A stress test for fisheries management:

Photo: Mark Holsman

using coupled physical-biological-socioeconomic models to evaluate alternative management approaches in Alaska

Kirstin Holsman[1]

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ACLIM PIs:
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3. Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
4. Institute of Marine Research, Bergen Norway
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The ACLIM team

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Kirstin Holsman

Alan Haynie

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Ingrid Spies

Stephen Kasperski

Cody Szuwalski

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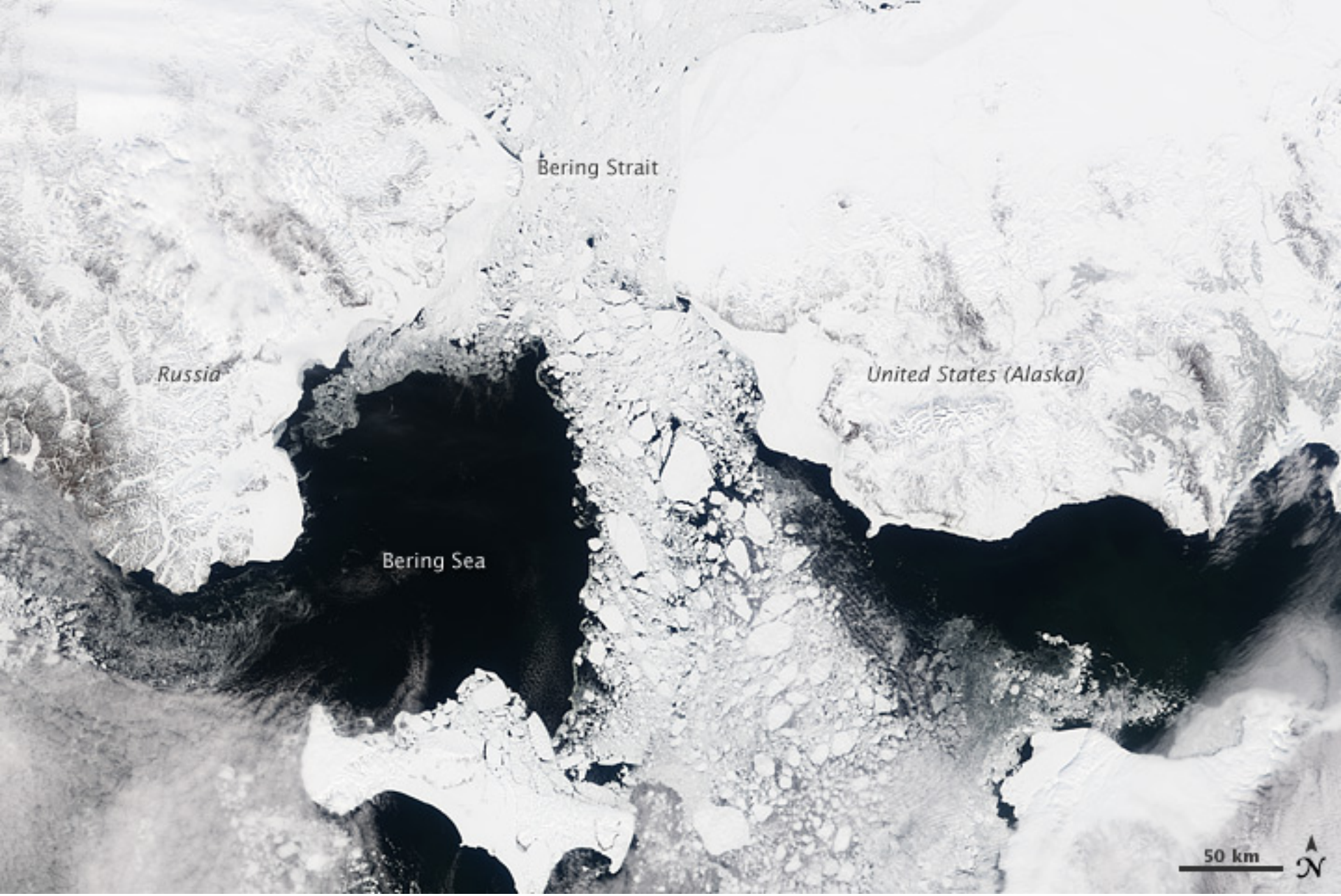
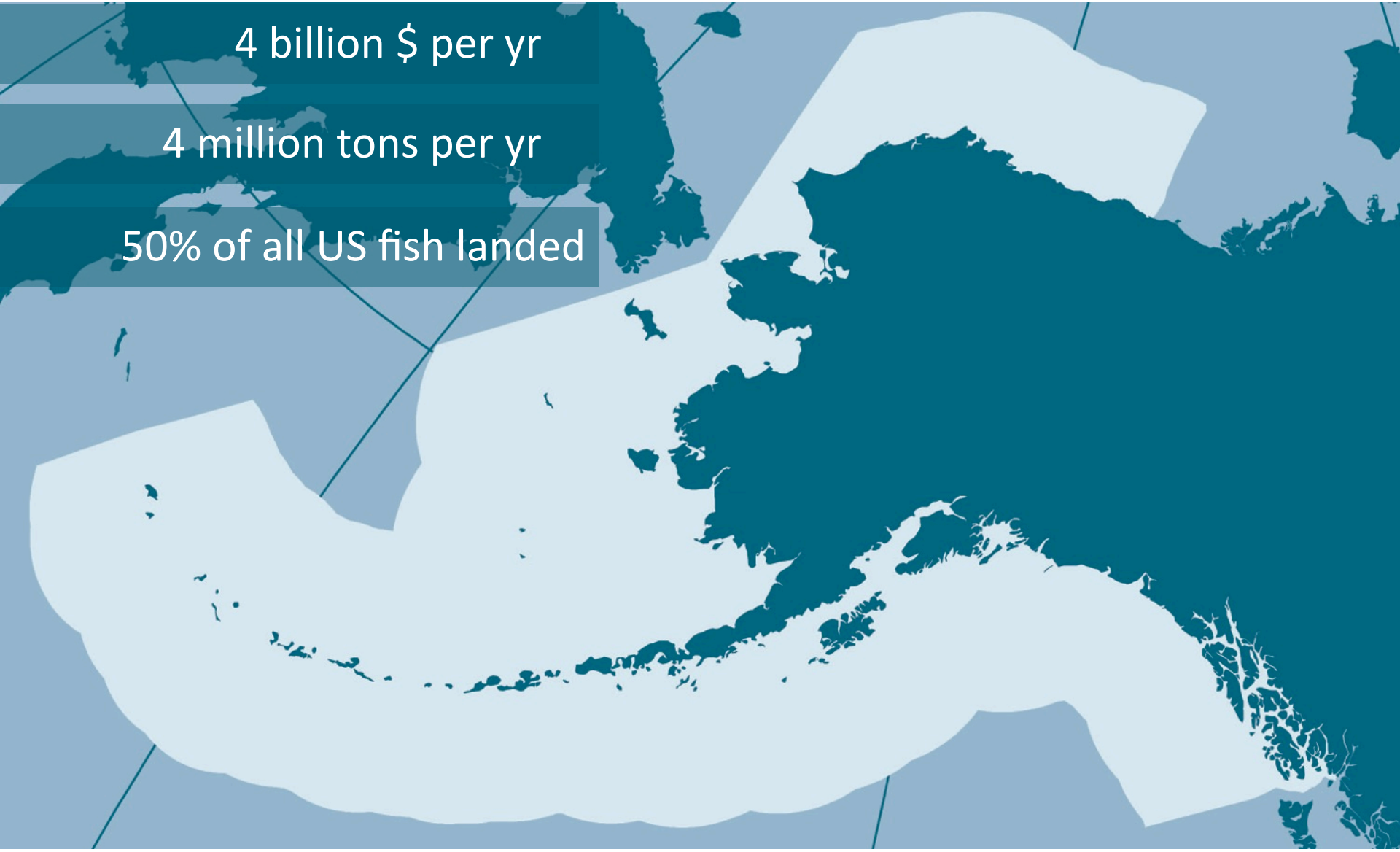


