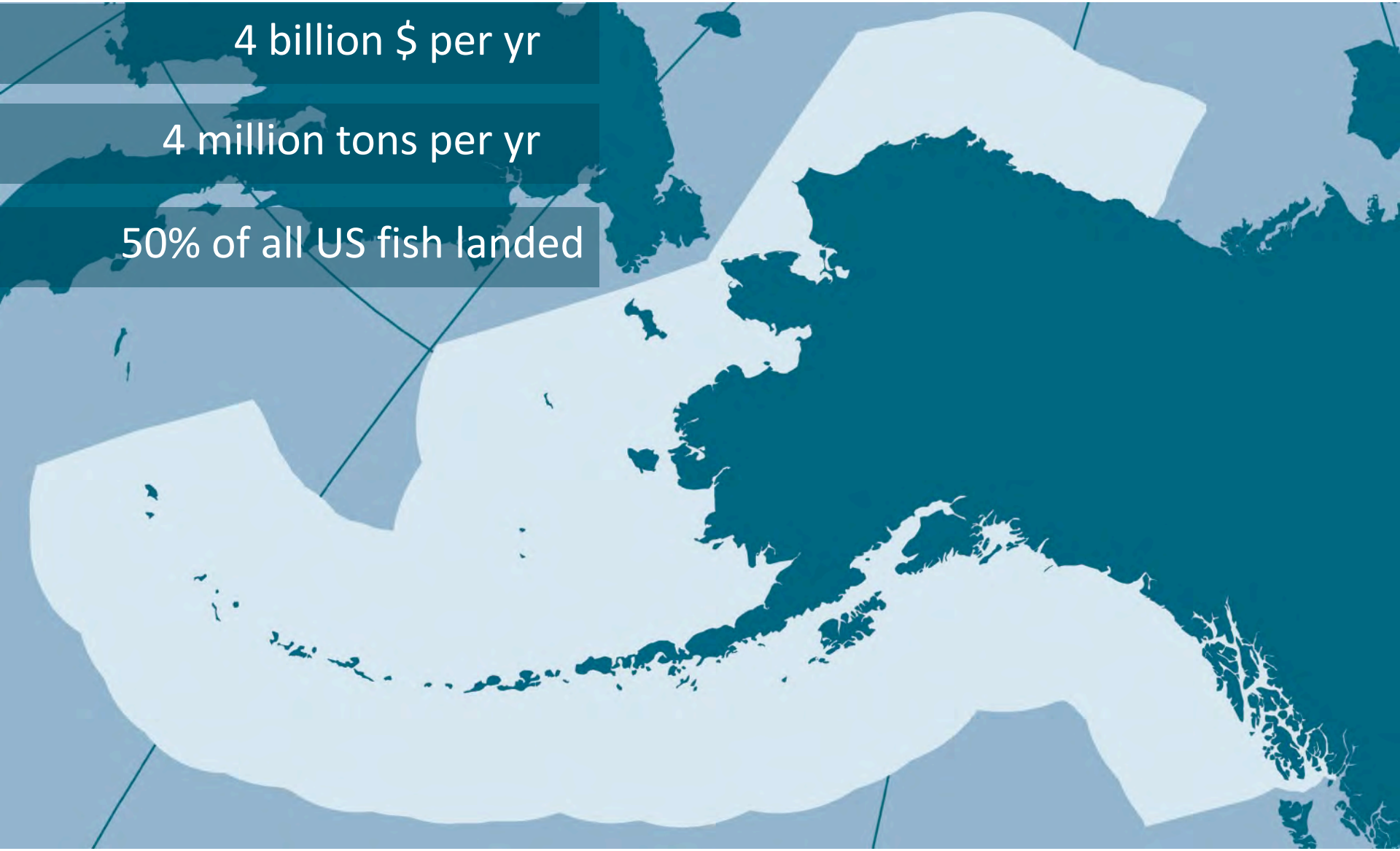


Figure SPM.4 | Observed and projected changes in annual average surface temperature. This figure informs understanding of climate-related risks in the WGII AR5. It illustrates temperature change observed to date and projected warming under continued high emissions and under ambitious mitigation.

Alaska-wide Fisheries



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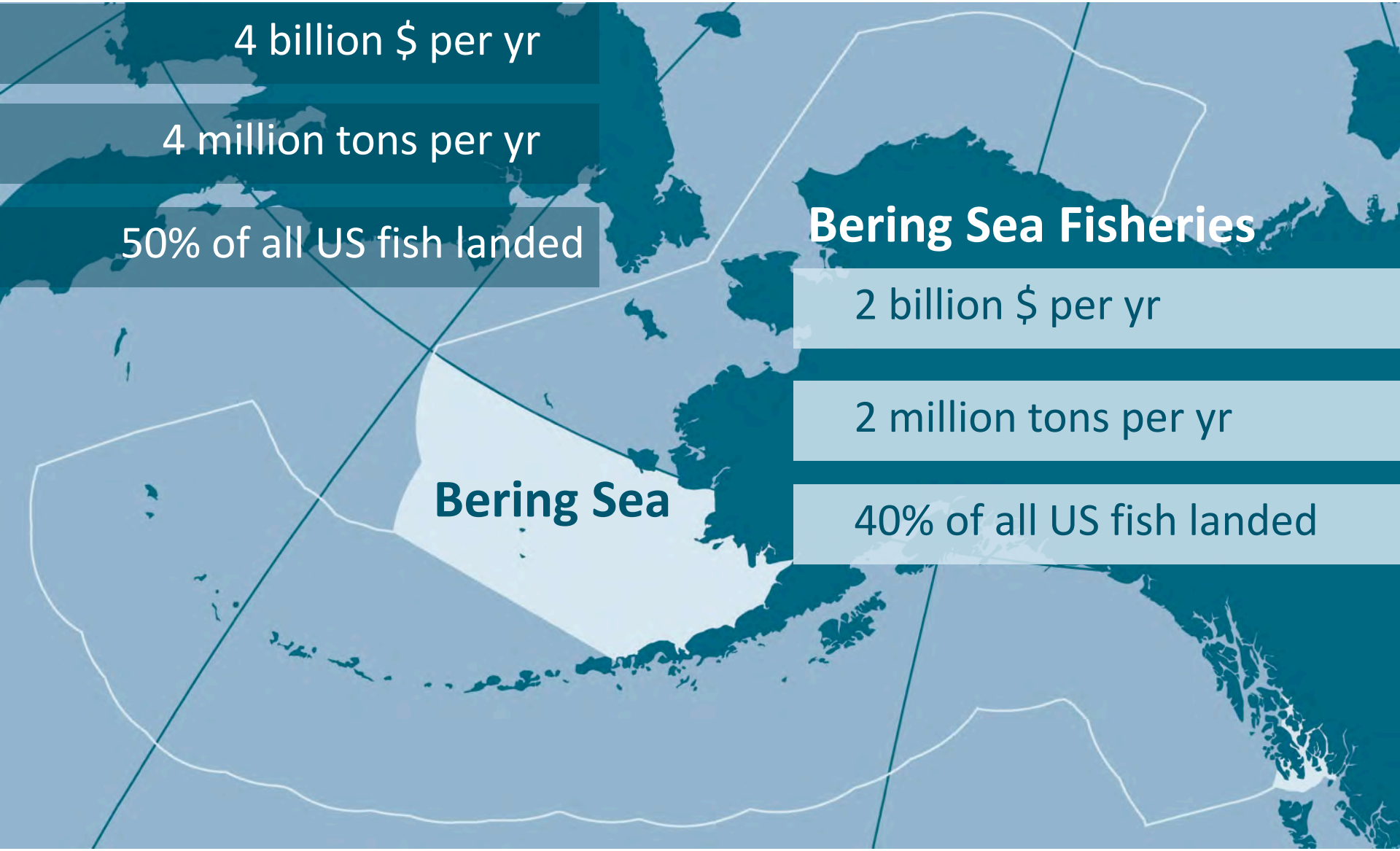

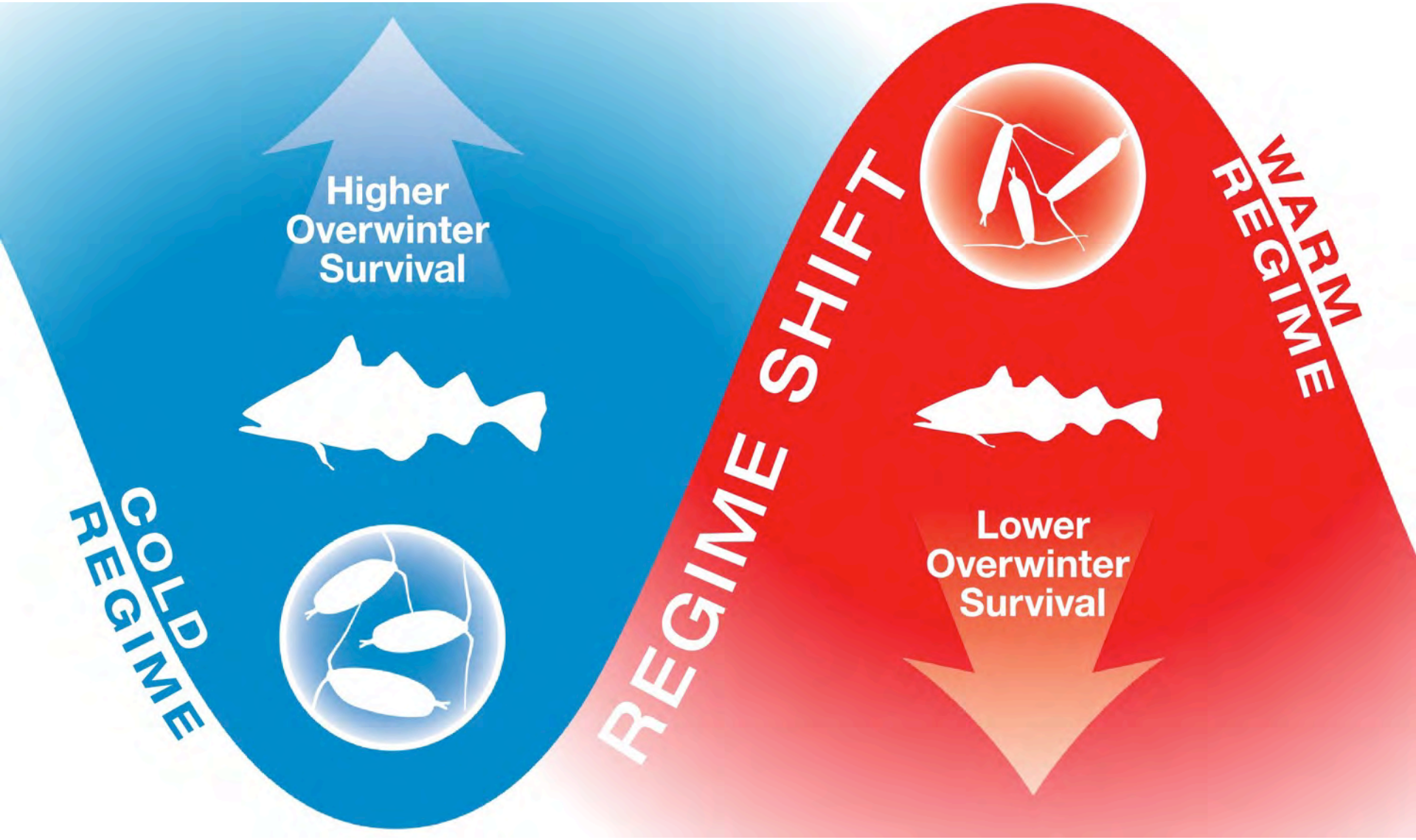

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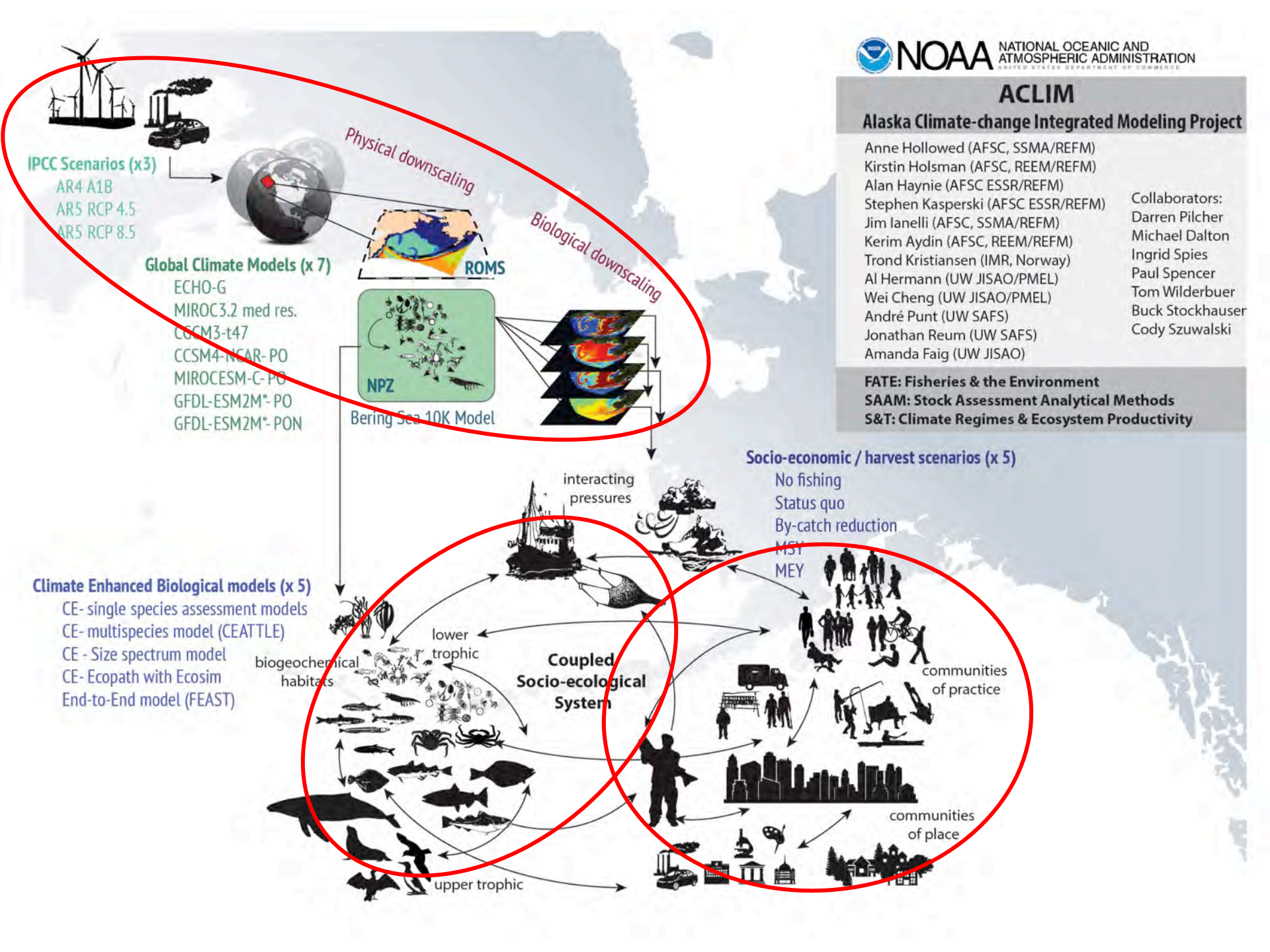
Slide courtesy of J. Duffy-Anderson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AR4 A1B
AR5 RCP 4.5
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Physical downscaling
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Global Climate Models (x 7)
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Bering Sea 10K Model
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No fishing
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CE- single species assessment models
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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