NASA MODIS image by Jesse Allen

Alaska-wide Fisheries



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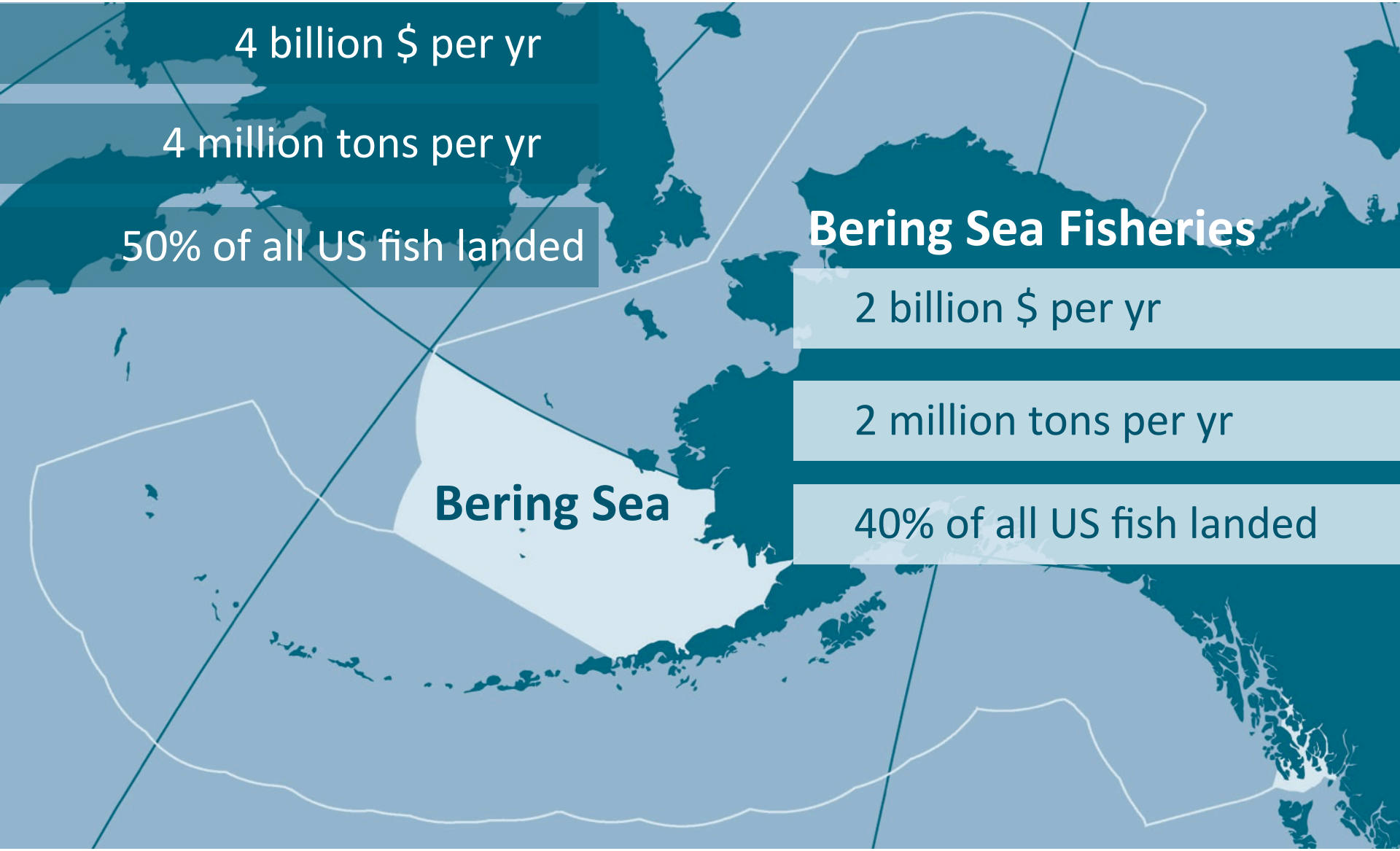
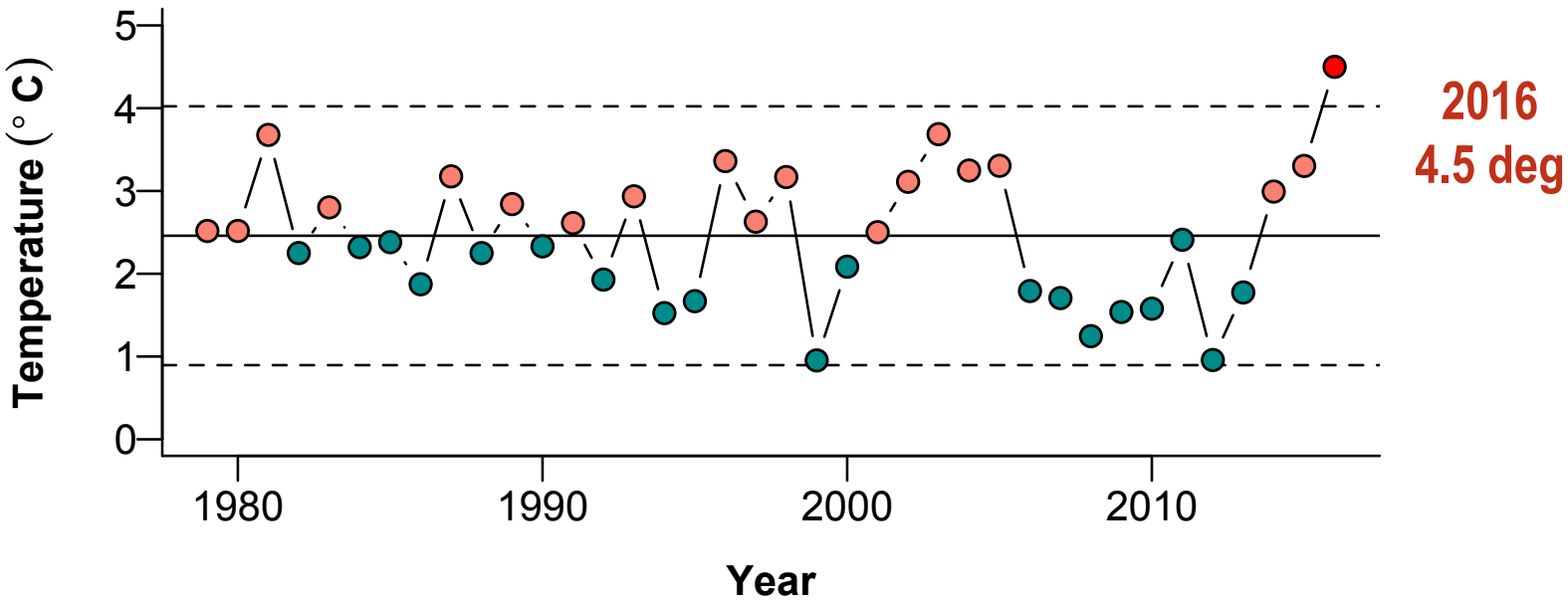
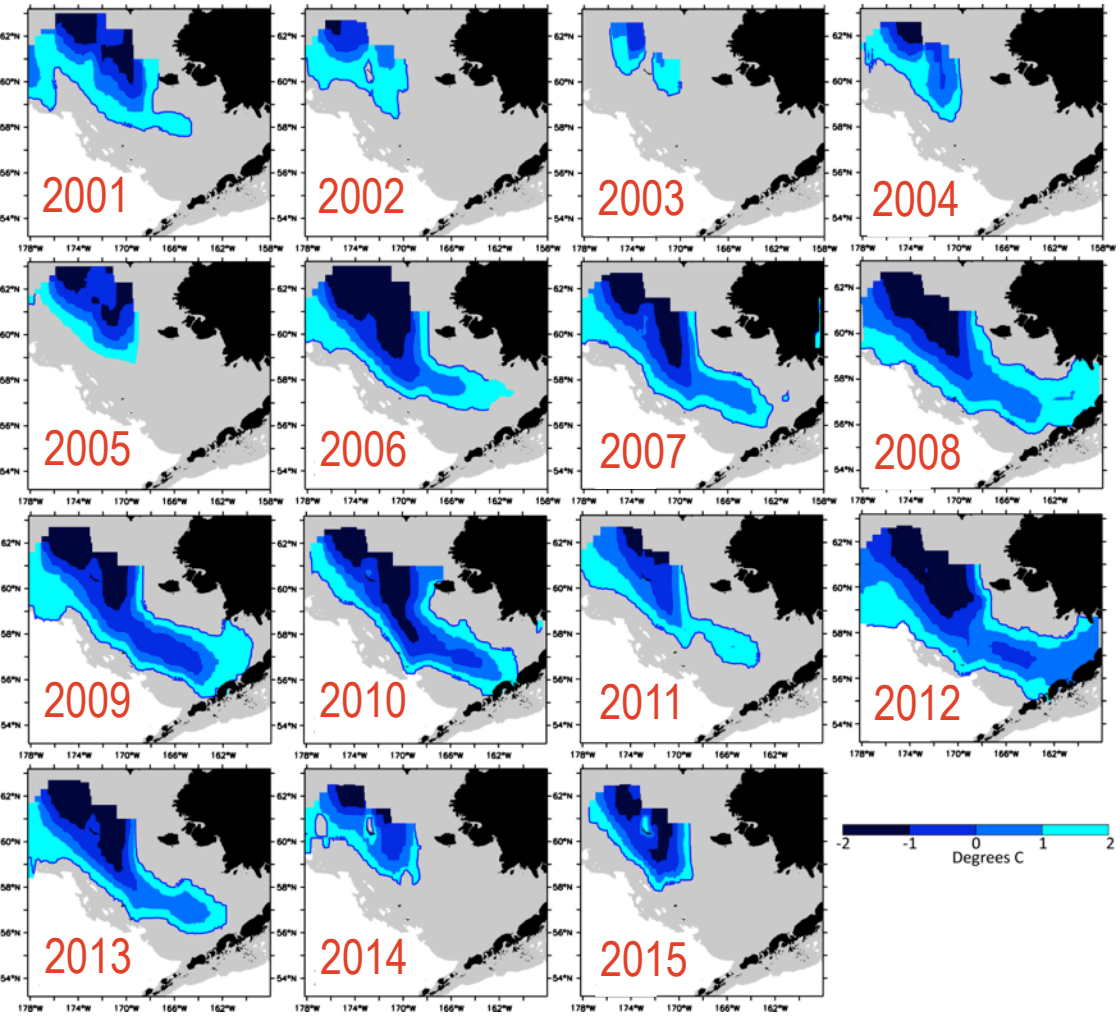


Observed Bottom Temperature (BT Survey)

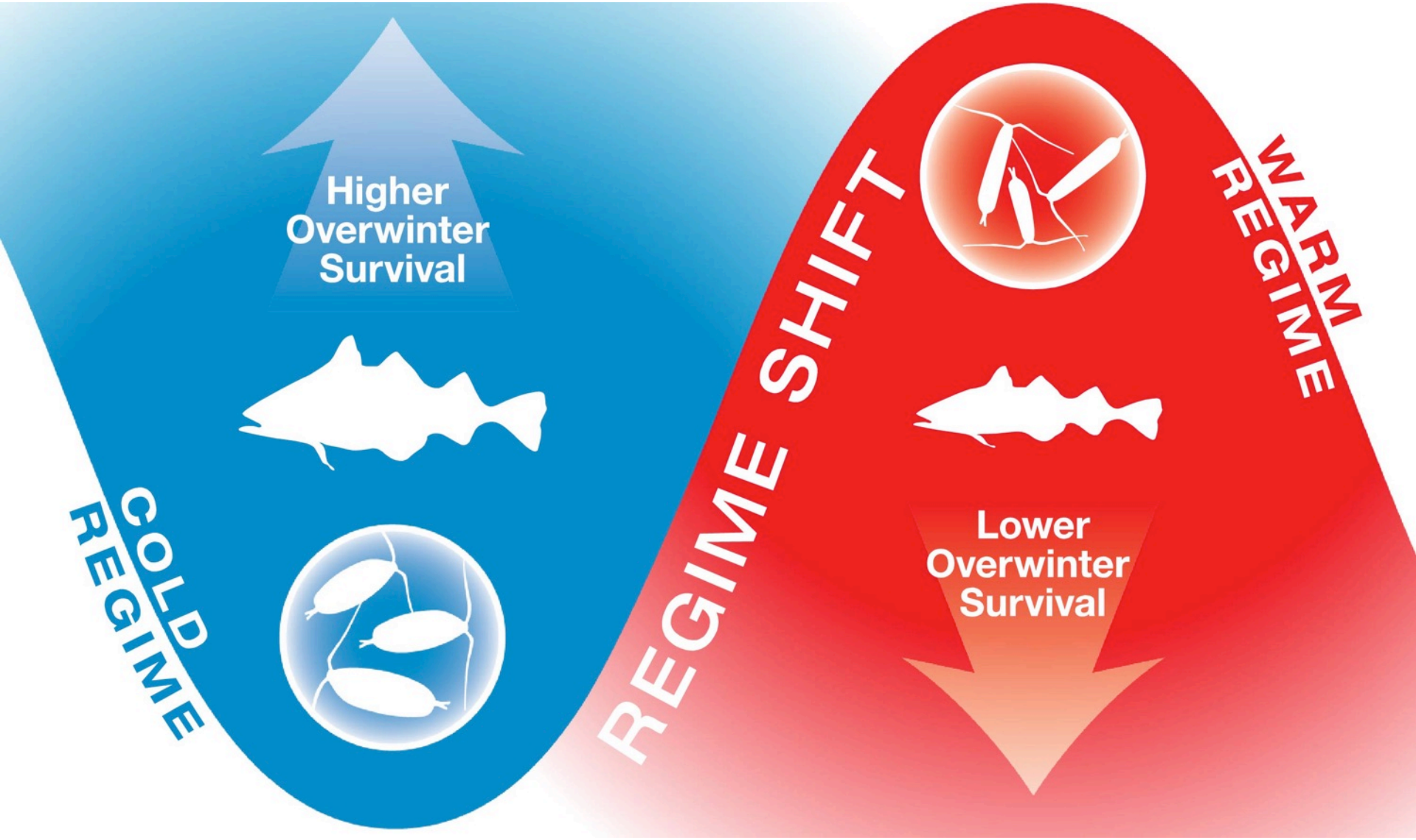


Bering Sea & Climate variability

Bering Sea “Cold Pool” 2001-2015



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



Slide courtesy of J. Duffy-Anderson

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Alaska Climate Integrated Modeling Project

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SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

Global Climate Models (x 7)
- ECHO-G
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Projection Scenarios (x3)
- AR4 A1B
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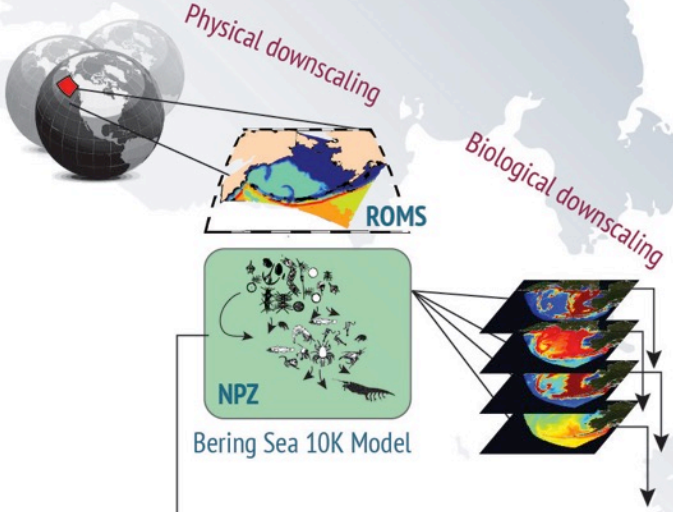

Socio-economic / harvest scenarios (x 5)
- No fishing
- Status quo
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- MSY
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Climate Enhanced Biological models (x 5)
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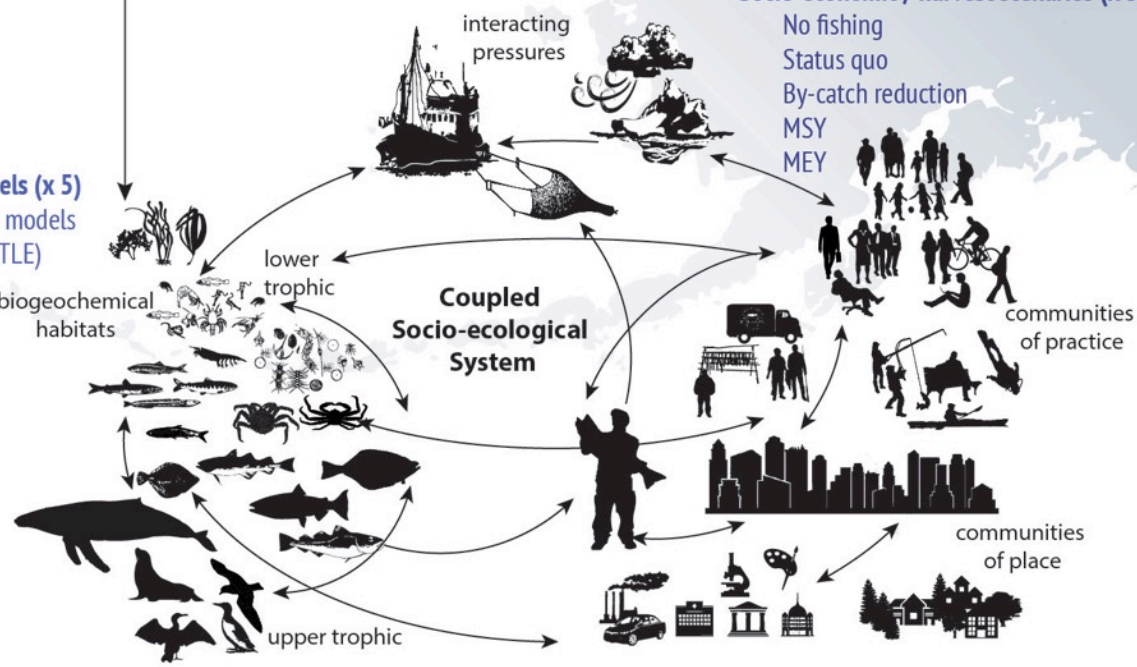
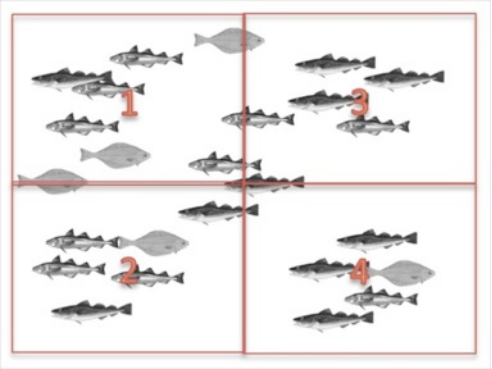


Tracking Sources of Error

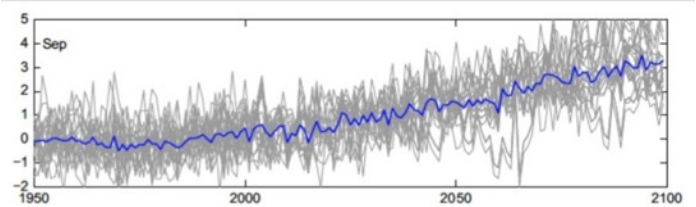
1. Observation error

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



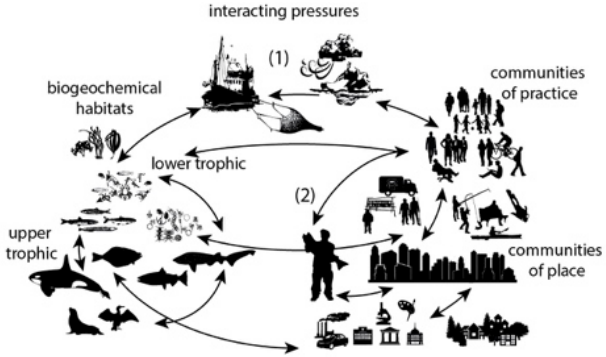
2. Process error

- “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”)?