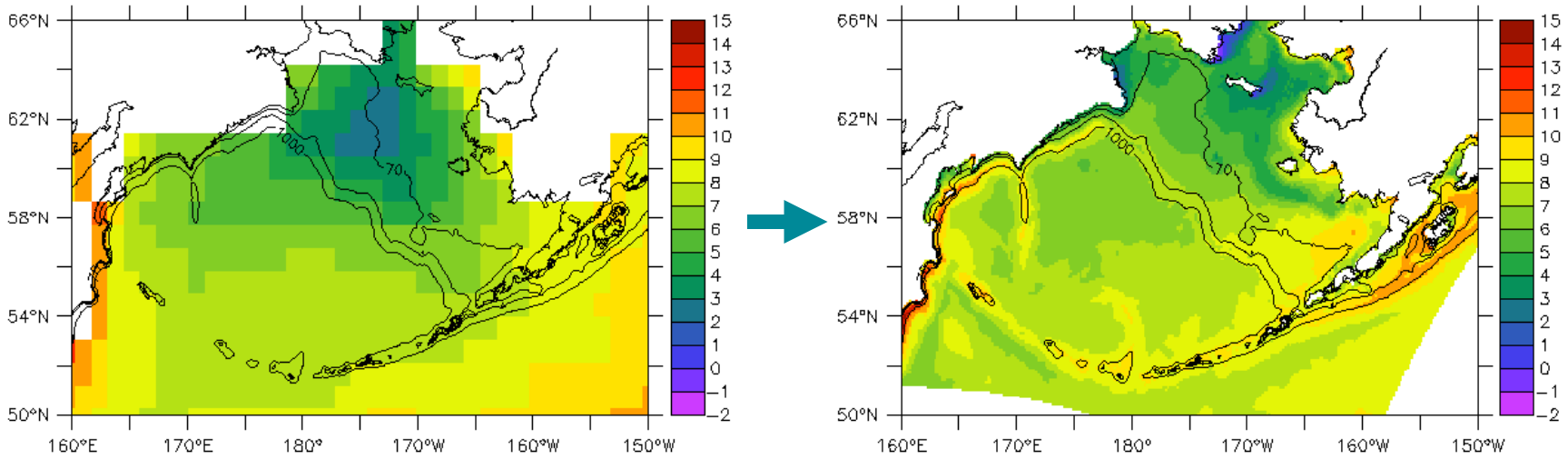
JISAO/UW and NOAA/PMEL

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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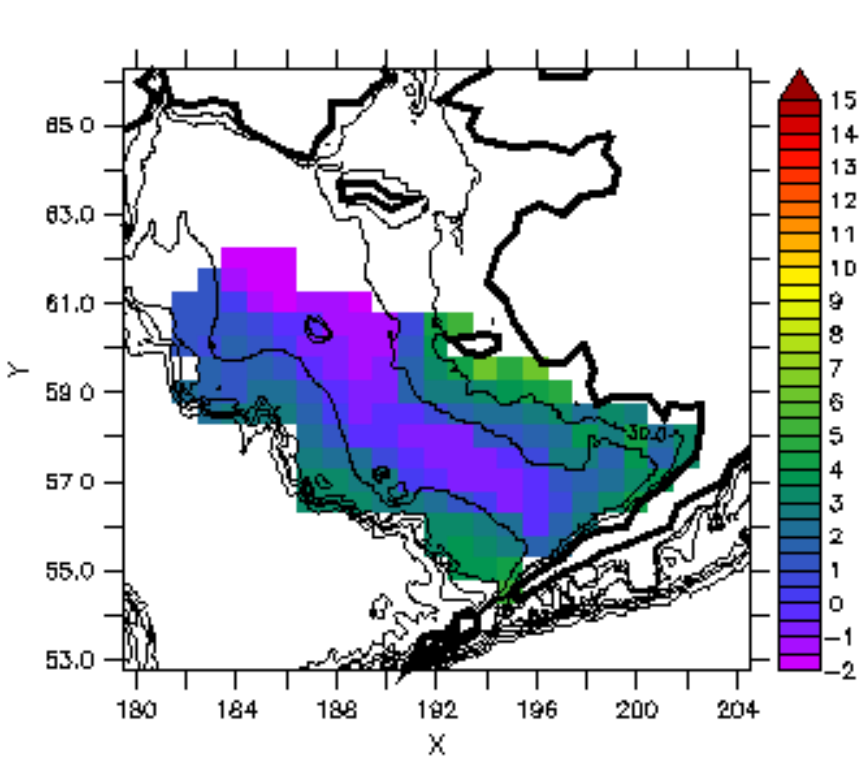
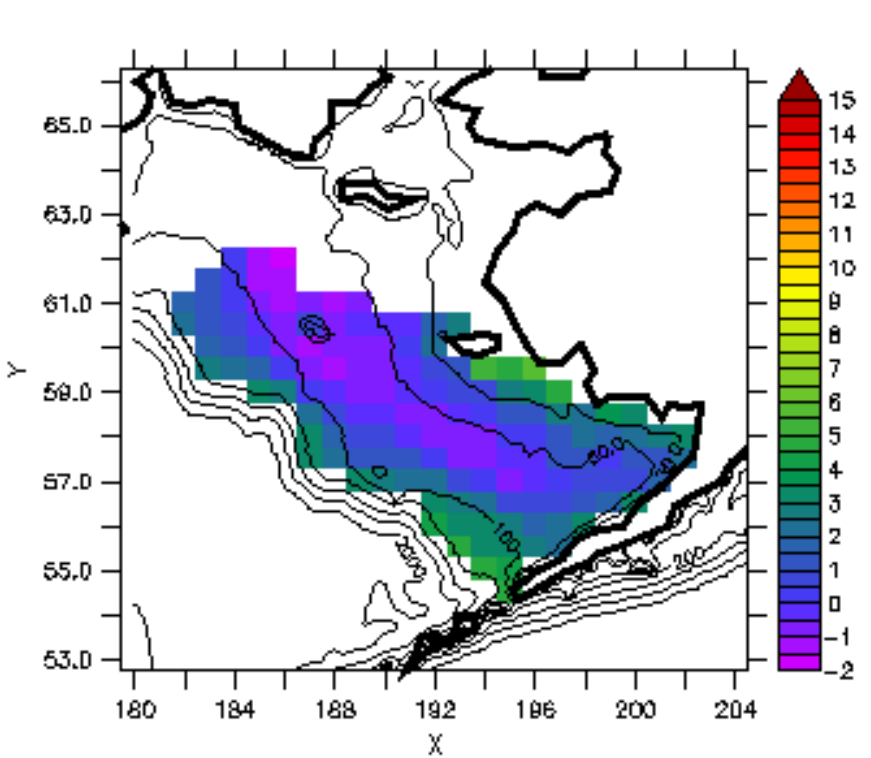
Bering10K validation:
Bottom Temp (deg C) summer 2009

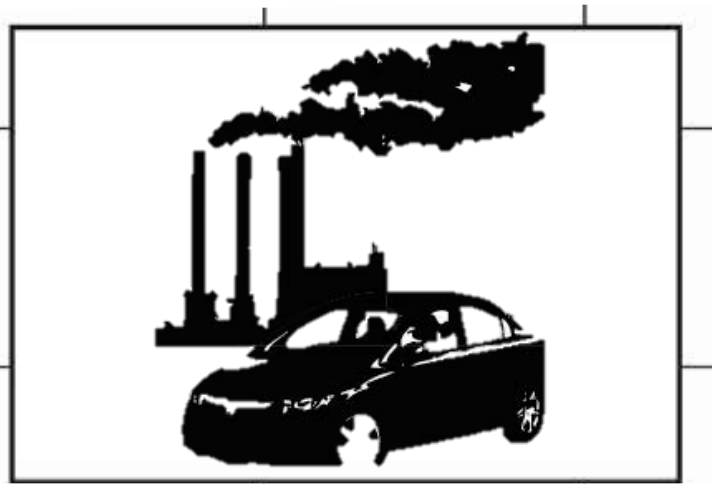
DATA



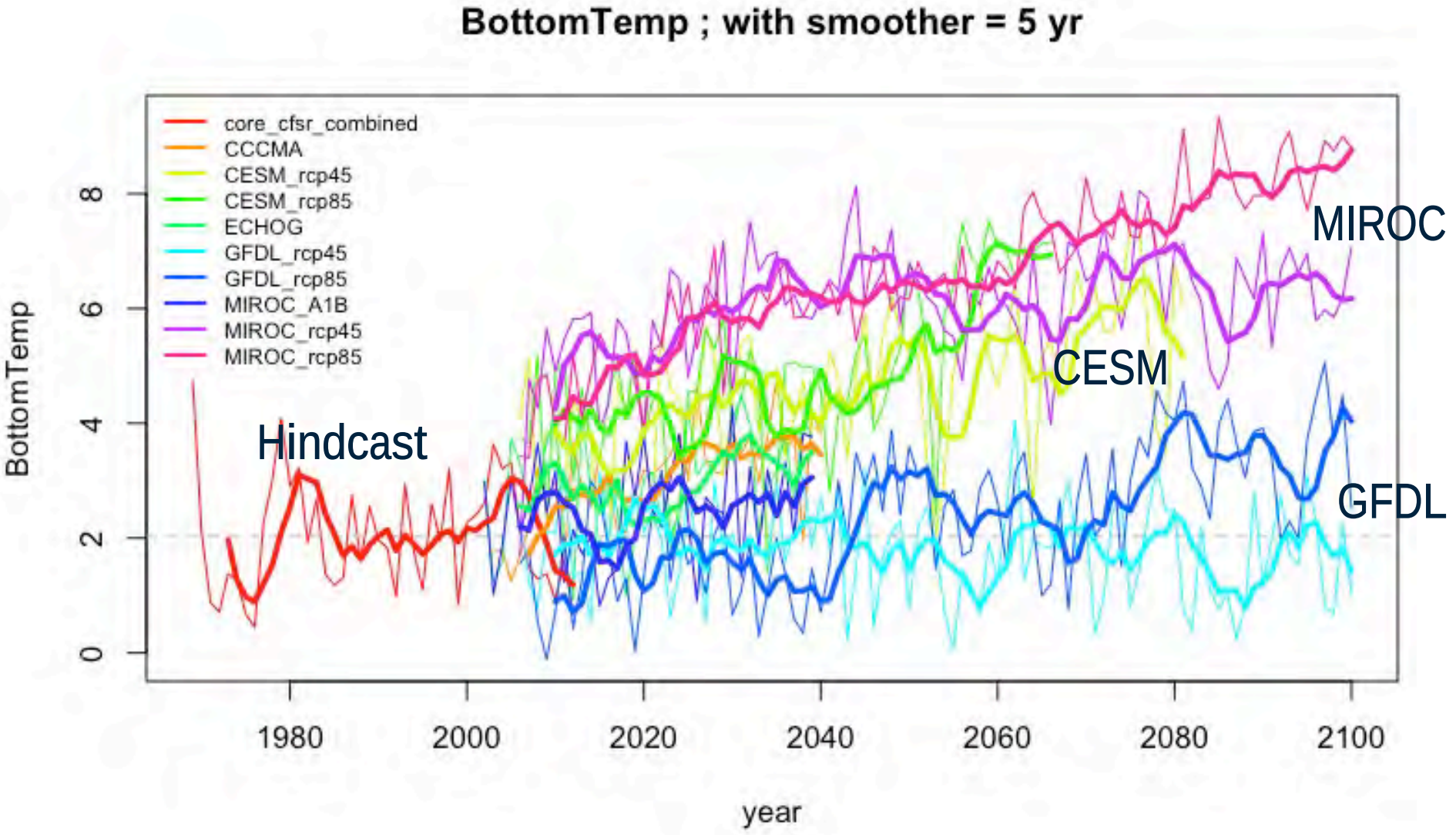
MODEL

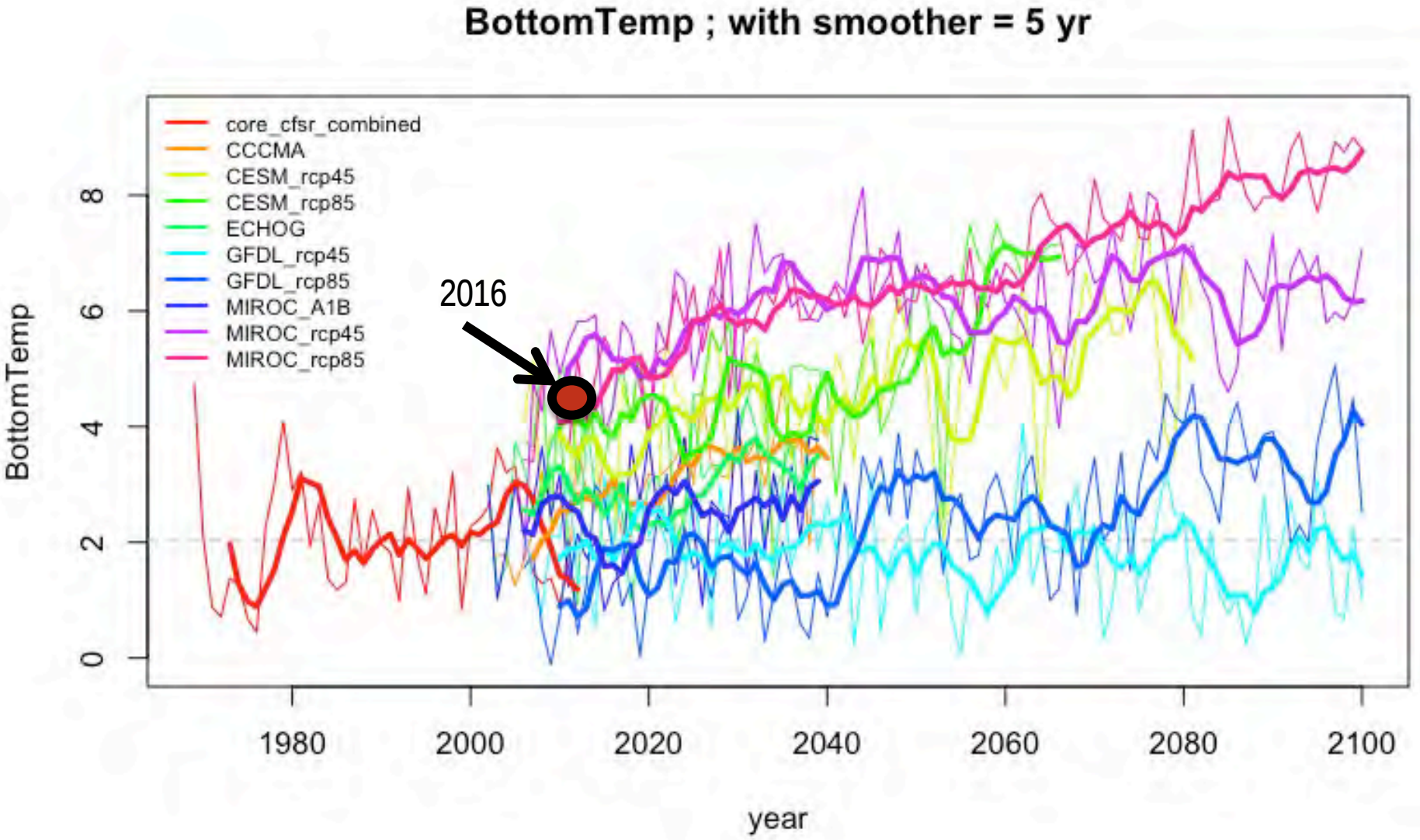


Carbon Emission Scenarios



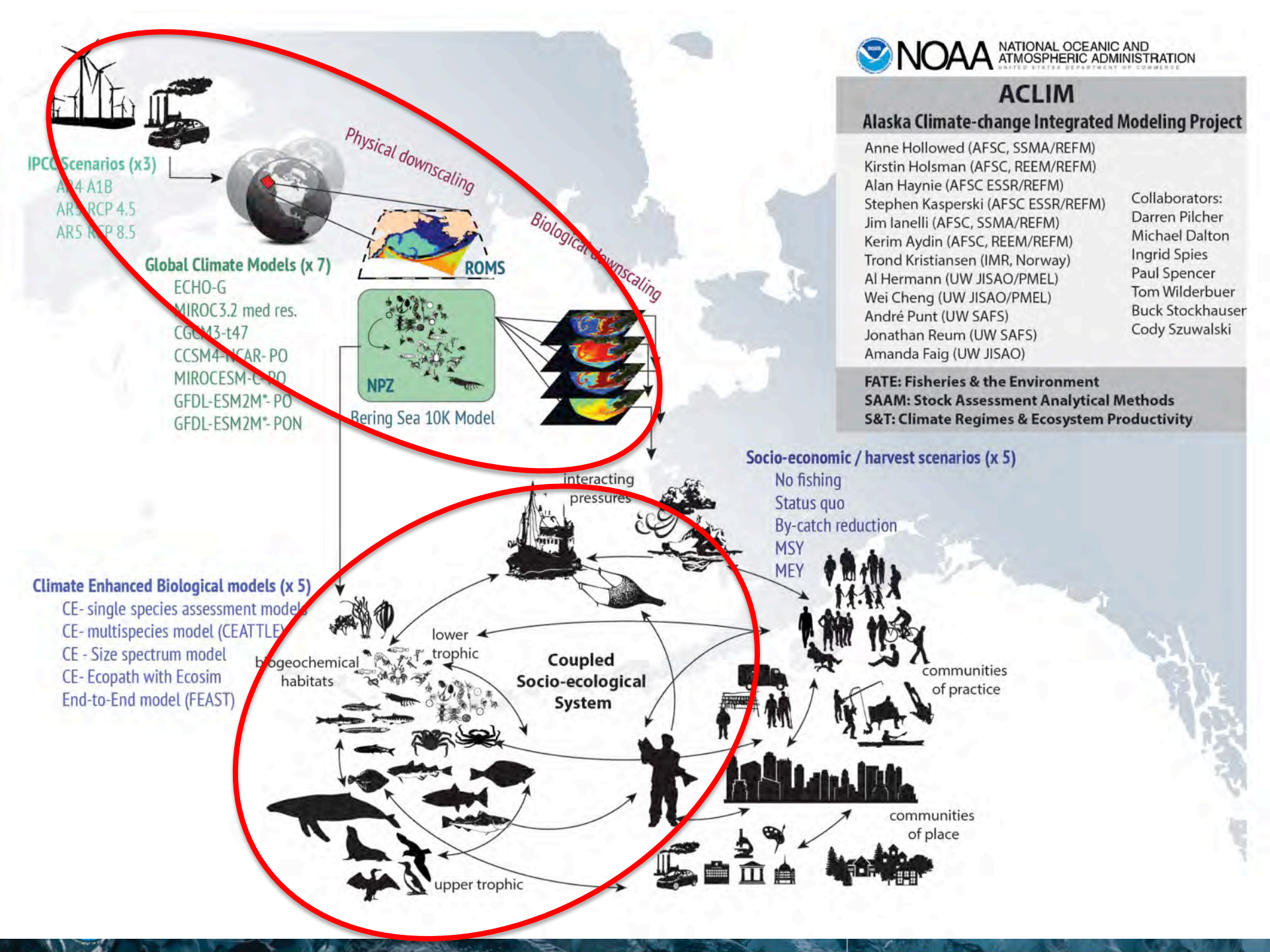
Ensemble of Bering10K output: Bottom Temperature




BottomTemp ; with smoother = 5 yr
core_cfsr_combined
CCCMA
CESM_rcp45
CESM_rcp85
ECHOG
GFDL_rcp45
GFDL_rcp85
MIROC_A1B
MIROC_rcp45
MIROC_rcp85
2016
BottomTemp
0
2
4
6
8
1980
2000
2020
2040
2060
2080
2100
year