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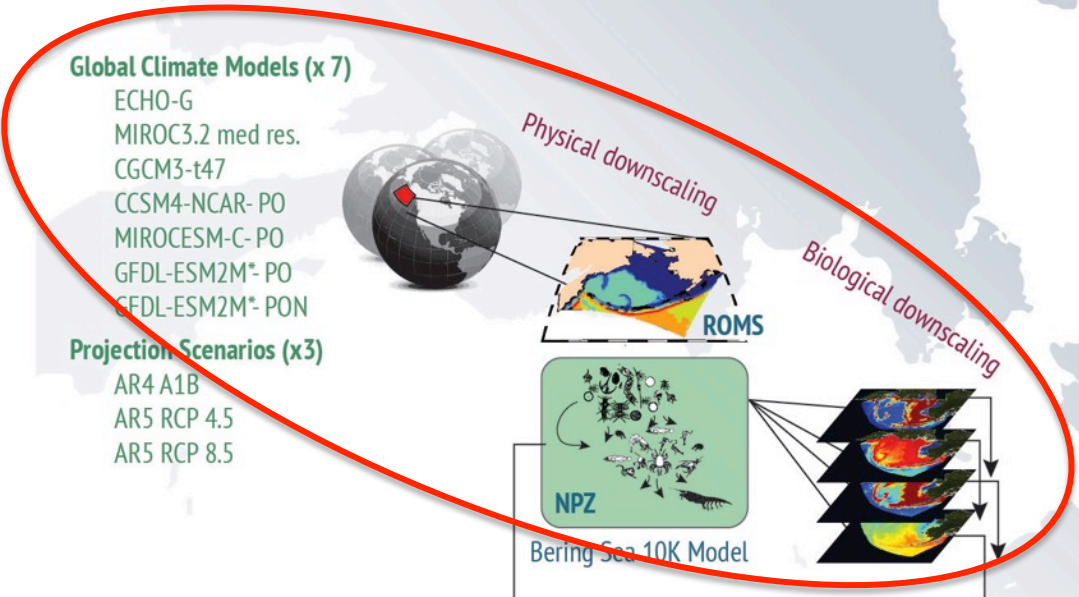
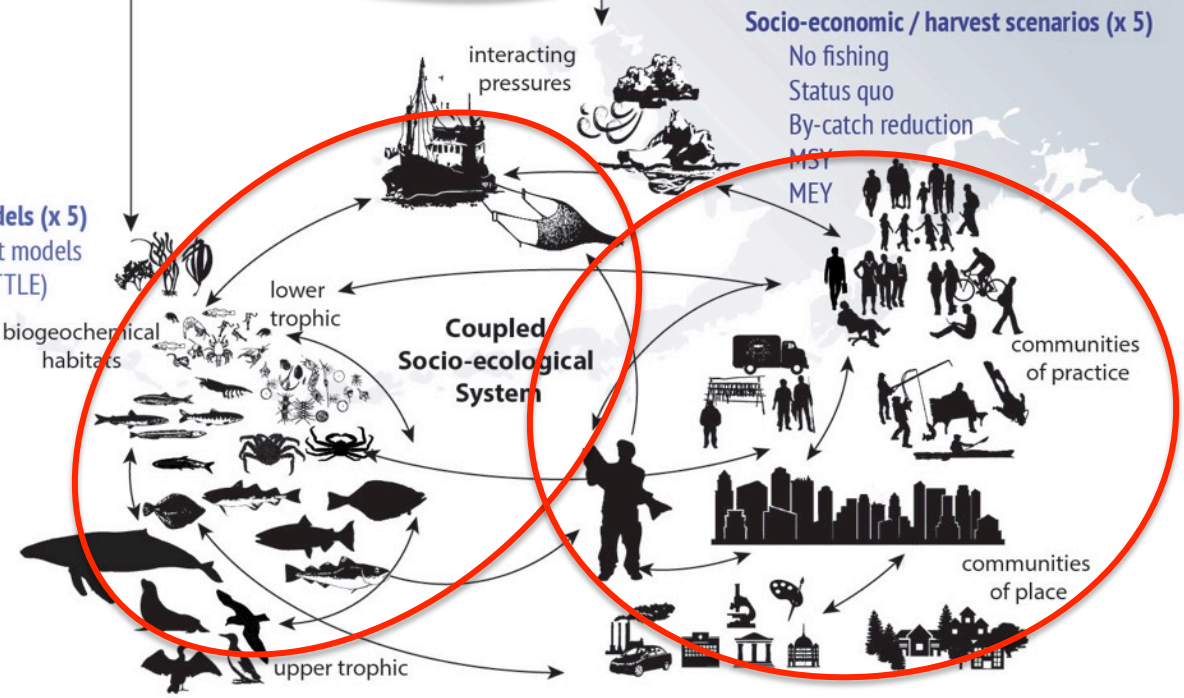




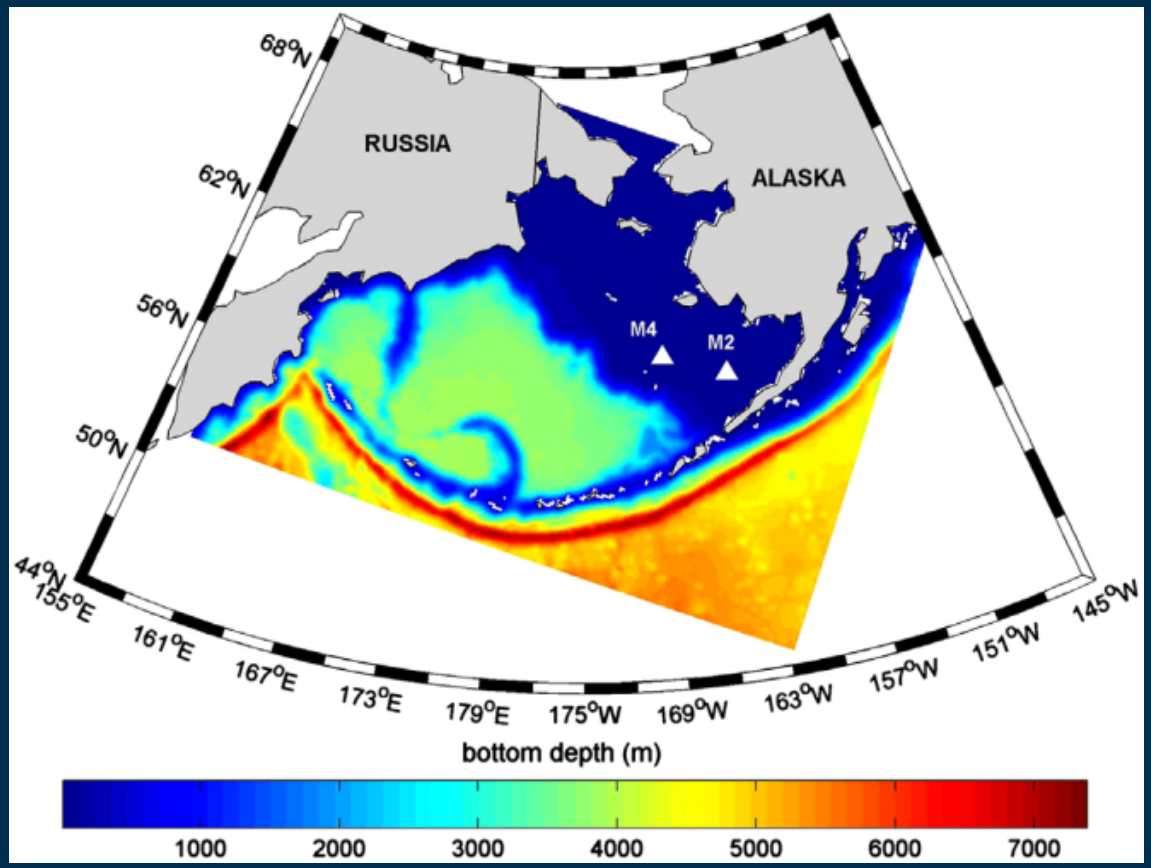
Physical & NPZ modeling

Dr. Al Hermann Dr. Wei Cheng

JISAO/UW and NOAA/PMEL

Photo: Mark Holsman

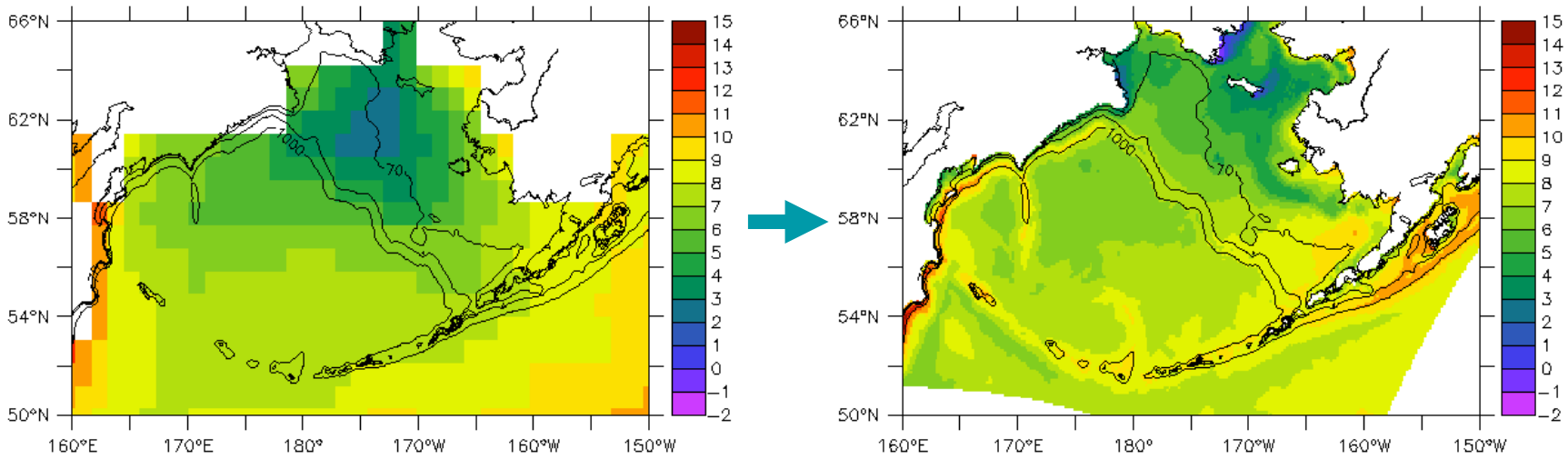
Bering10K model



- 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)

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

GCM model (MIROC) Regional model (Bering10K)



GCM global atmosphere provides *surface forcing*

GCM global ocean provides *boundary conditions*

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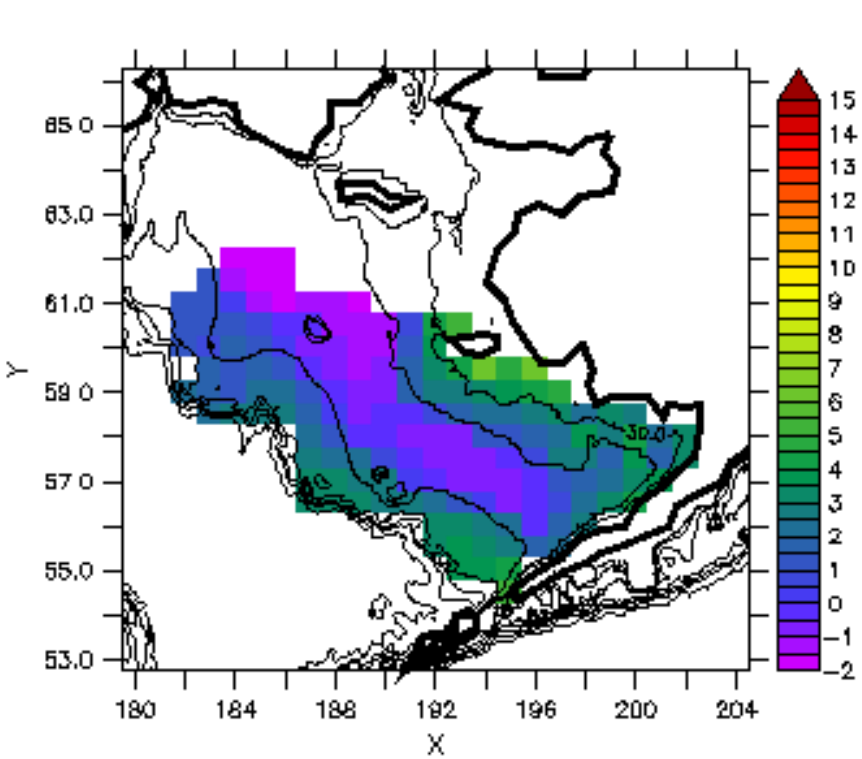
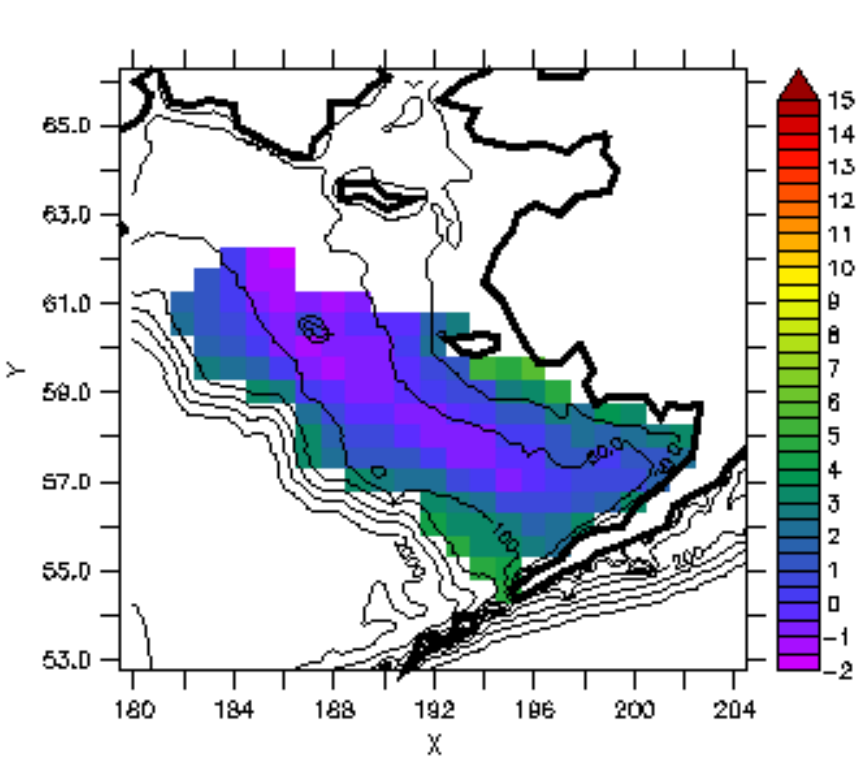
Bering10K validation: Bottom T. (°C) summer 2009

DATA



MODEL



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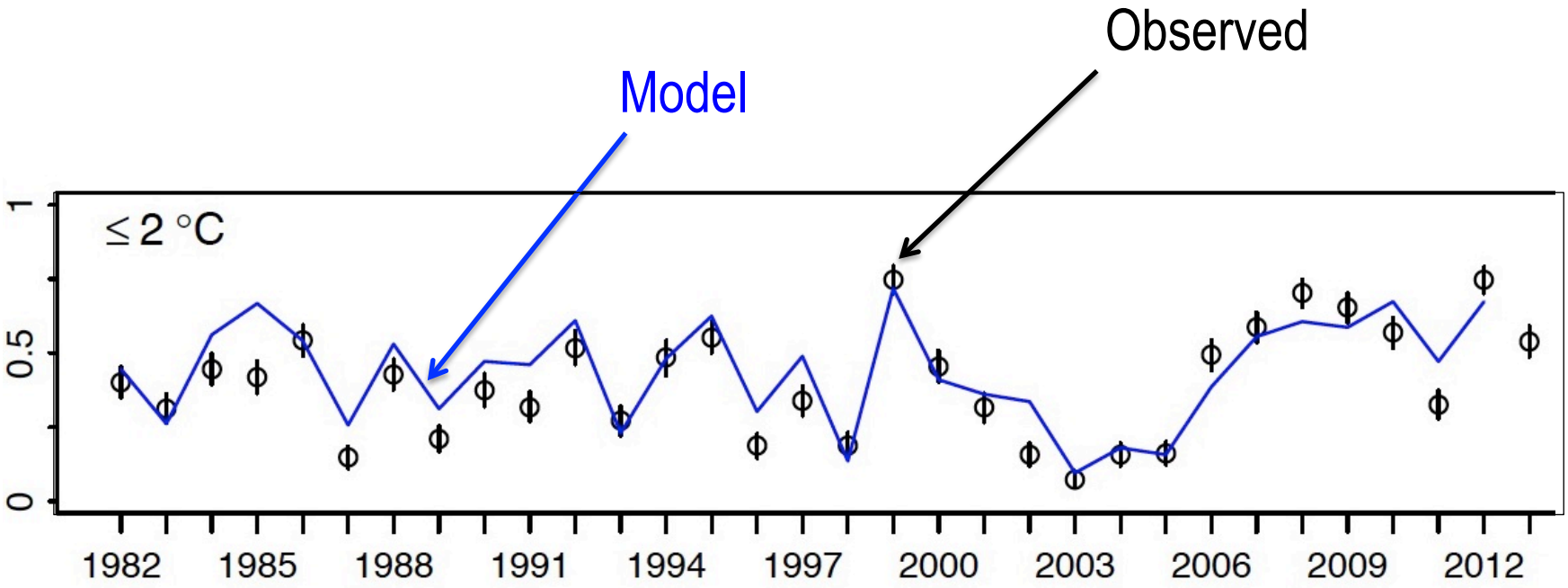
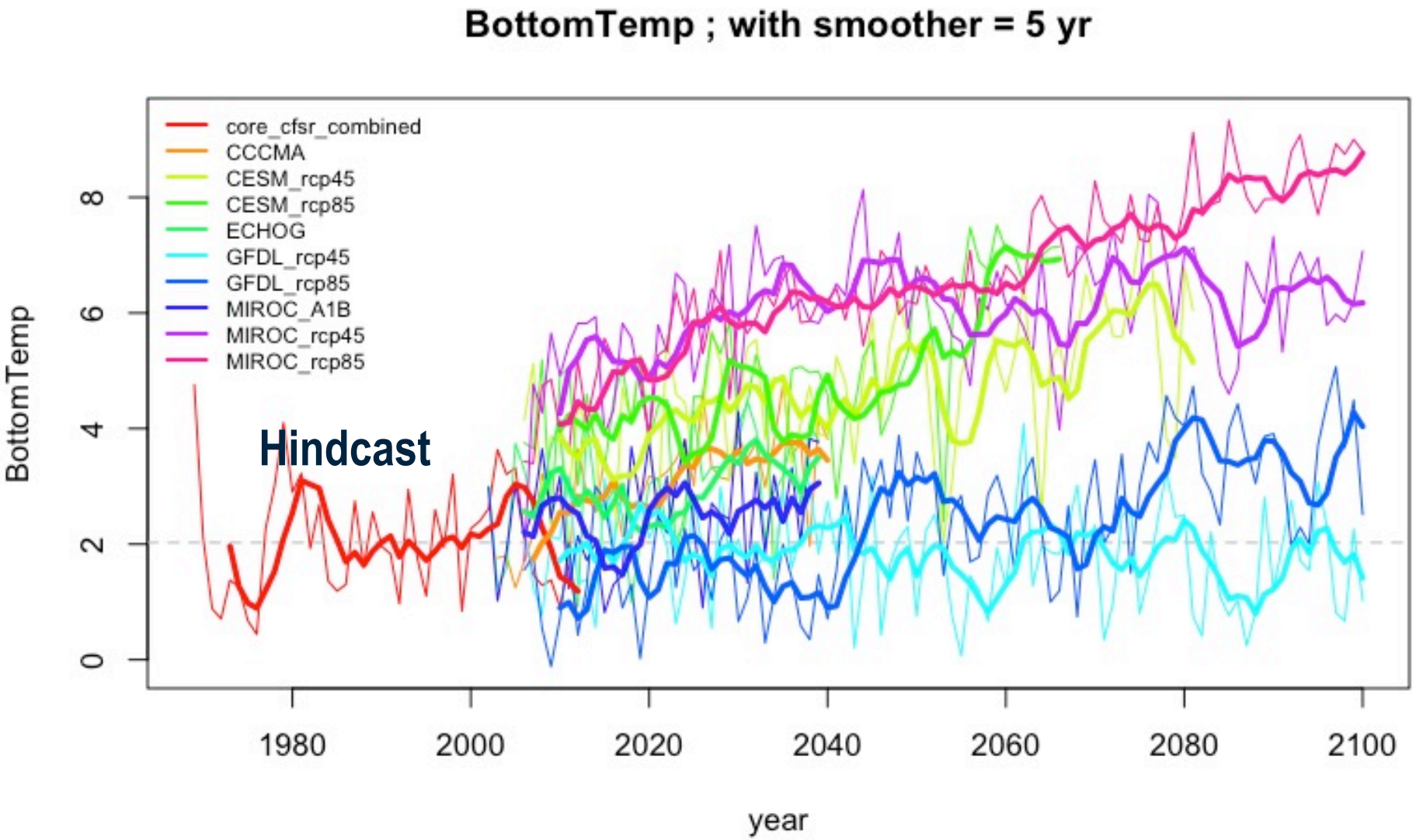
Model prediction: cold pool area