Biological modeling

Photo: Mark Holsman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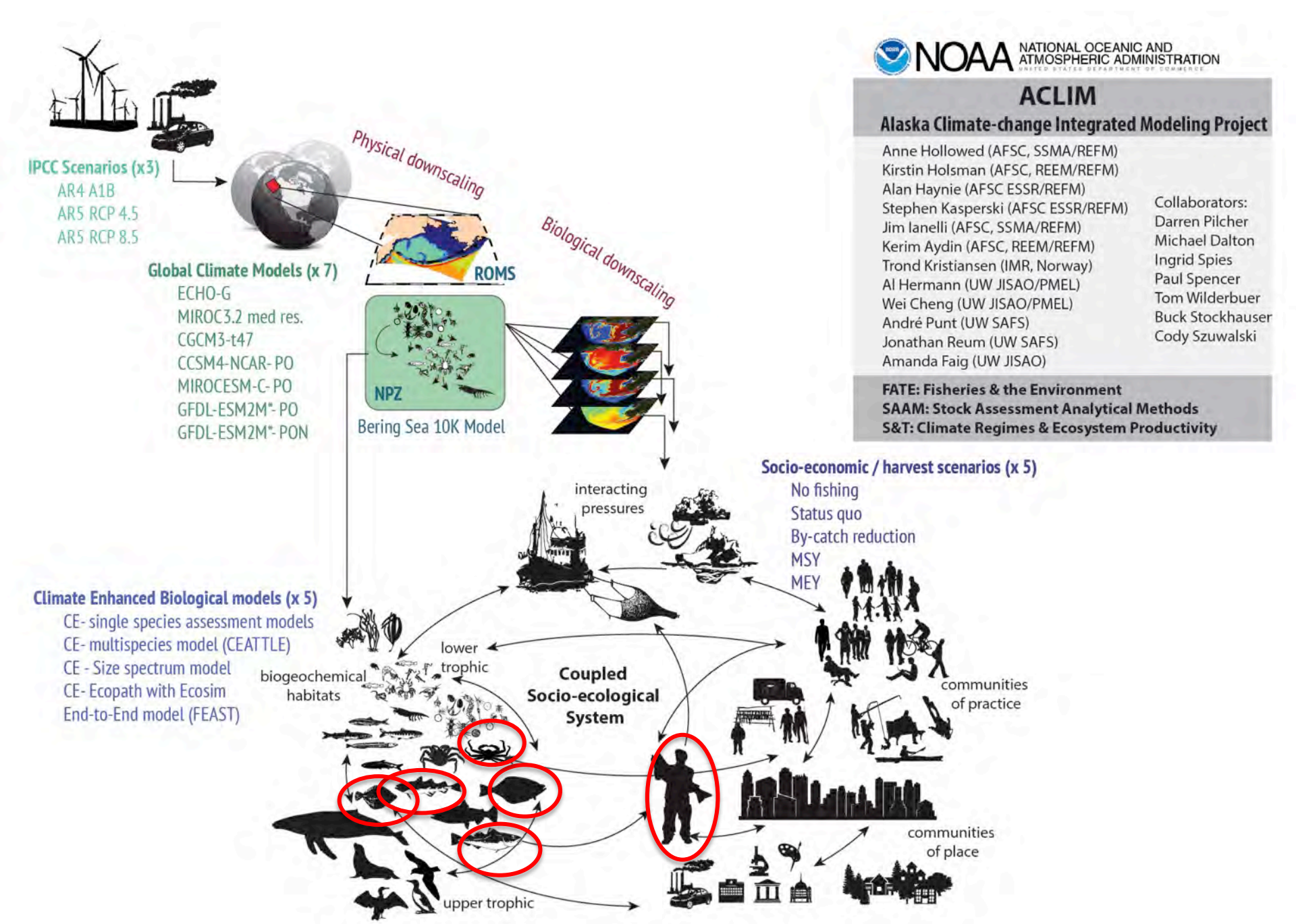
upper trophic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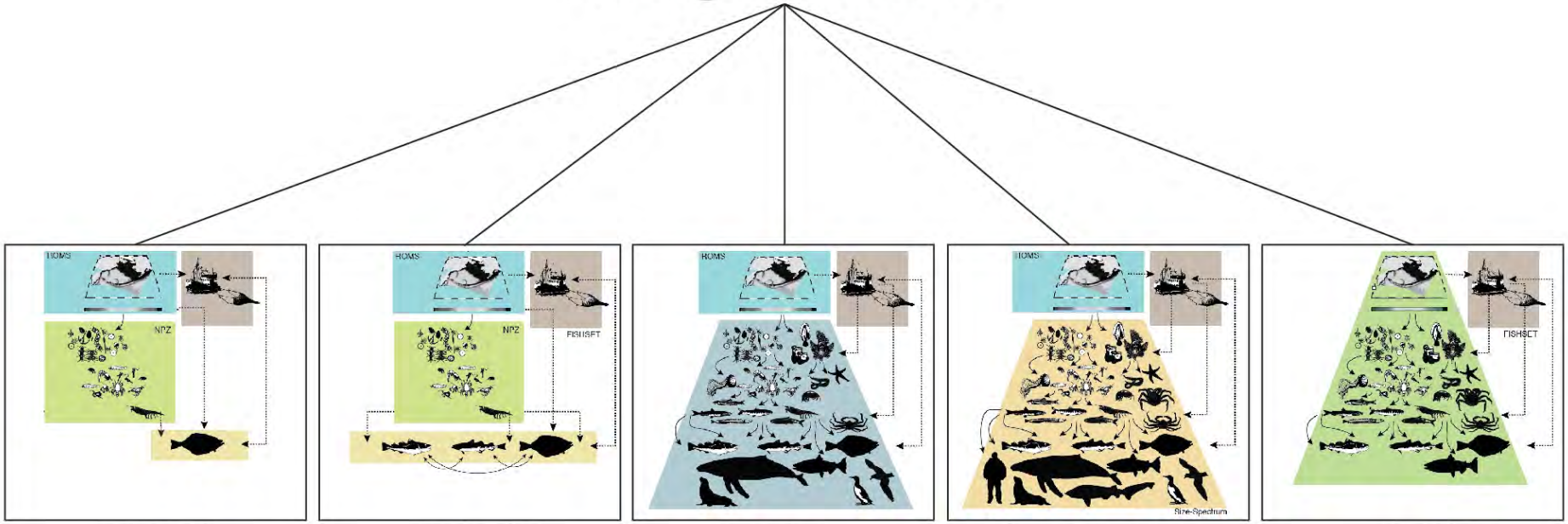
Bering Sea Models



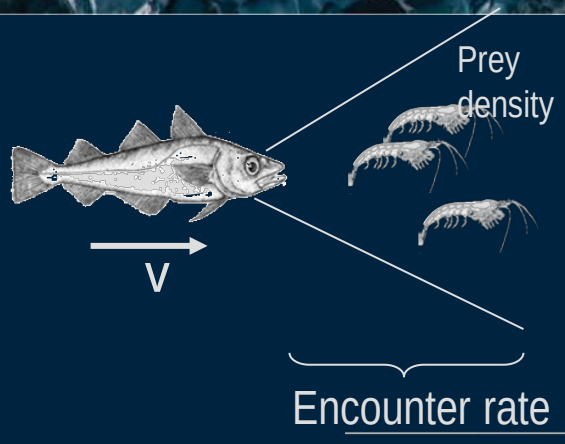
CE-SSM | CEATTLE | Ecosim | Size-Spectrum | FEAST

Additive Pressures

Multiple Interacting (non-linear) Pressures

Increasing complexity

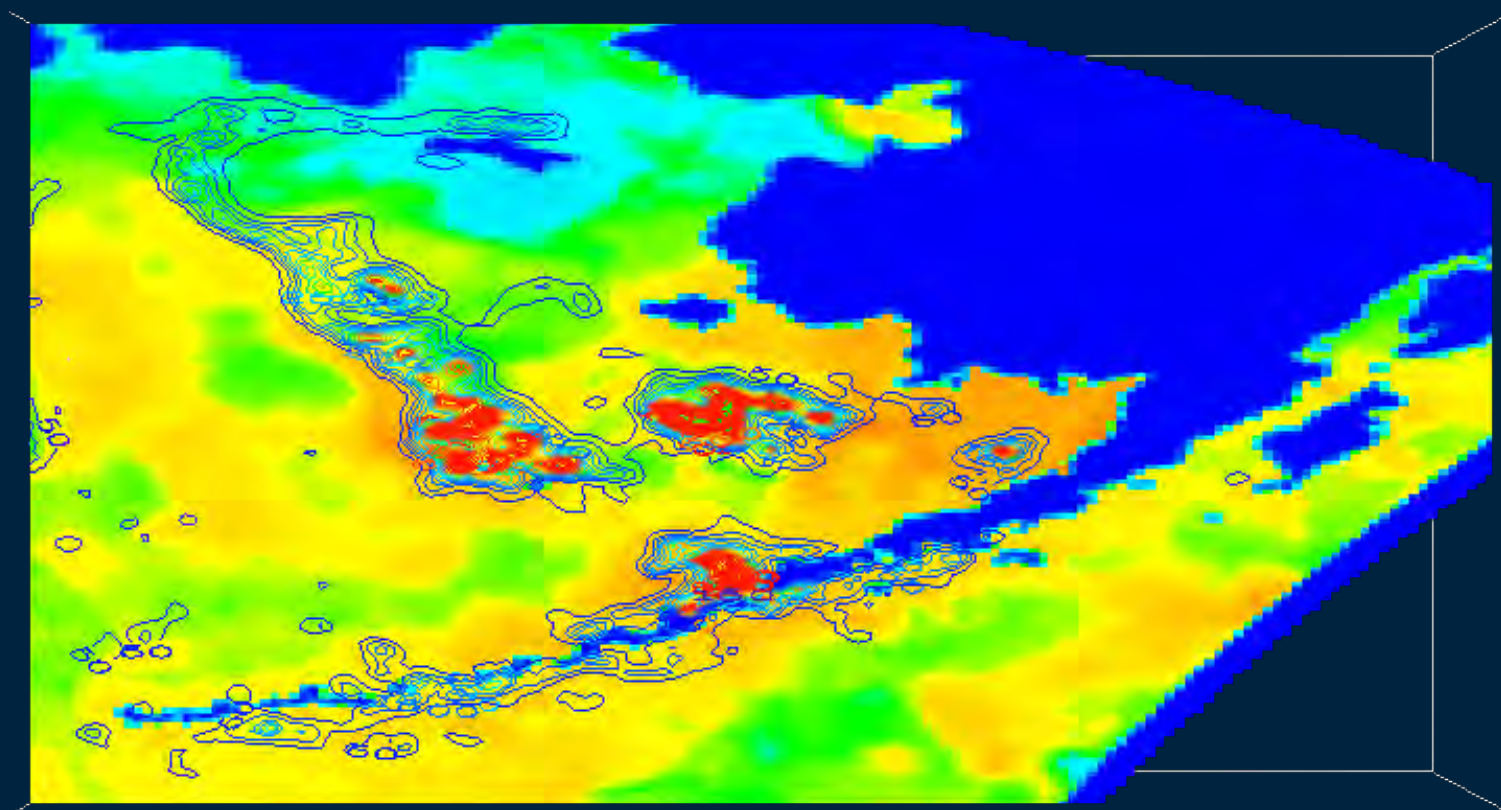
Faster



Modeled age 5 pollock biomass (colored contours) and 0-300m integrated euphausiid density (color field) for July, 2004.

FEAST

Ortiz et al. 2016



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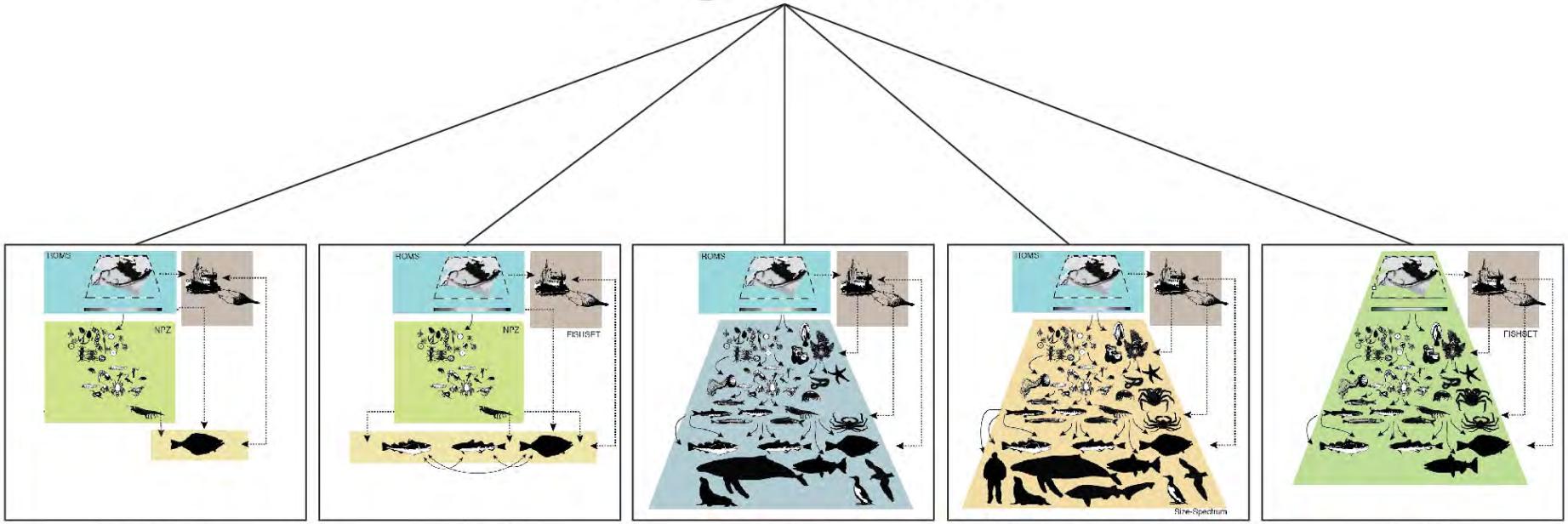
Bering Sea Models



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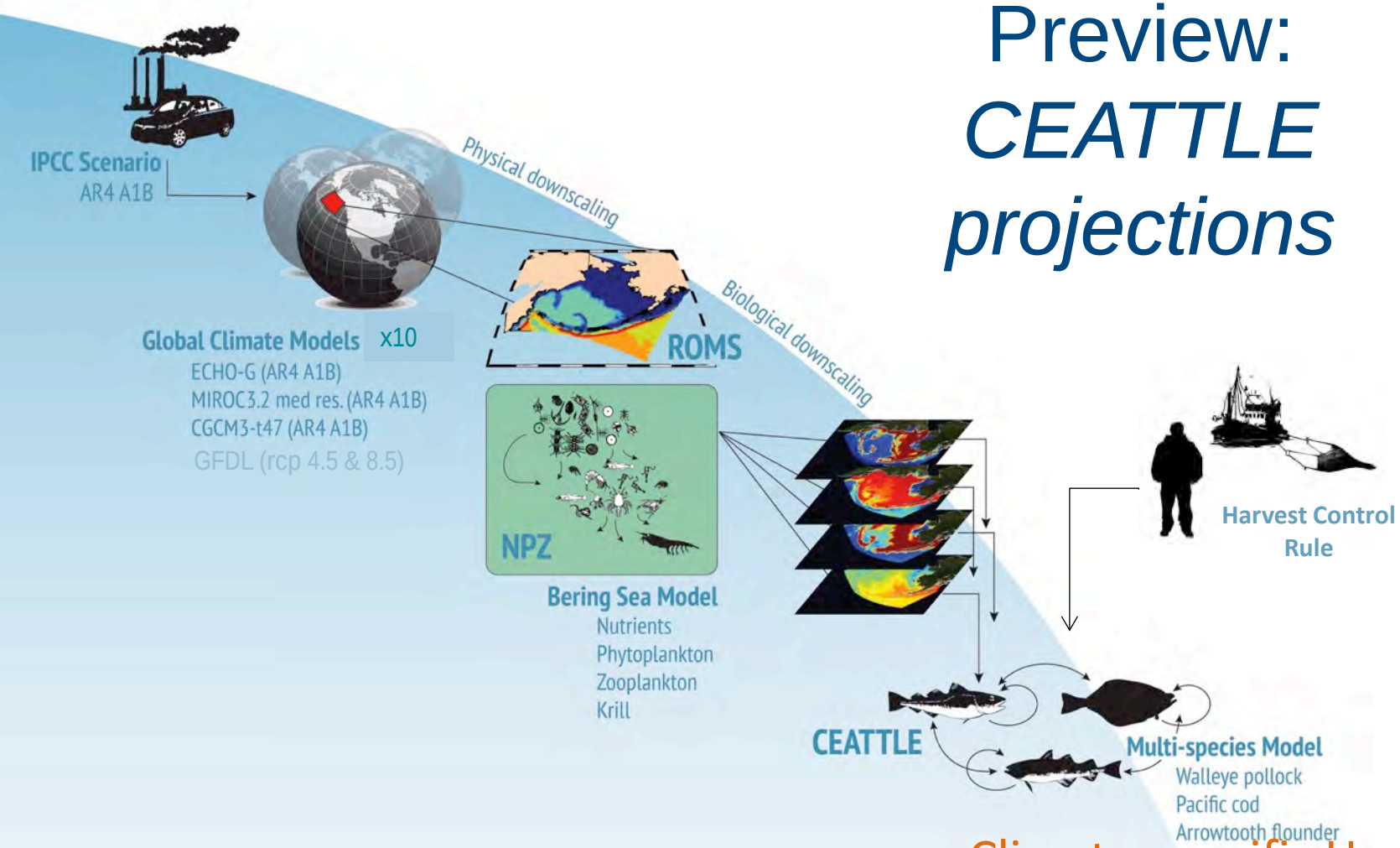
Preview: *CEATTLE projections*



Holsman et al. in prep

Climate-specific Harvest & Population Projections

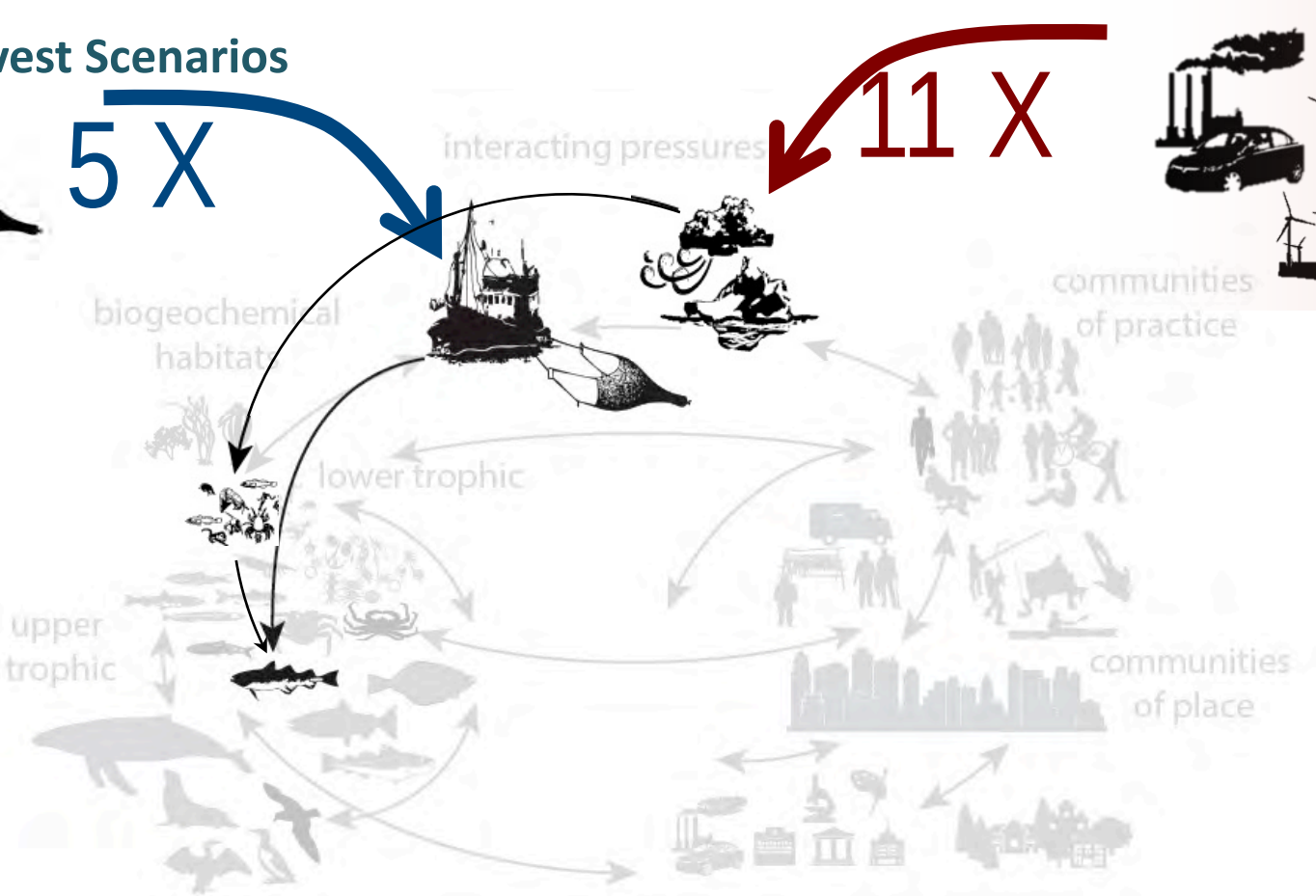
Coupled Socio-Ecological System

Future Climate Scenarios

Harvest Scenarios

5 X

11 X



Climate-enhanced Single-species Assessment Model

ACLIM: *Alaska Climate-change Integrated Modeling project*

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Future Climate Scenarios

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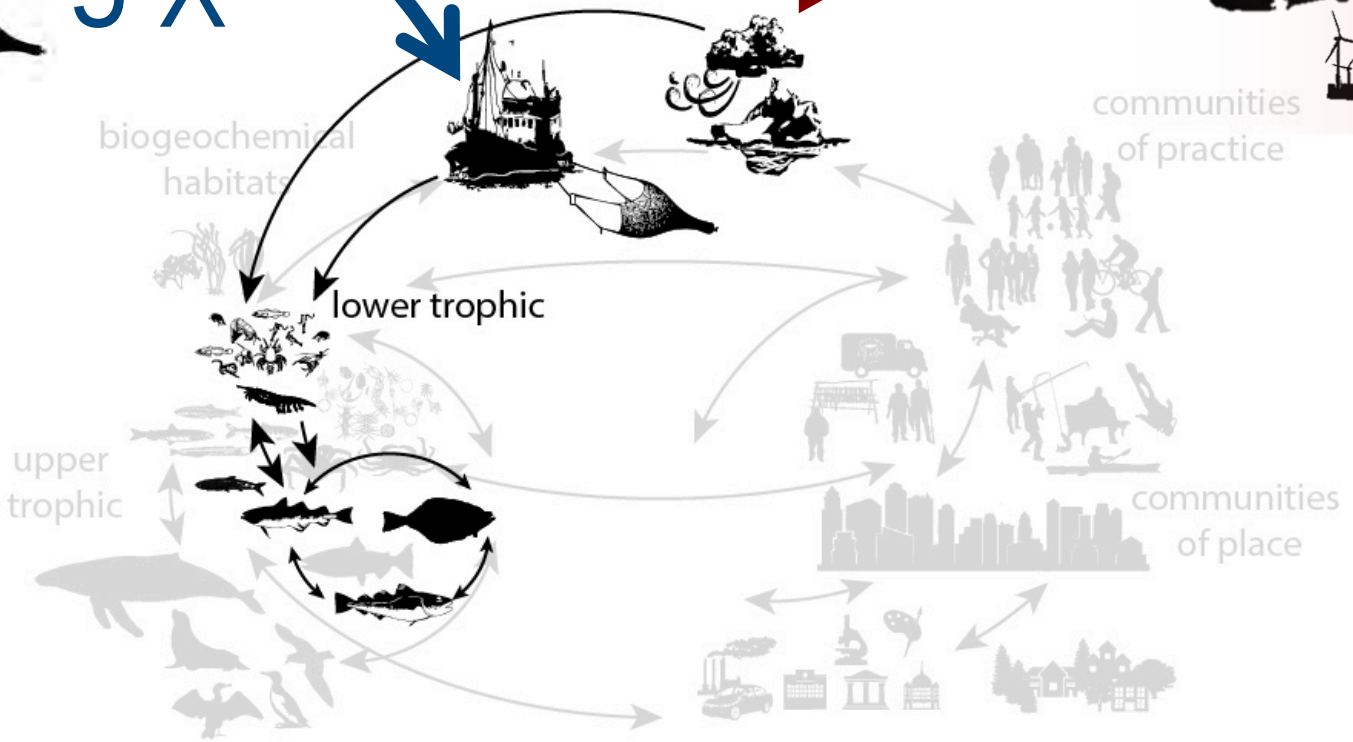
11 X



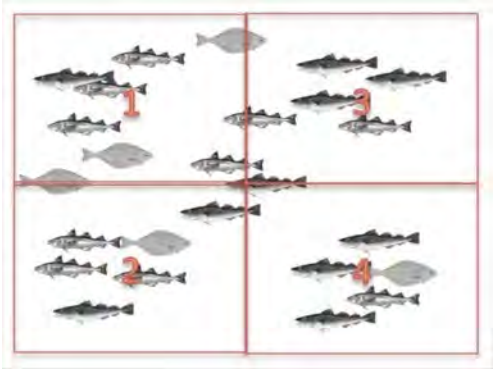
Climate-enhanced Multi-species Assessment Model

ACLIM: *Alaska Climate-change Integrated Modeling project*

Sources of Error

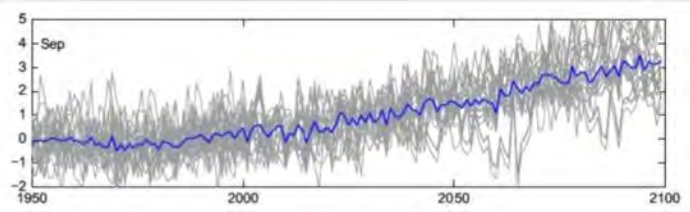
1. Observation error

- Measurement error
- Spatial heterogeneity
- Temporal variability
- Reduce through replication



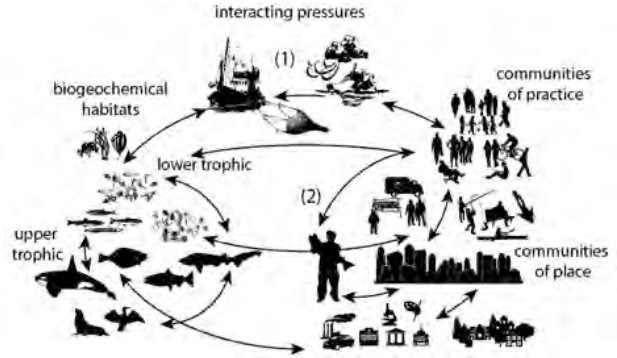
2. Process error

- “Noise” due to environmental variability
- Can be recreated using climate models
- MCMC to get “avg” trend right

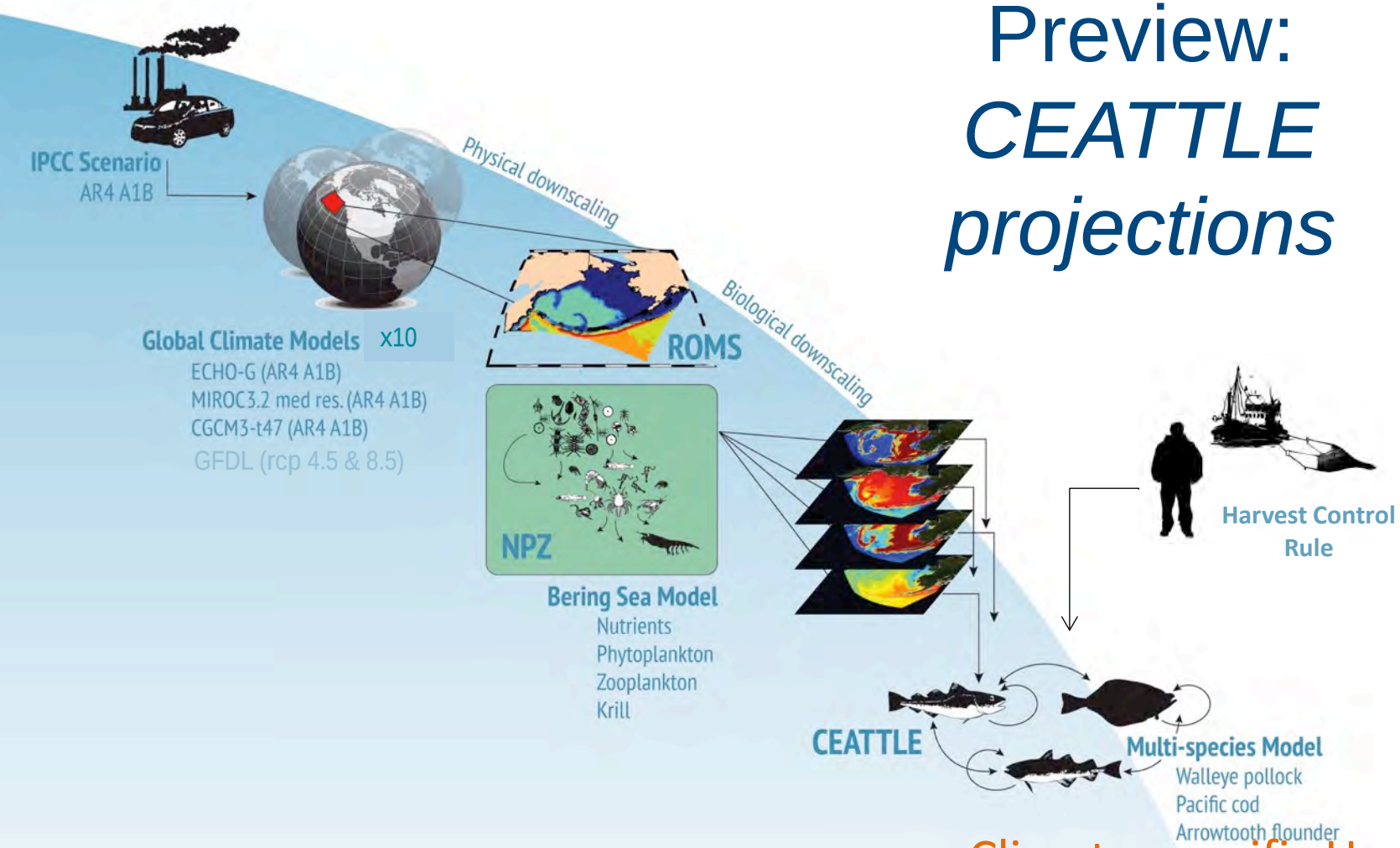


3. Model misspecification error

- Can result from spurious correlations
- Under or over estimate interactions
- More likely with indirect effects ?
- Experimental manipulation to reduce error
- Avg. from multiple models can help reduce error (“multi-model inference”)?