Ensemble of Bering10K output: Bottom Temperature



Biological modeling

Photo: Mark Holsman

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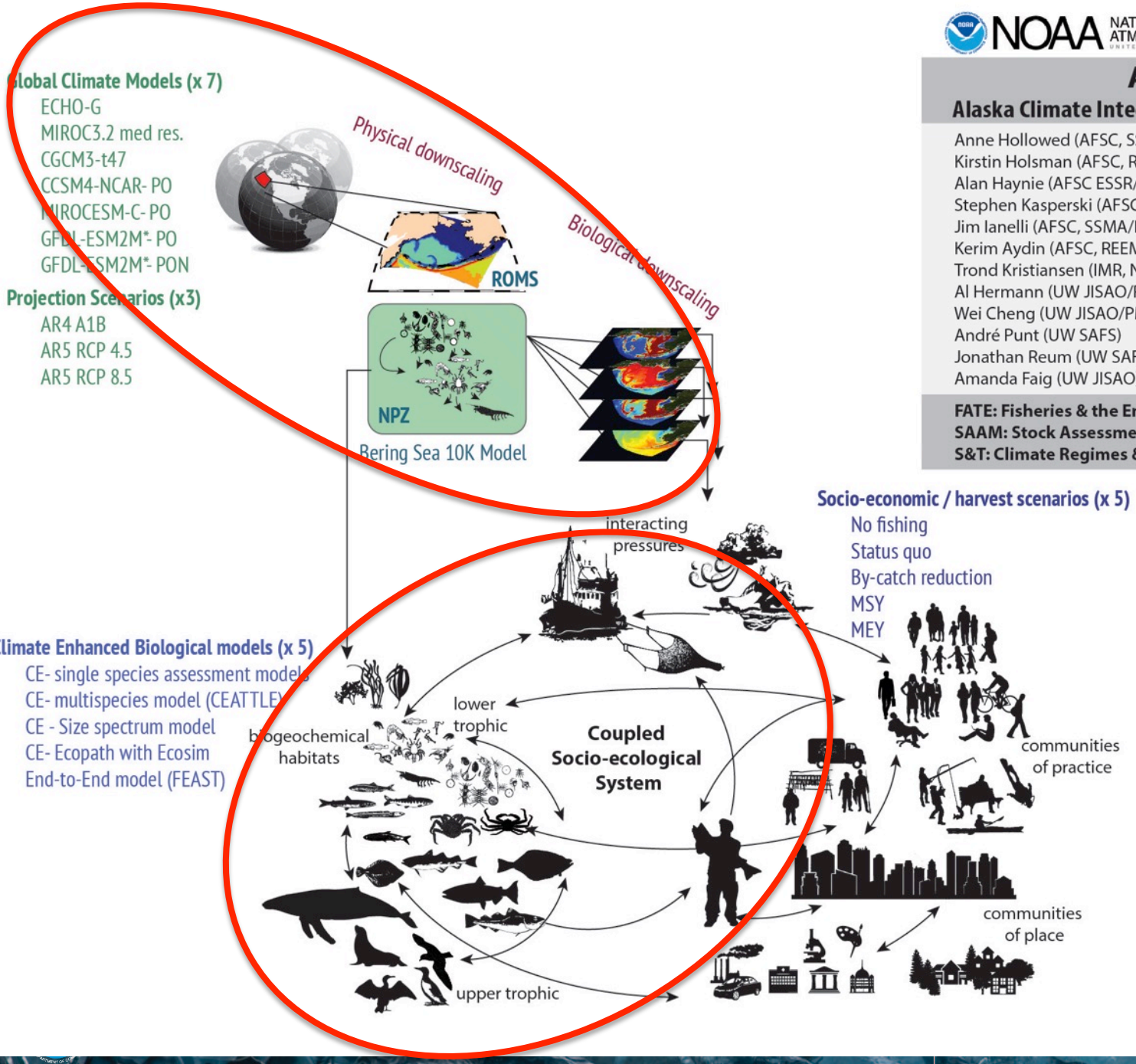

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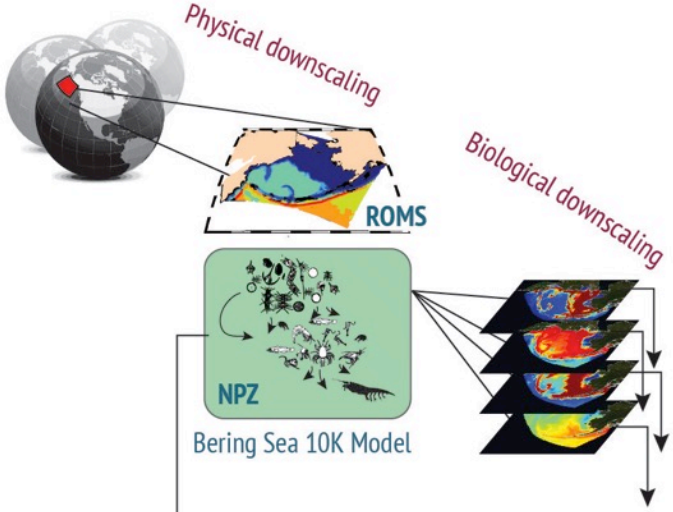