Preview: *CEATTLE projections*



Holsman et al. in prep

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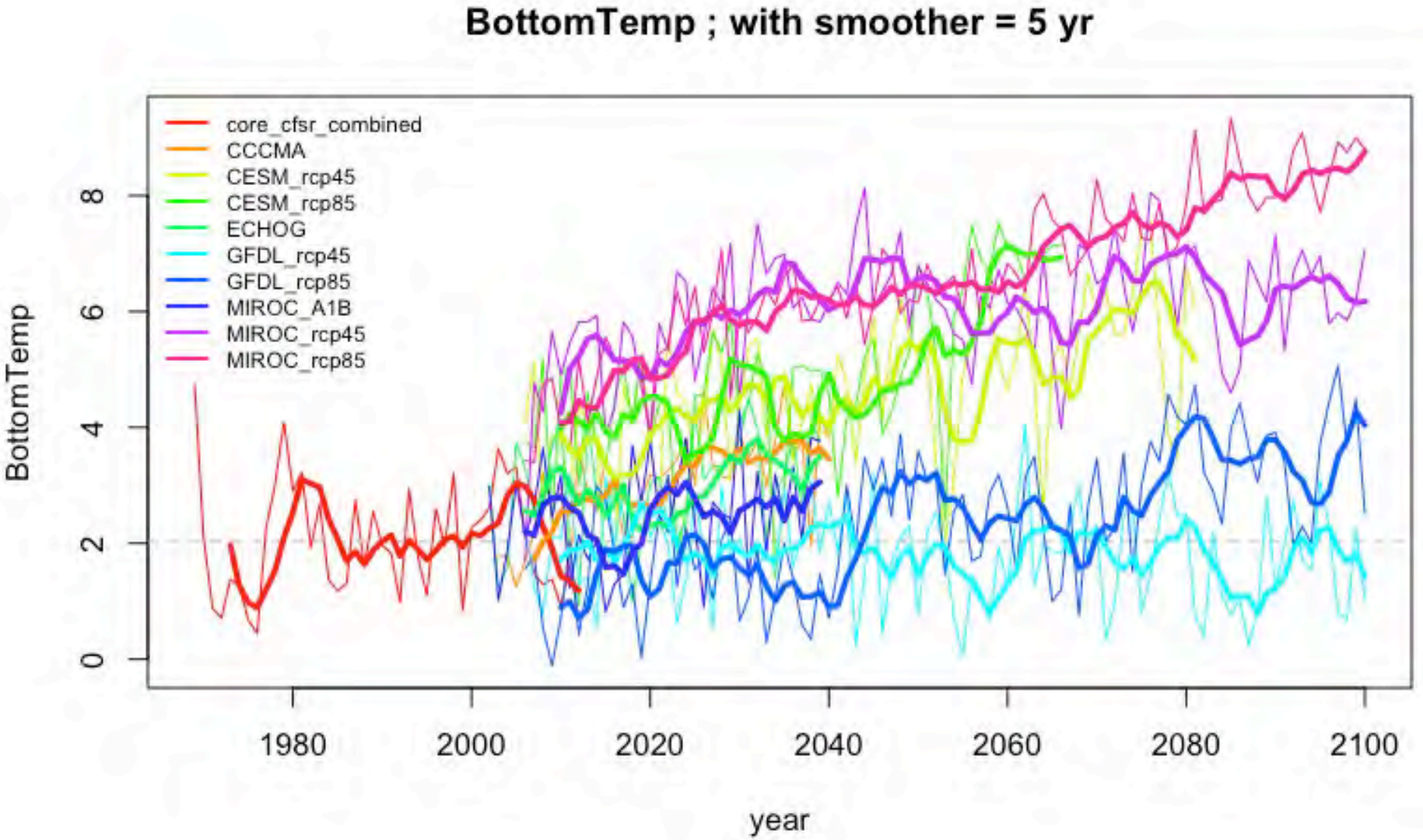
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BottomTemp
0
2
4
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8
1980
2000
2020
2040
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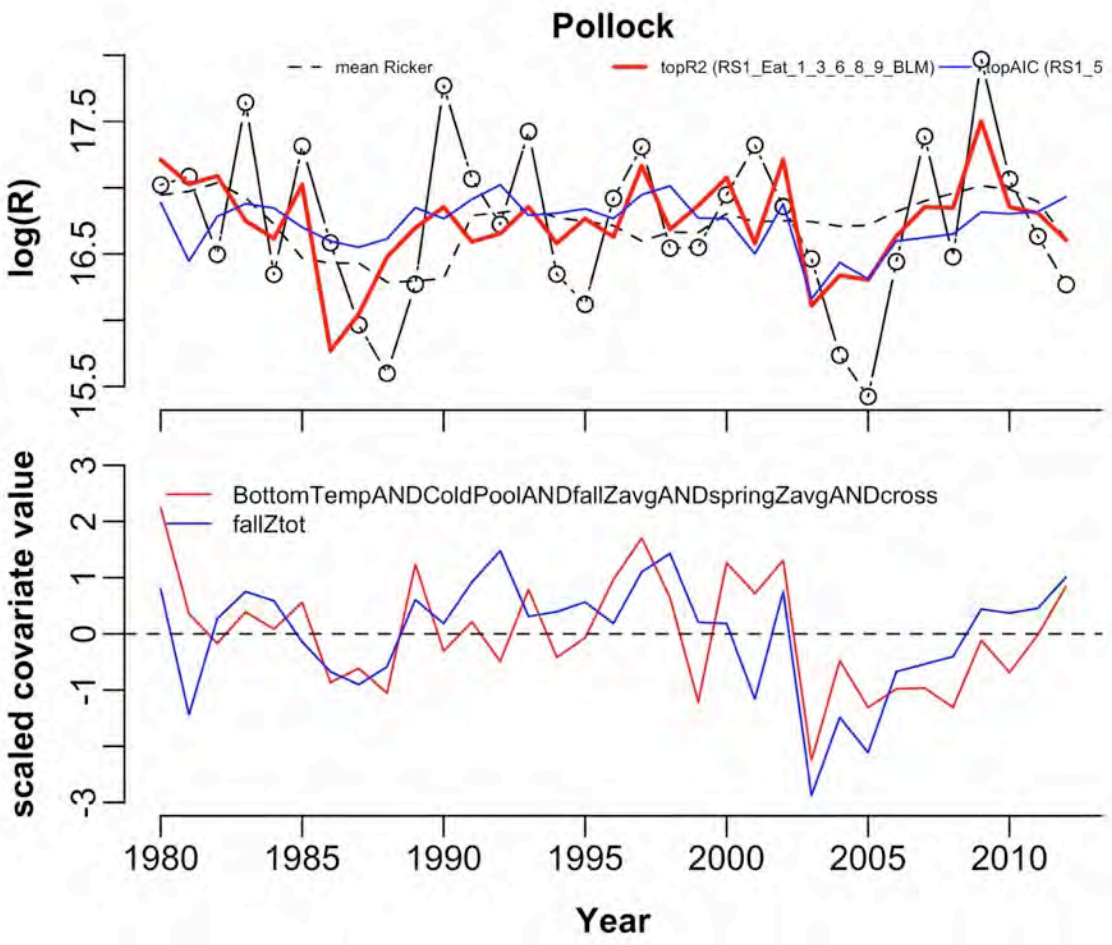
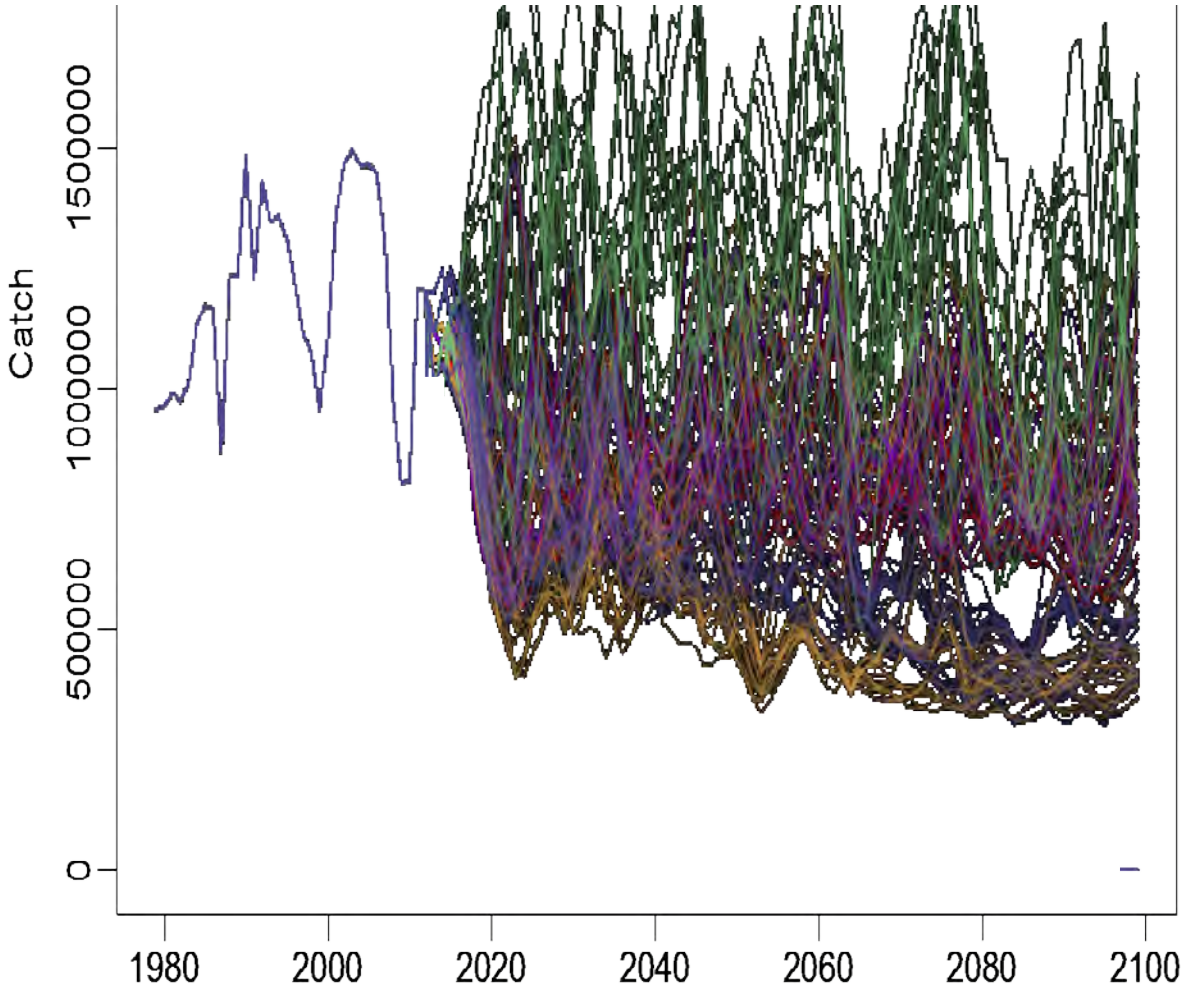
2080
2100
year

CEATTLE: Recruitment



Catch under mean F



Ianelli et al. in press: Blended Forecasts

Deep-Sea Research II ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Multi-model inference for incorporating trophic and climate uncertainty into stock assessments

James Ianelli [a,*], Kirstin K. Holsman [b], André E. Punt [c], Kerim Aydin [a]

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[b] University of Washington JISAO/Alaska Fisheries Science Center NOAA Fisheries, 7600 Sand Point Way N.E., Building 4, Seattle, WA 98115, USA
[c] University of Washington School of Aquatic and Fisheries Sciences, 1122 NE Boat St., Seattle, WA 98105, USA

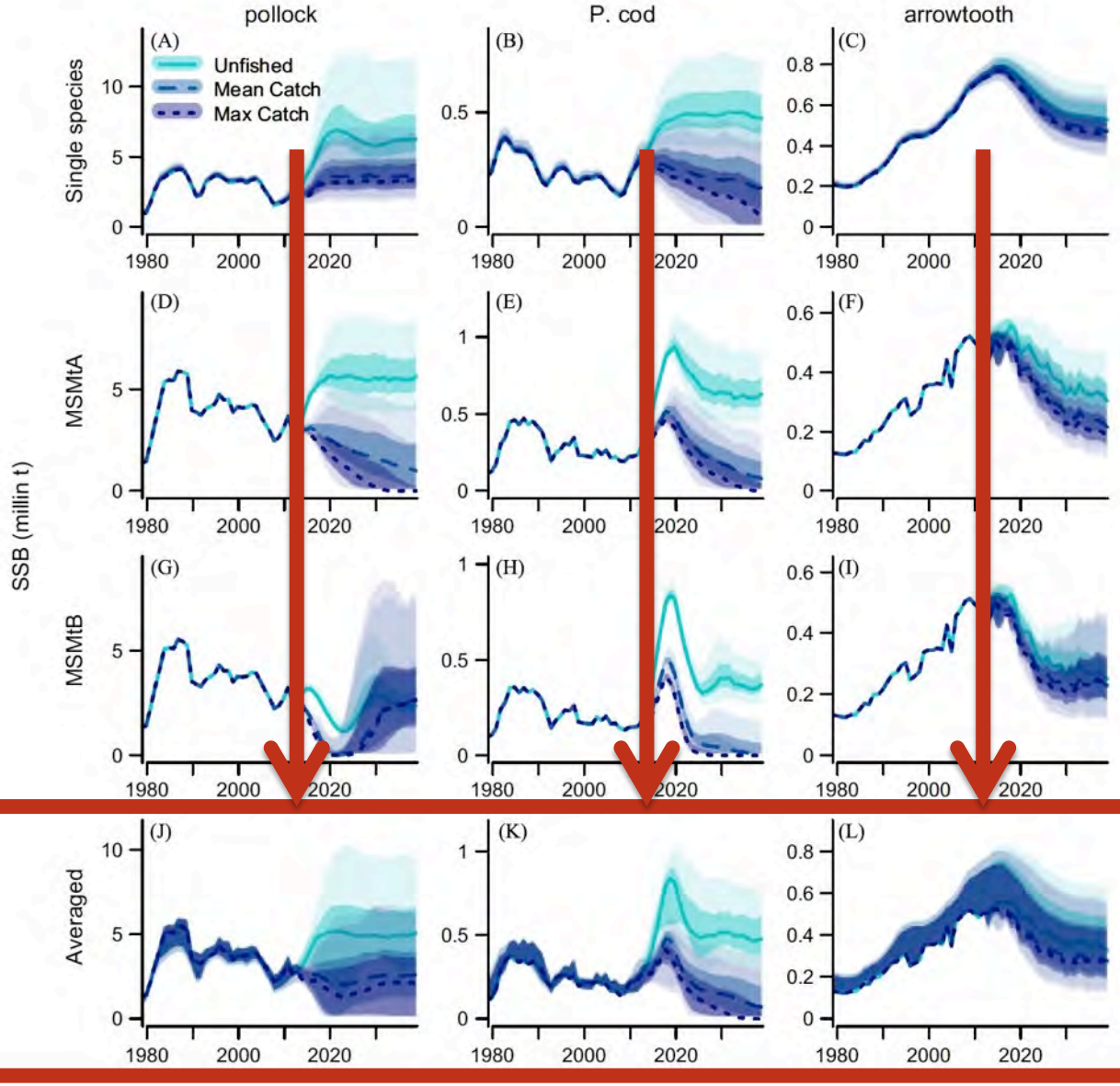
ARTICLE INFO

Keywords:
Model averaging
Model ensemble
Multi-species model

ABSTRACT

Ecosystem-based fisheries management (EBFM) approaches allow a broader and more extensive consideration of objectives than is typically possible with conventional single-species approaches. Ecosystem linkages may include trophic interactions and climate change effects on productivity for the relevant species within the system. Presently, models are evolving to include a comprehensive set of fishery and ecosystem information to address these broader management considerations. The increased

Blended results (three models)



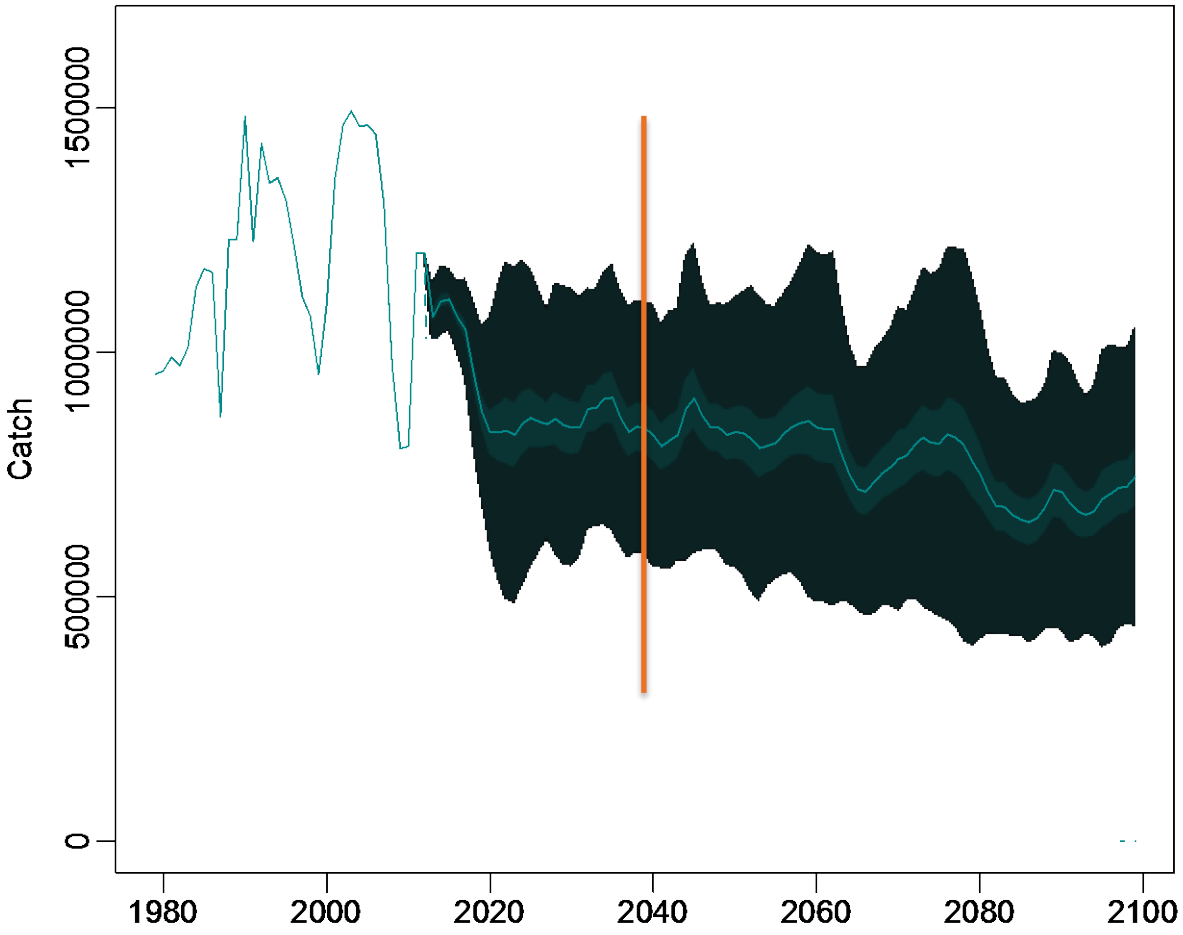
Single spp.
No Temp.