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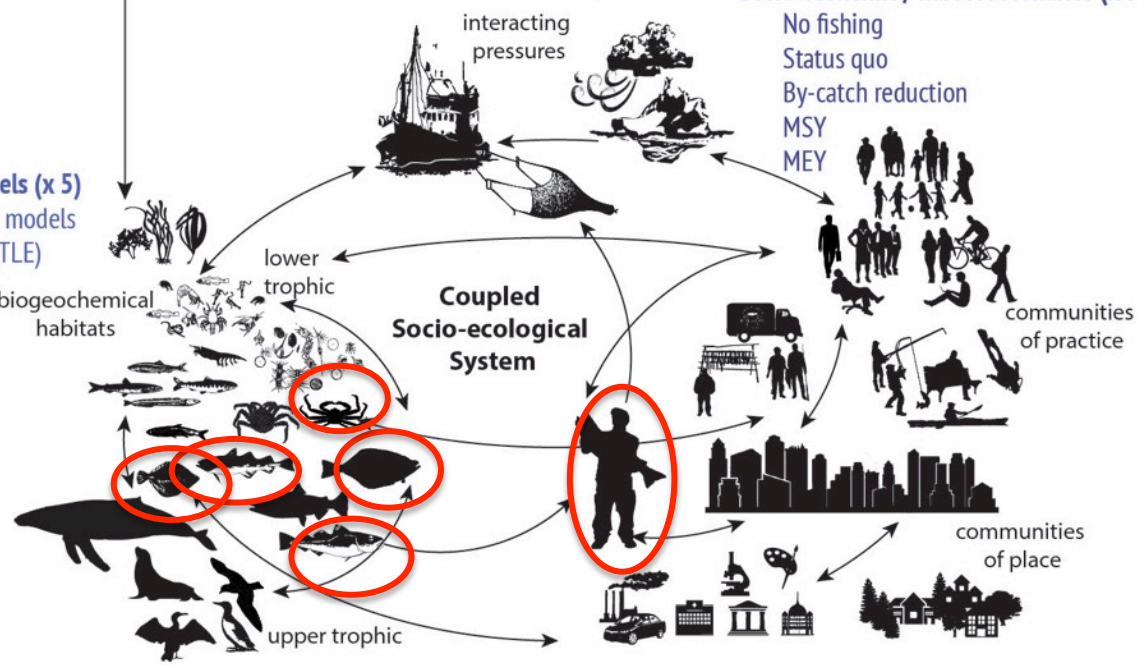
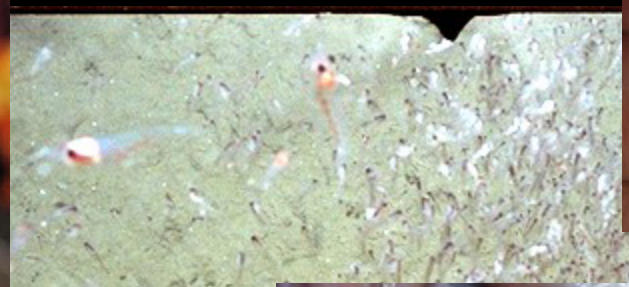
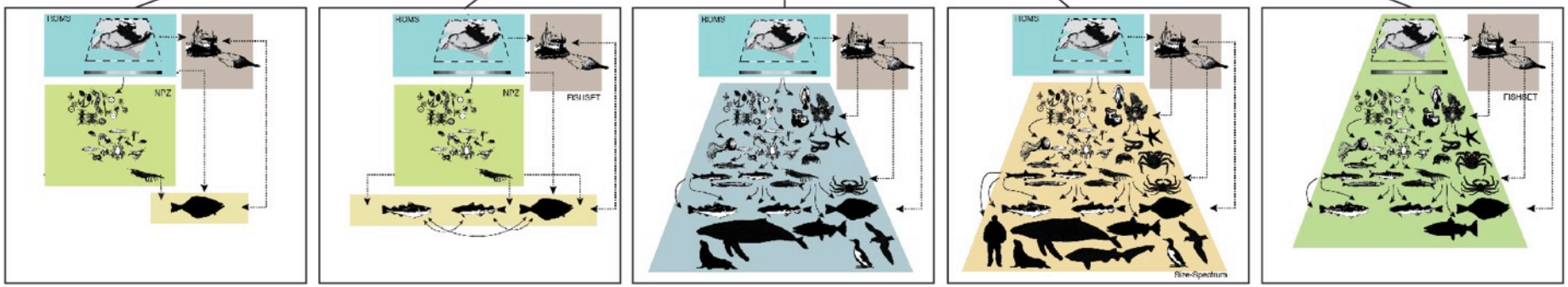


Mark Lovewell



Bering Sea Models



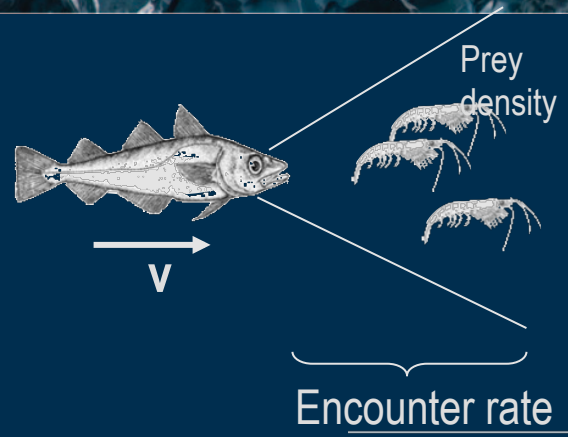
CE-SSM | CEATTLE | Ecosim | Size-Spectrum | FEAST