Single spp.
Avg. R_{hist}
Temp. → W@A

Multi spp.
Temp. →Ration
Avg. R_{hist}
Temp.→ W@A

Blended Result

Catch under mean F



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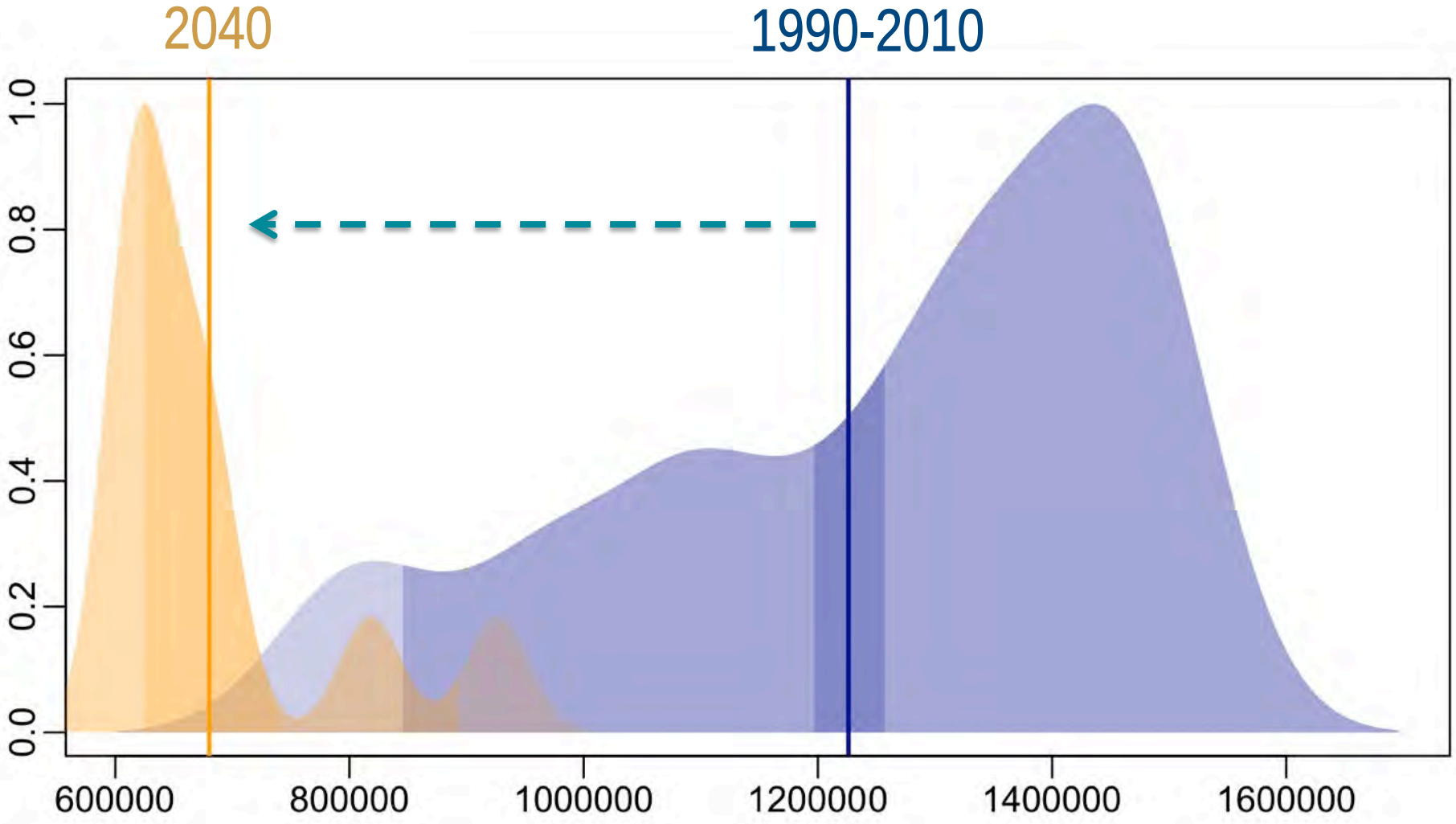

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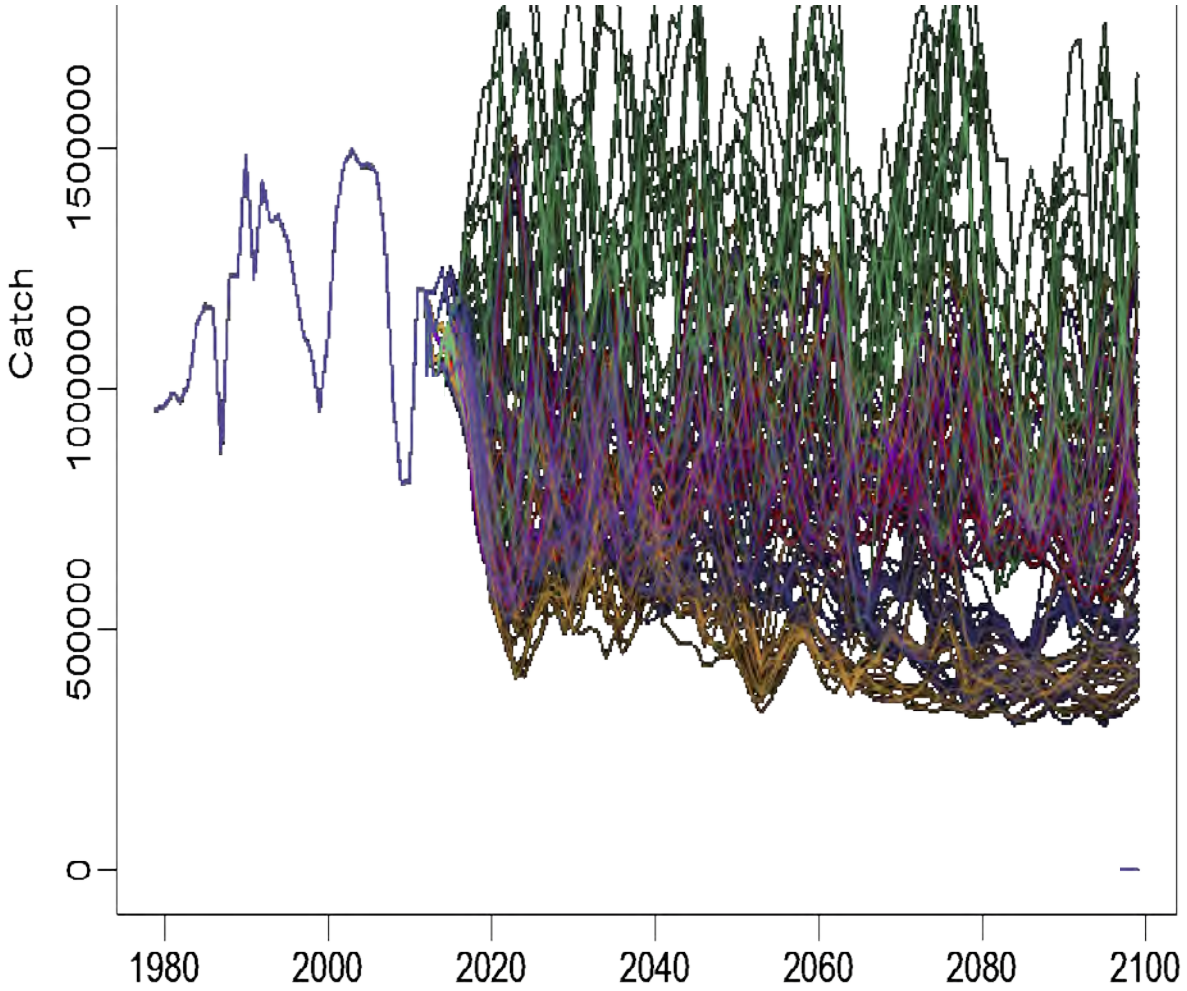

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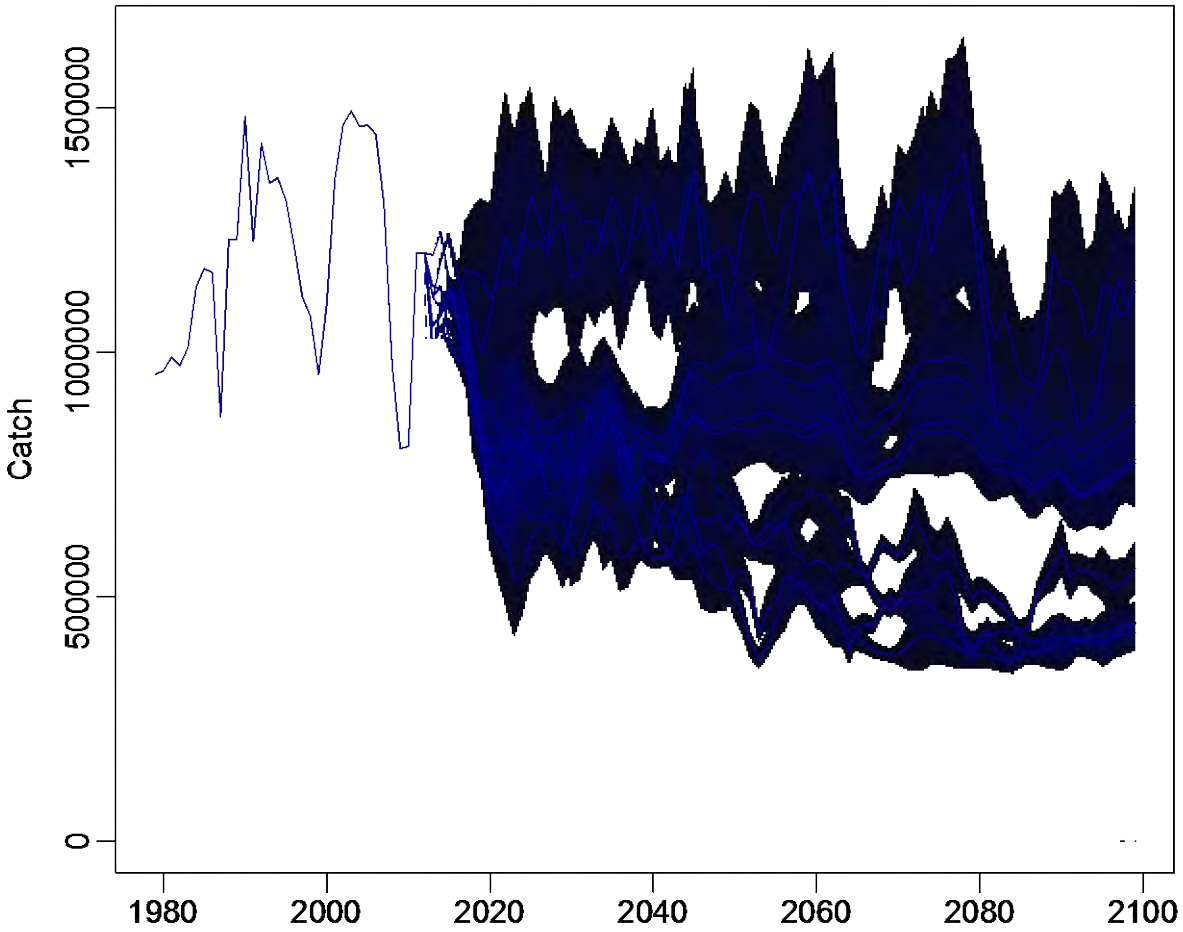
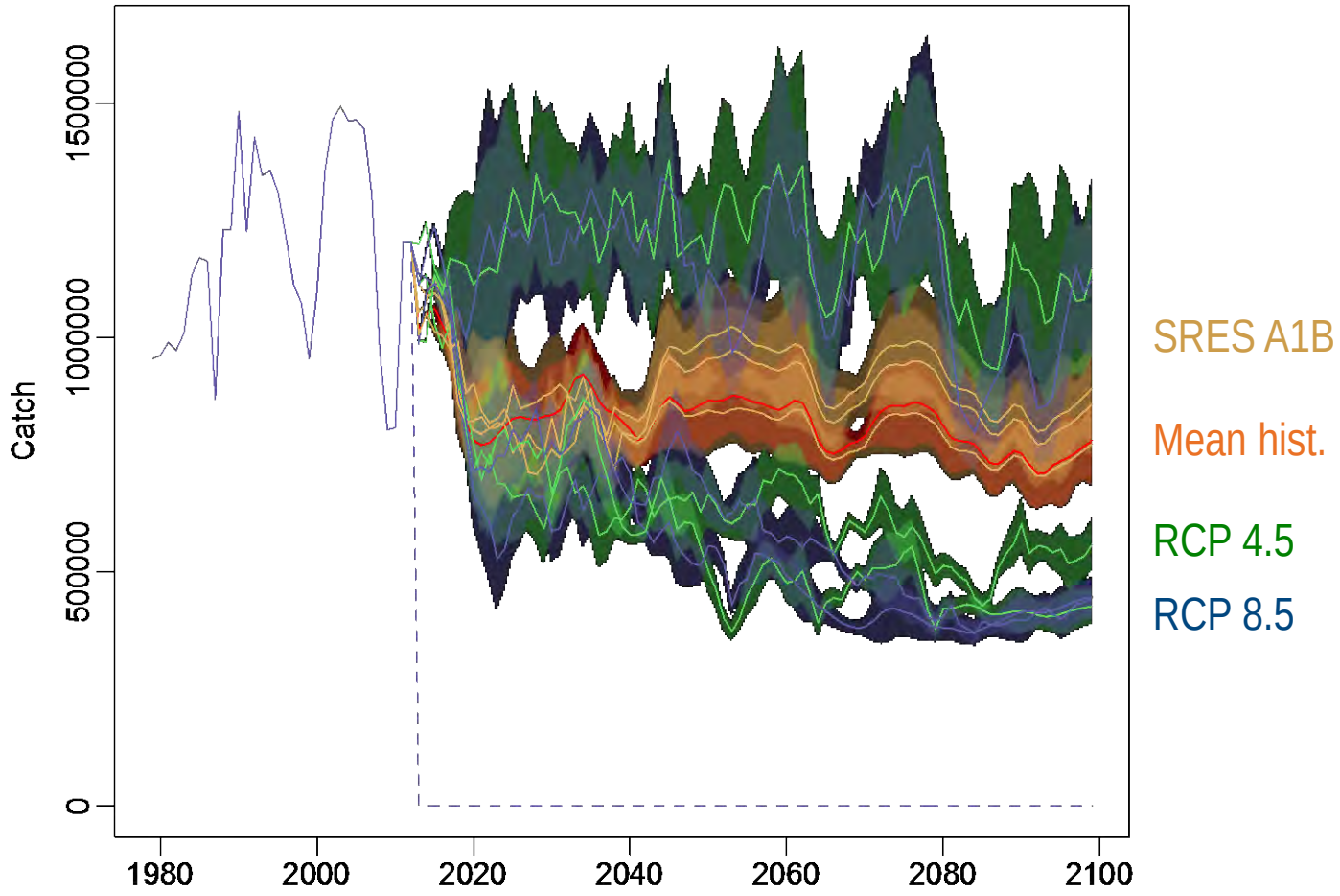


Catch under mean F

By climate scenario



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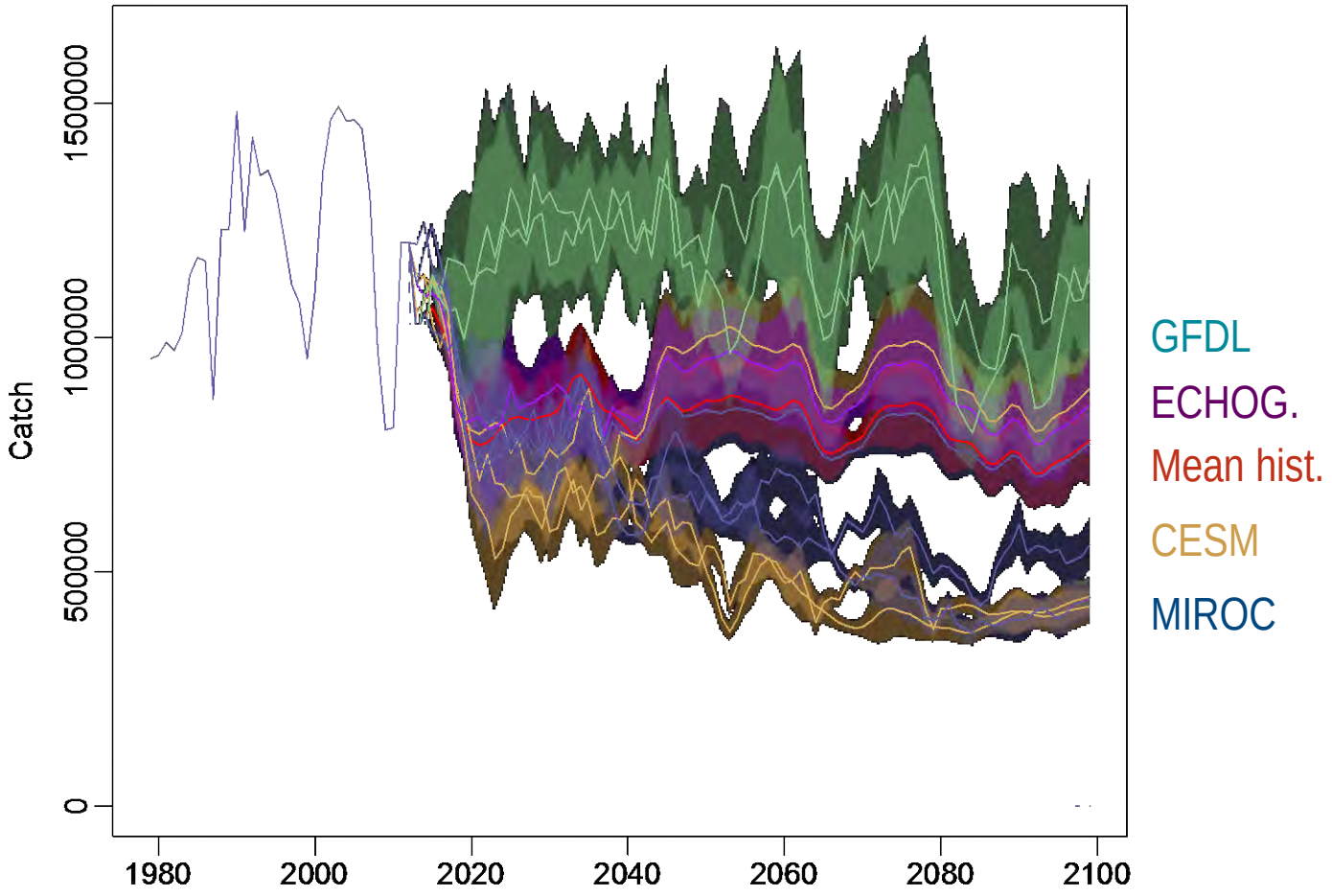

Considerations for MMI:

- Consider “baseline”→ bias correction
- Near-term or long-term? → Avg. or indiv.
- Tactical vs strategic? → communication
- Model weighting

Photo: Mark Holsman

Coupled Socio-Ecological System

Future Climate Scenarios

Harvest Scenarios

5 X

11 X

interacting pressures

biogeochemical habitats

communities of practice

lower trophic

upper trophic

communities of place

Climate-enhanced Biological Models

5 X

ACLIM: *Alaska Climate-change Integrated Modeling project*

Socioeconomic elements (Alan Haynie)

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NMFS/AFSC/NOAA
alan.haynie@noaa.gov

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

NOAA FISHERIES

Coupled Socio-Ecological System

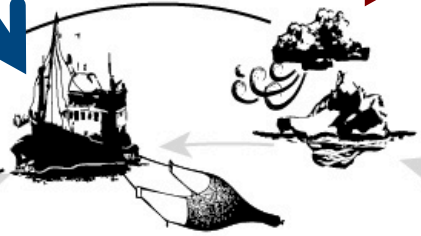
Future Climate Scenarios

Harvest Scenarios

5 X

11 X

interacting pressures

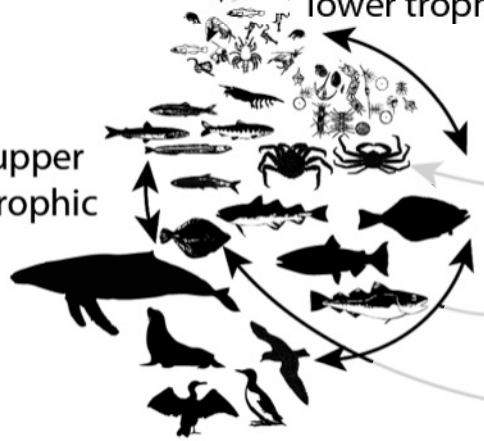


biogeochemical habitats

communities of practice

lower trophic

upper trophic

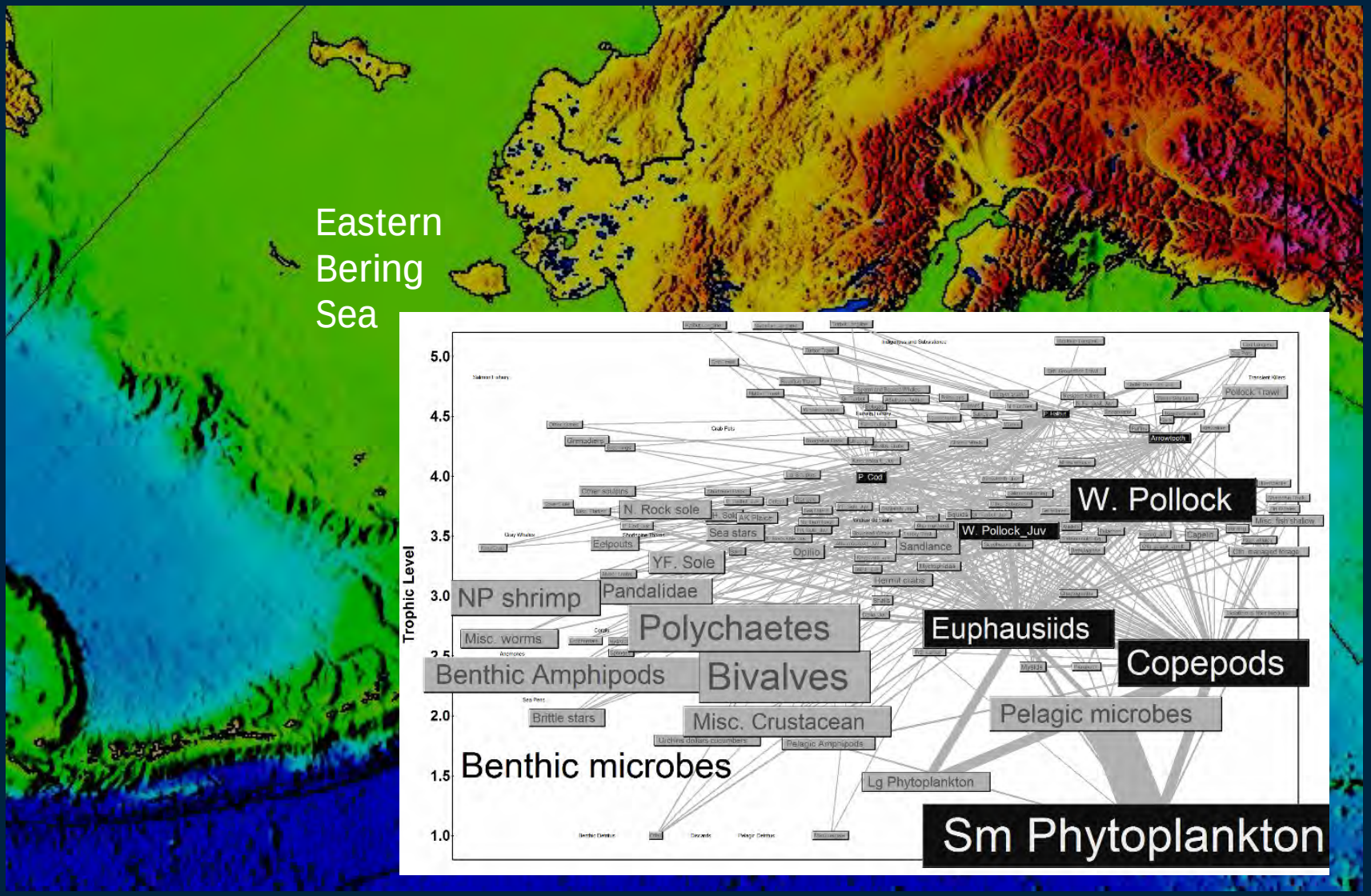


communities of place

Climate-enhanced Ecosystem Models

ACLIM: *Alaska Climate-change Integrated Modeling project*

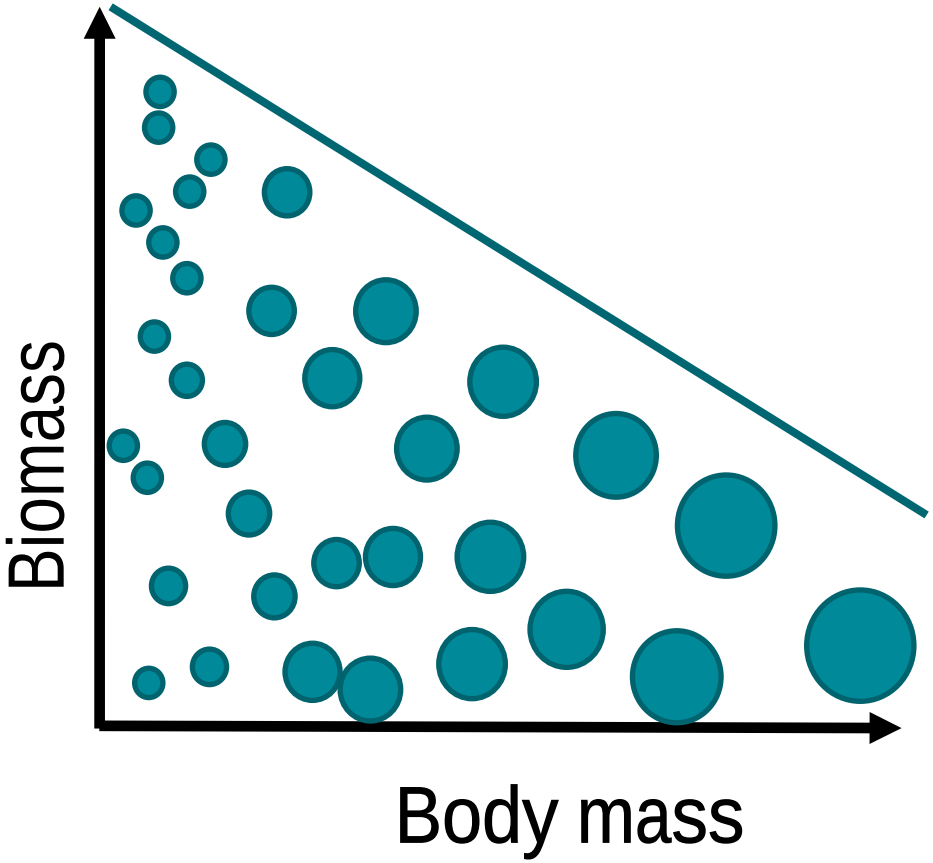
Ecopath food web model (Aydin et al. 2007)



NOAA FISHERIES

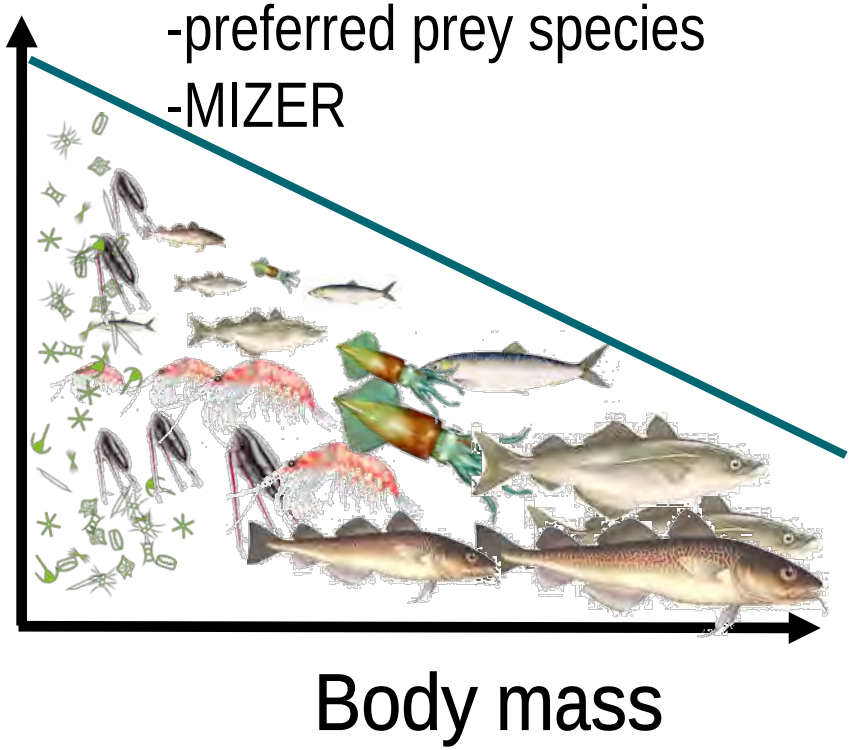
Size-spectrum model (Dr. Reum)

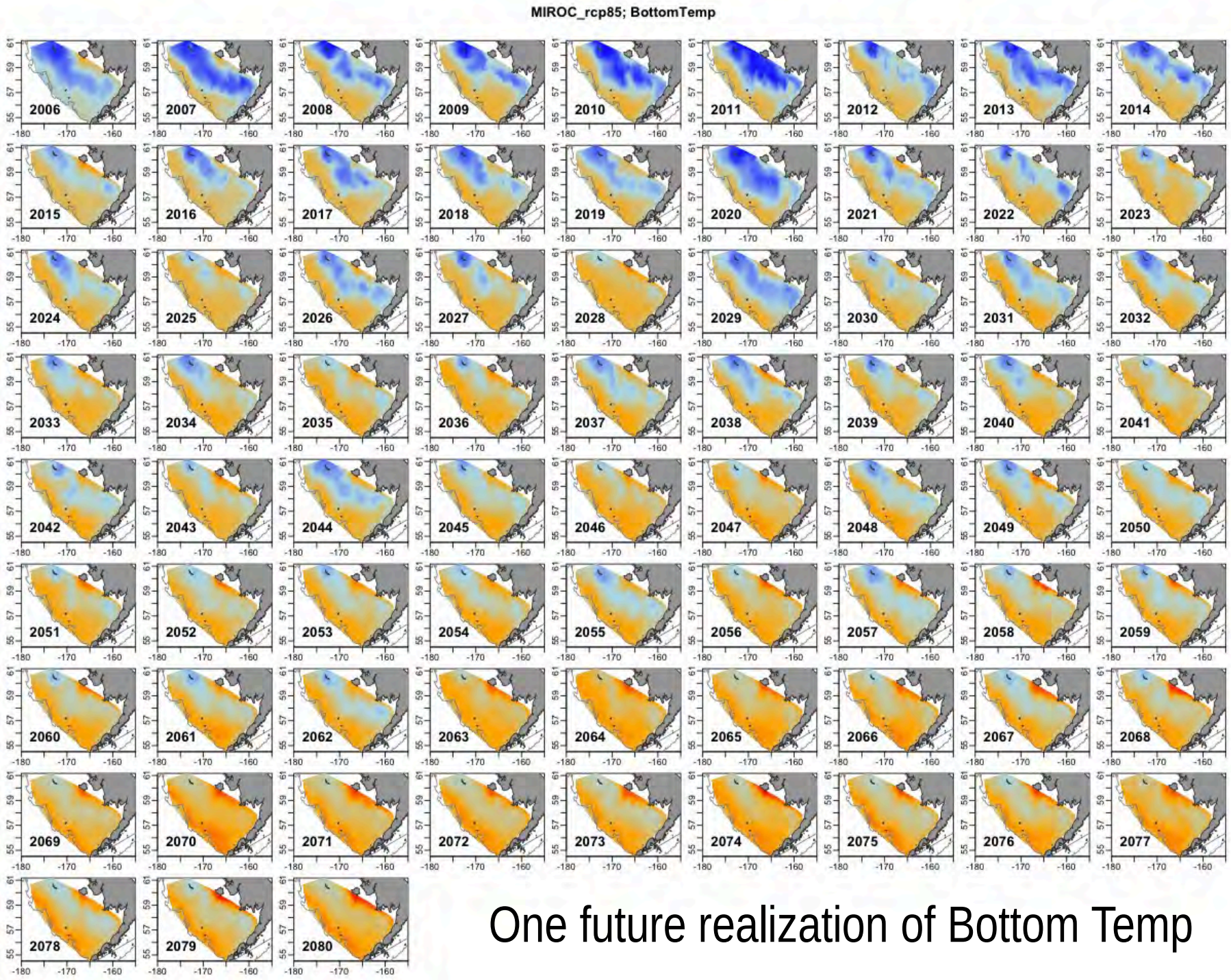
Particles that eat, grow and reproduce



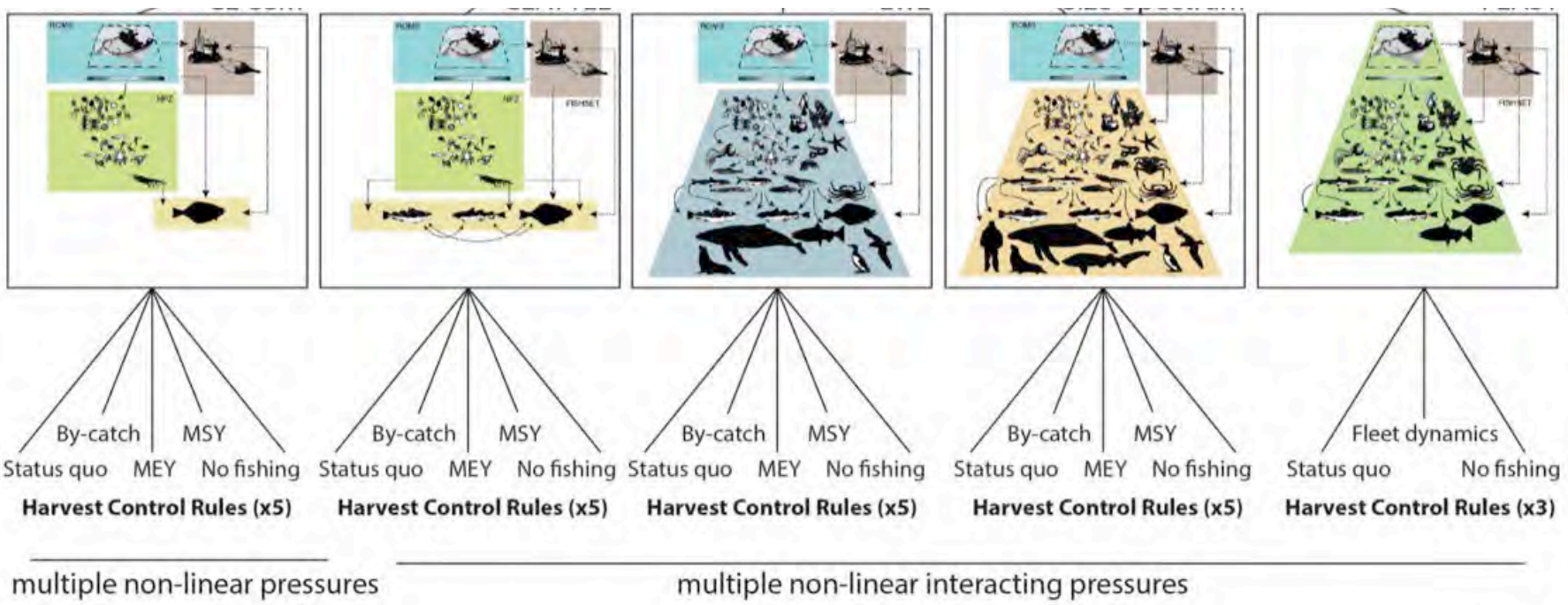
Species level attributes

- -Maximum size
- -Minimum size
- -Size at maturation
- -preferred prey size
- -preferred prey species
- -MIZER

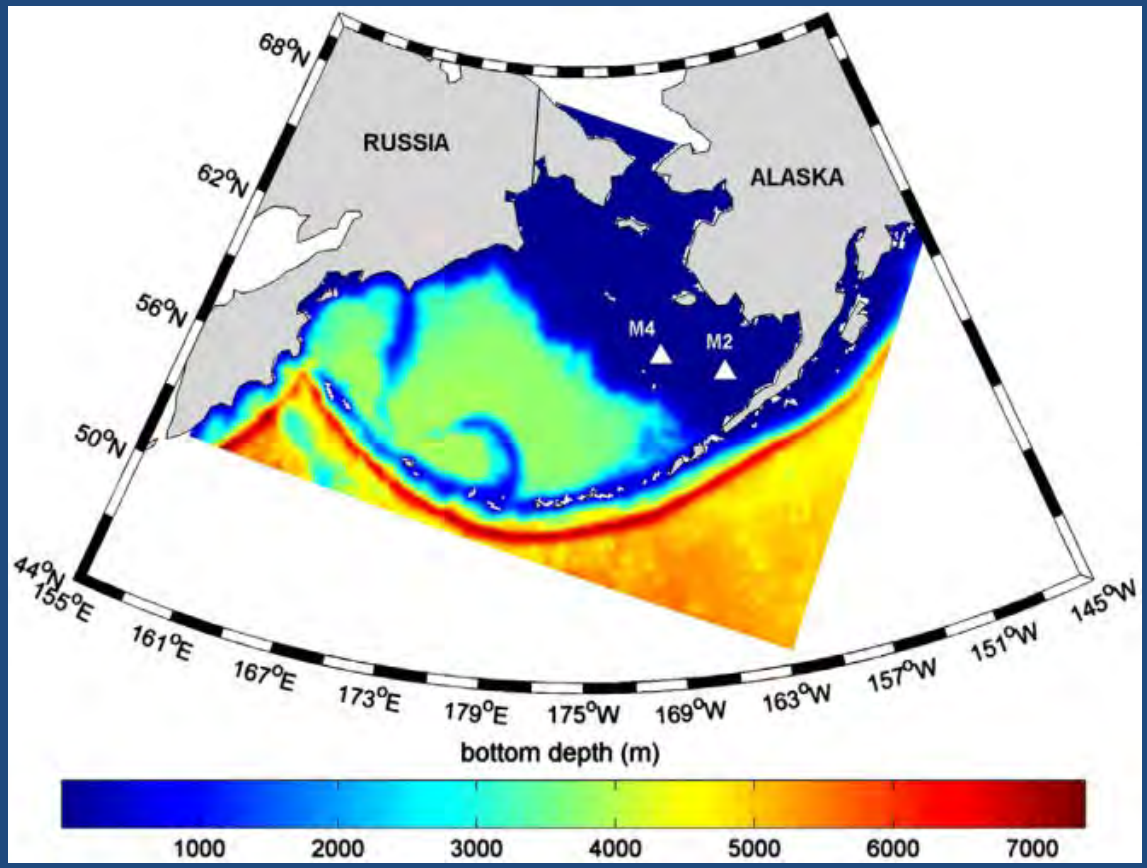




One future realization of Bottom Temp


CE-Single Species
CE- Multispecies
CE- EWE
CE- Size spectrum
FEAST
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
Fleet dynamics
Status quo
No fishing
Harvest Control Rules (x3)
multiple non-linear pressures
multiple non-linear interacting pressures

Bering10K model



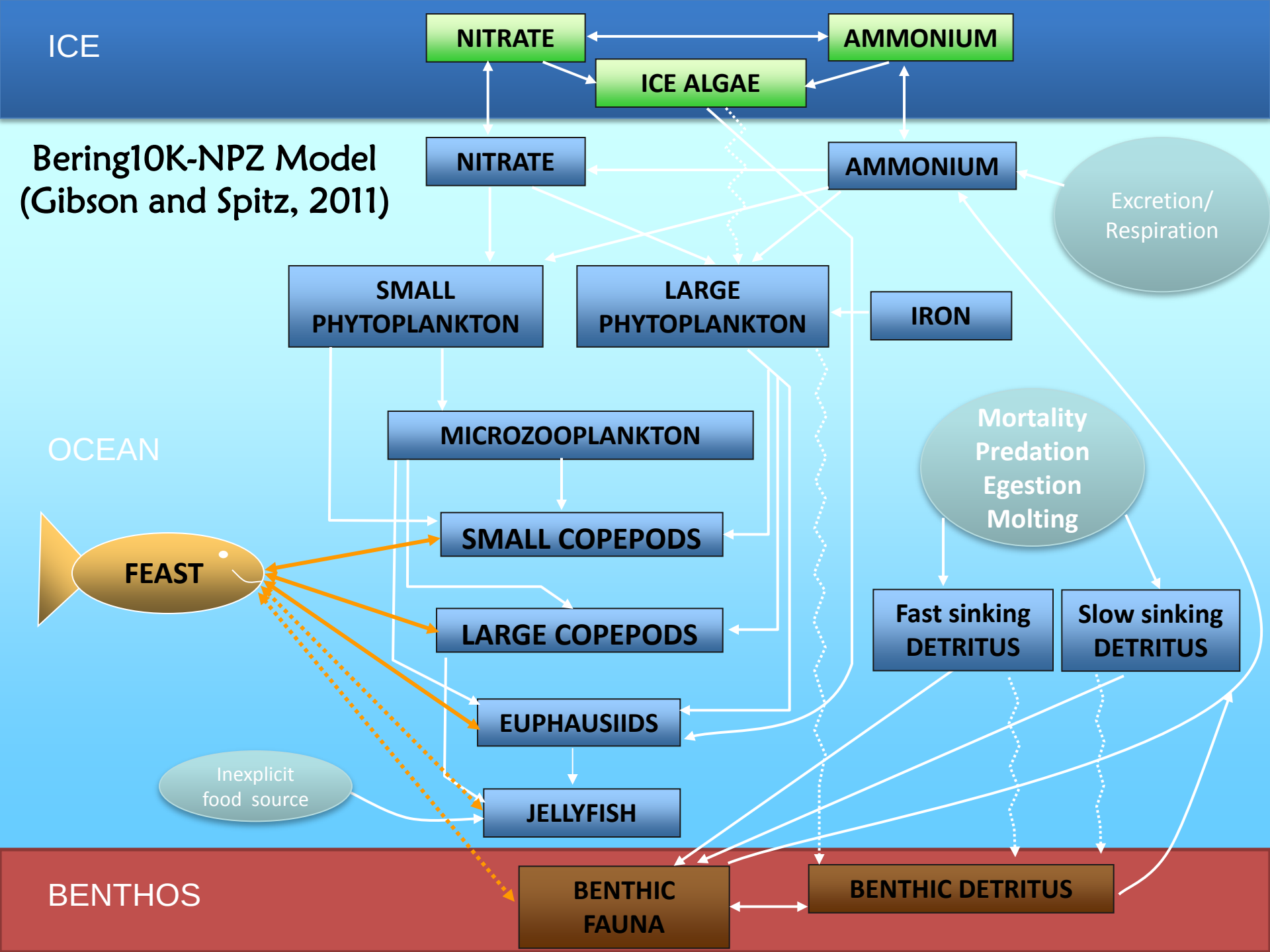
- Descendent of NEP5 (Danielson et al. 2012)
- 10 layers, 10-km grid Includes ice and tides
- CCSM bulk flux
- Details in Hermann et al. (DSR2, 2013, 2016)

Challenges

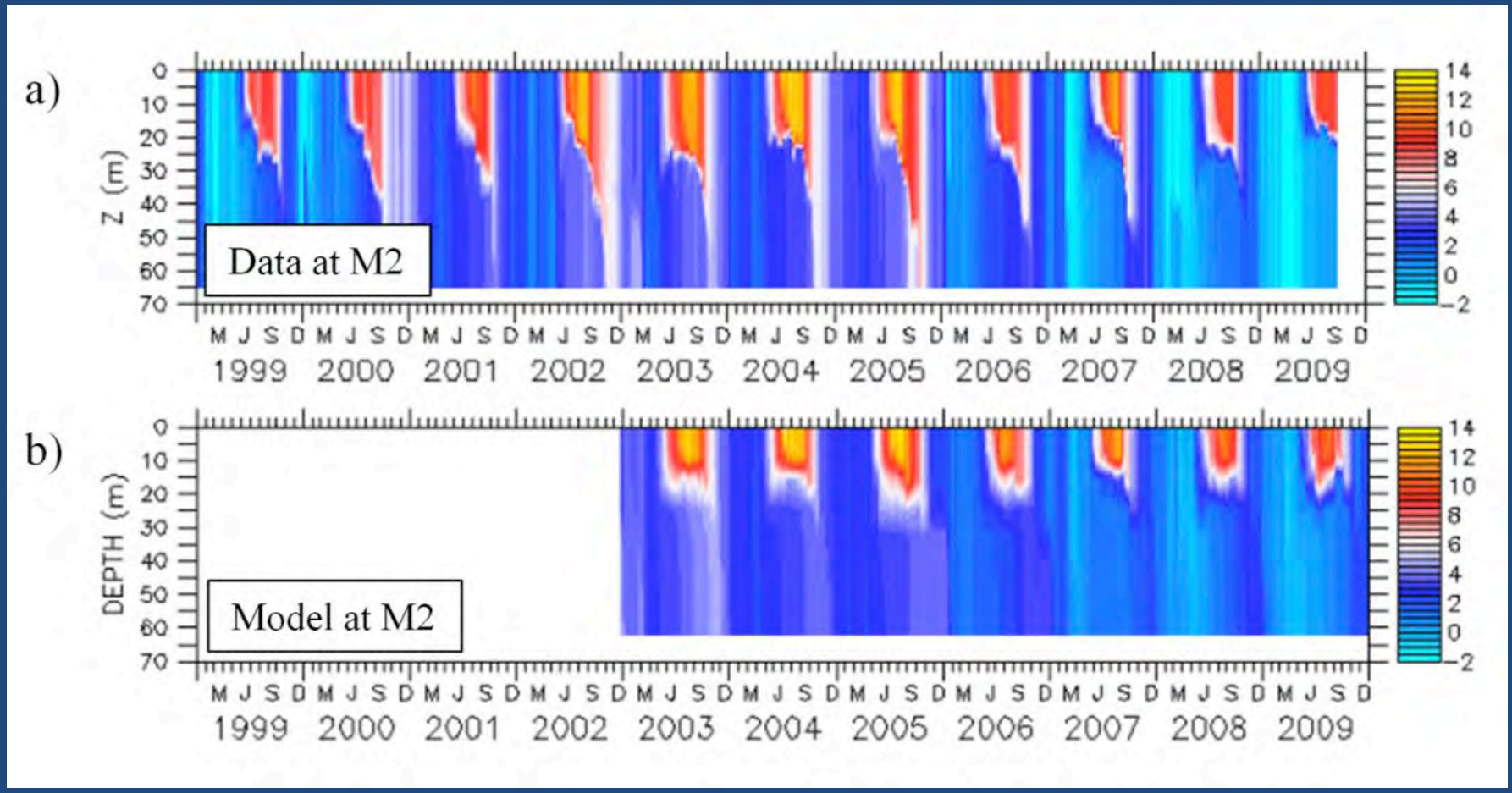
- GCM selection
- Computing capacity limitations
- Data-sharing/Translating model outputs
- Models based on current ecological understanding
- Evolution of models to incorporate nascent science

Successes

- Strong integrated research program at AFSC
- Right mix of people and tools
- Engagement with council & stakeholders is iterative
- Long-term analyses can inform short-term forecasts


ICE
NITRATE
AMMONIUM
ICE ALGAE
Bering10K-NPZ Model
(Gibson and Spitz, 2011)
NITRATE
AMMONIUM
Excretion/
Respiration
SMALL
PHYTOPLANKTON
LARGE
PHYTOPLANKTON
IRON
OCEAN
MICROZOOPLANKTON
Mortality
Predation
Egestion
Molting
SMALL COPEPODS
FEAST
LARGE COPEPODS
Fast sinking
DETRITUS
Slow sinking
DETRITUS
EUPHAUSIIDS
Inexplicit
food source
JELLYFISH
BENTHOS
BENTHIC
FAUNA
BENTHIC DETRITUS

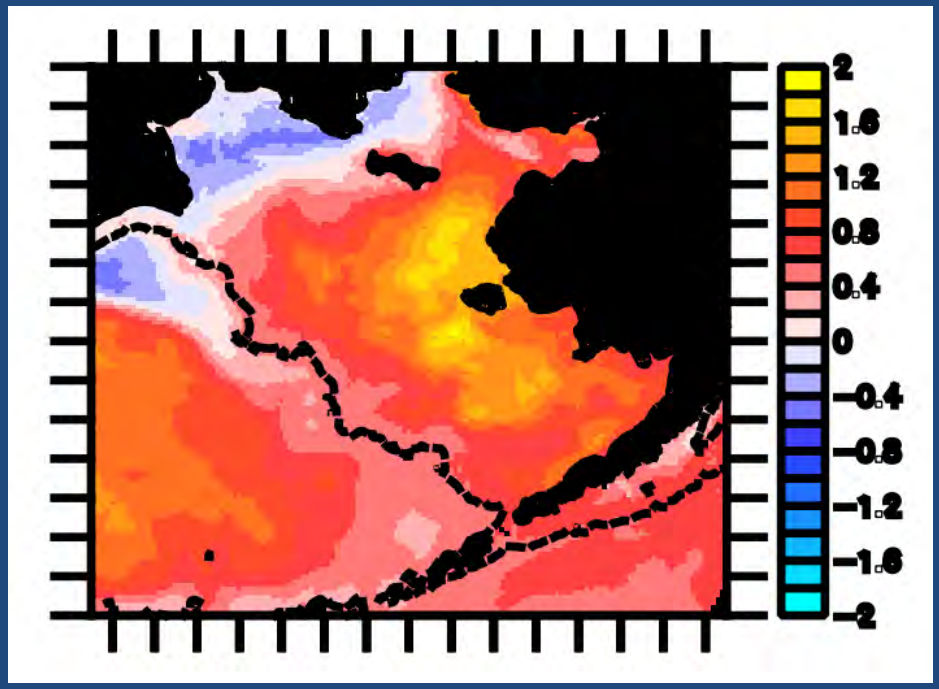
Bering10K validation:
Modeled/Observed mid-shelf temperatures (deg C)



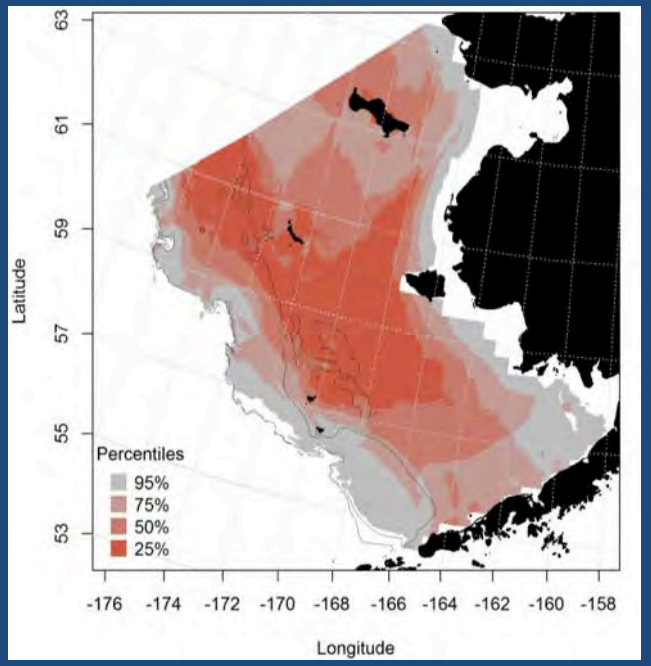
Bering Sea vulnerability analysis:

Compare present time variance and mean anticipated change with present fish distribution

Summer Bottom Temp anticipated change



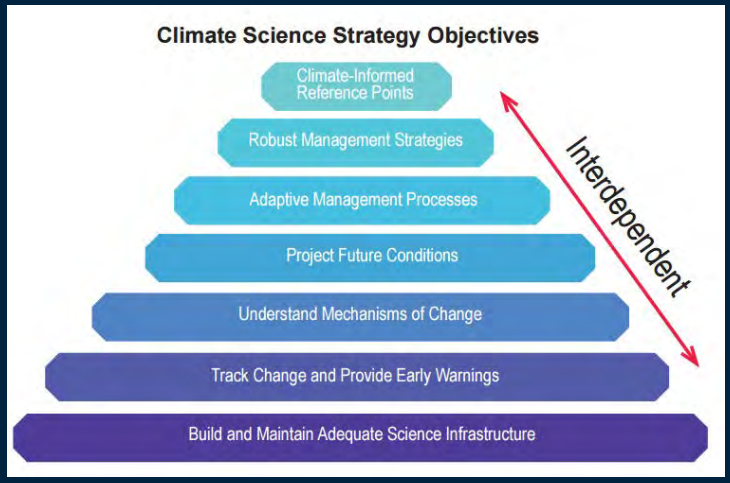
Walleye pollock Essential Fish Habitat

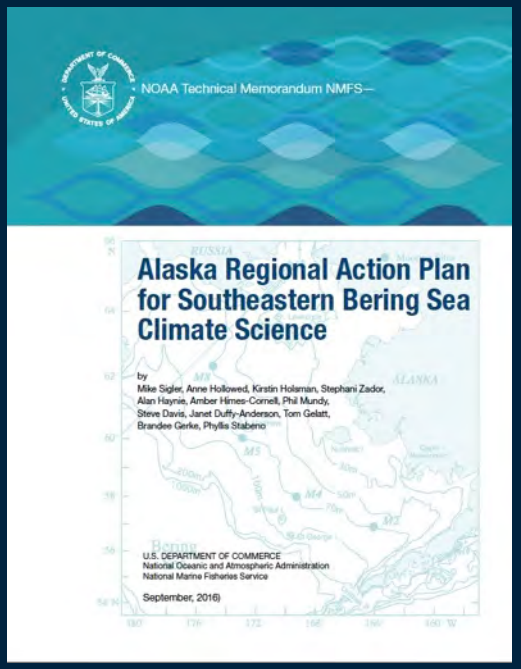


ACLIM Purpose and Need

National and international climate impact assessments 2020-2022

- Scientific advancement, regional feedback
- Operationalization of national climate-ecosystem projection enterprise
- Testing management strategies for climate Informed decision making - NPFMC FEP





http://www.st.nmfs.noaa.gov/ecosystems/climate/national-climate-strategy

The Bering Sea (Alaska)

world's most extensive eelgrass beds

450 species of fish and shell fish

35 million birds

25 species of marine mammals.

40% of the total US commercial catch of fish and shellfish

world's largest sockeye salmon fishery

75% of the subsistence harvest for 55,000 Alaskans

Long history of integrated ecosystem research programs- Most recently the Bering Sea Project (NPRB, NSF, NOAA): 90 investigators, $52 M

Closing Remarks

- Integrated modeling teams seeking to quantify implications of different climate and management scenarios.
- Addresses multiple sources of uncertainty
- Projections vary considerably between GCMs
- Phase II: RTAP proposal to rapidly uptake AR6 model results to align IPCC WG 1 & 2
- Coordinated research teams within NMFS SCs and internationally through ICES & PICES - SICCME.