Additive Pressures

Multiple Interacting (non-linear) Pressures

Increasing model complexity

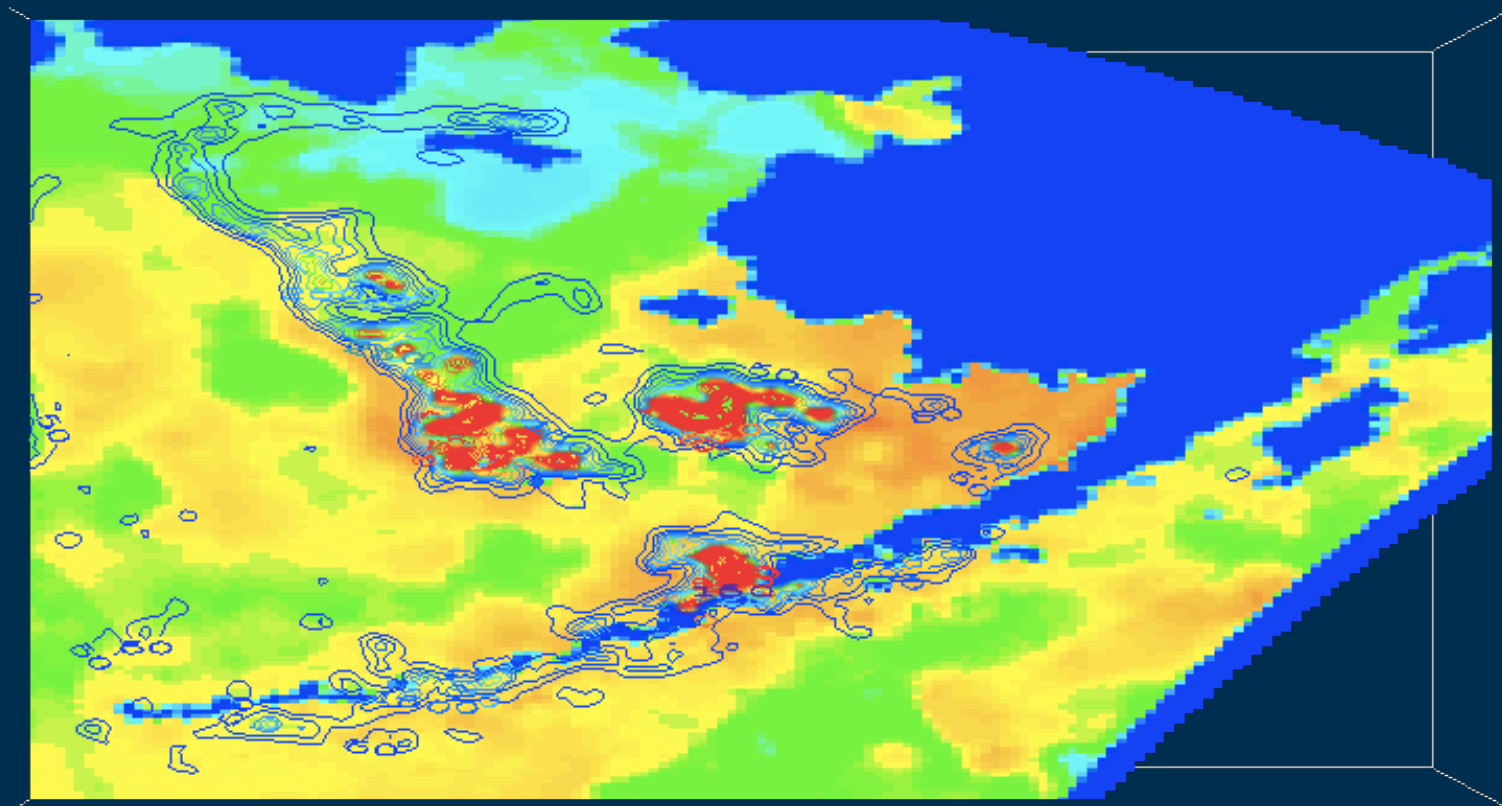
Faster



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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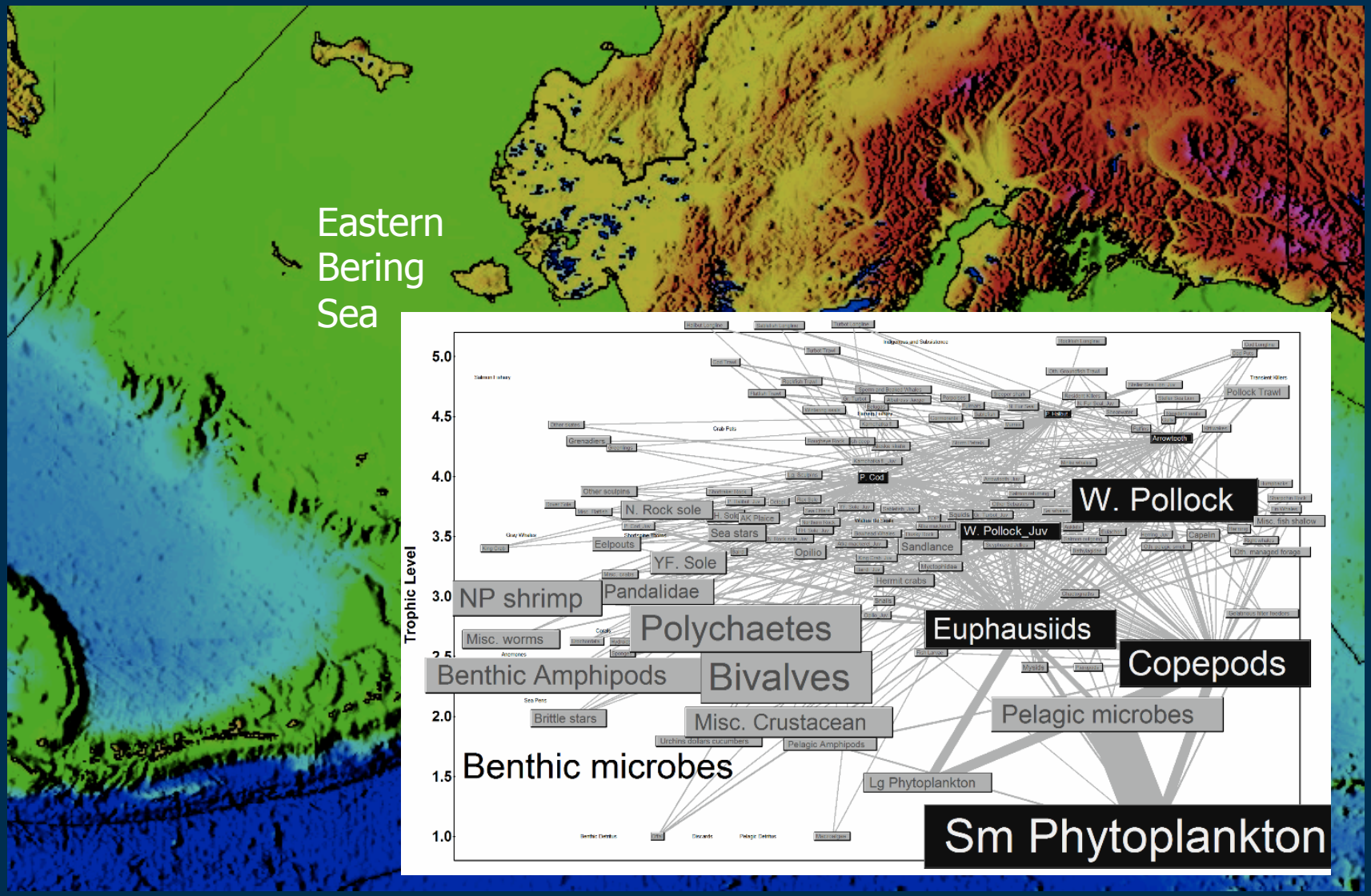
Ecopath food web model (Aydin et al. 2007)



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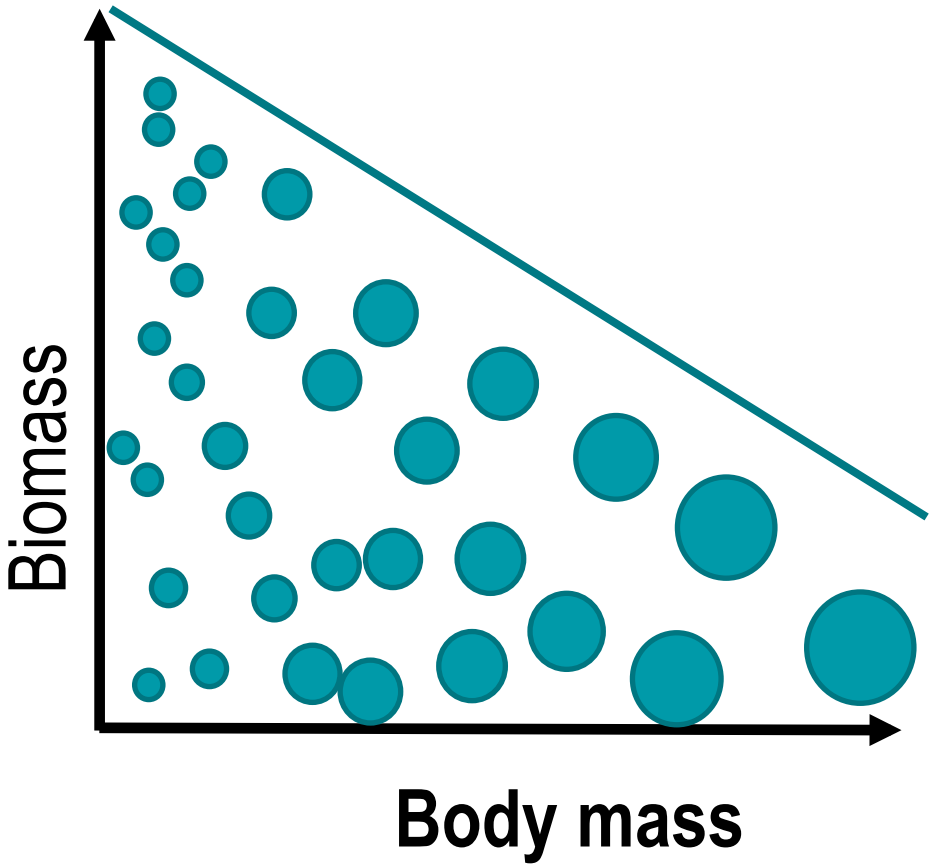
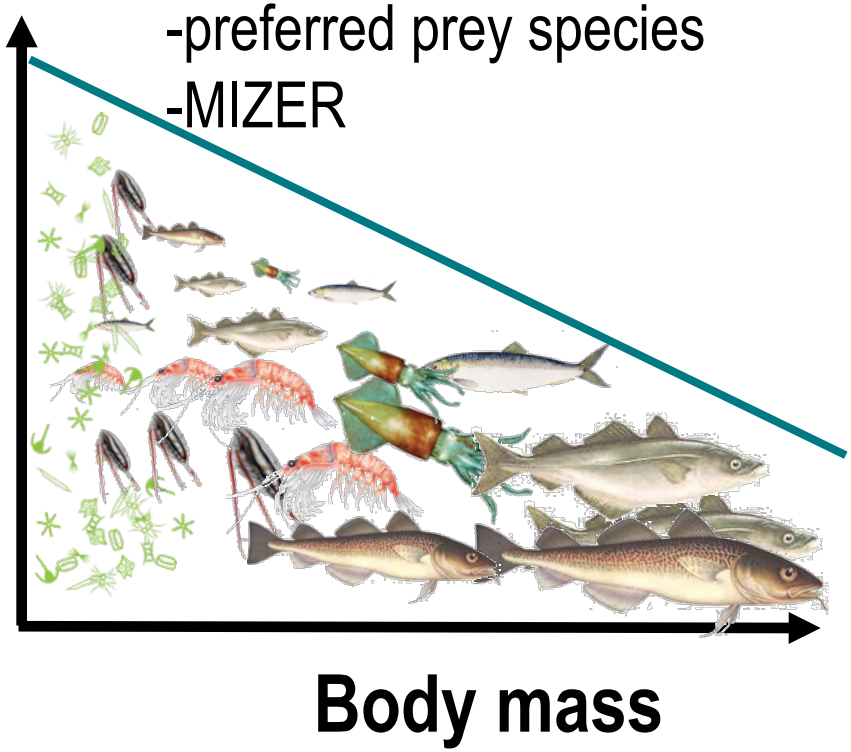
Size-spectrum model (Dr. Reum)

Particles that eat, grow and reproduce



Species level attributes

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



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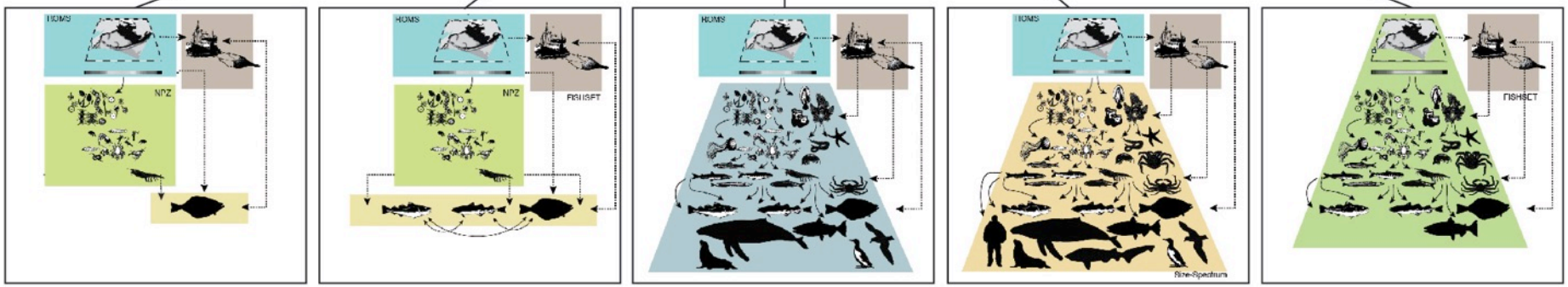

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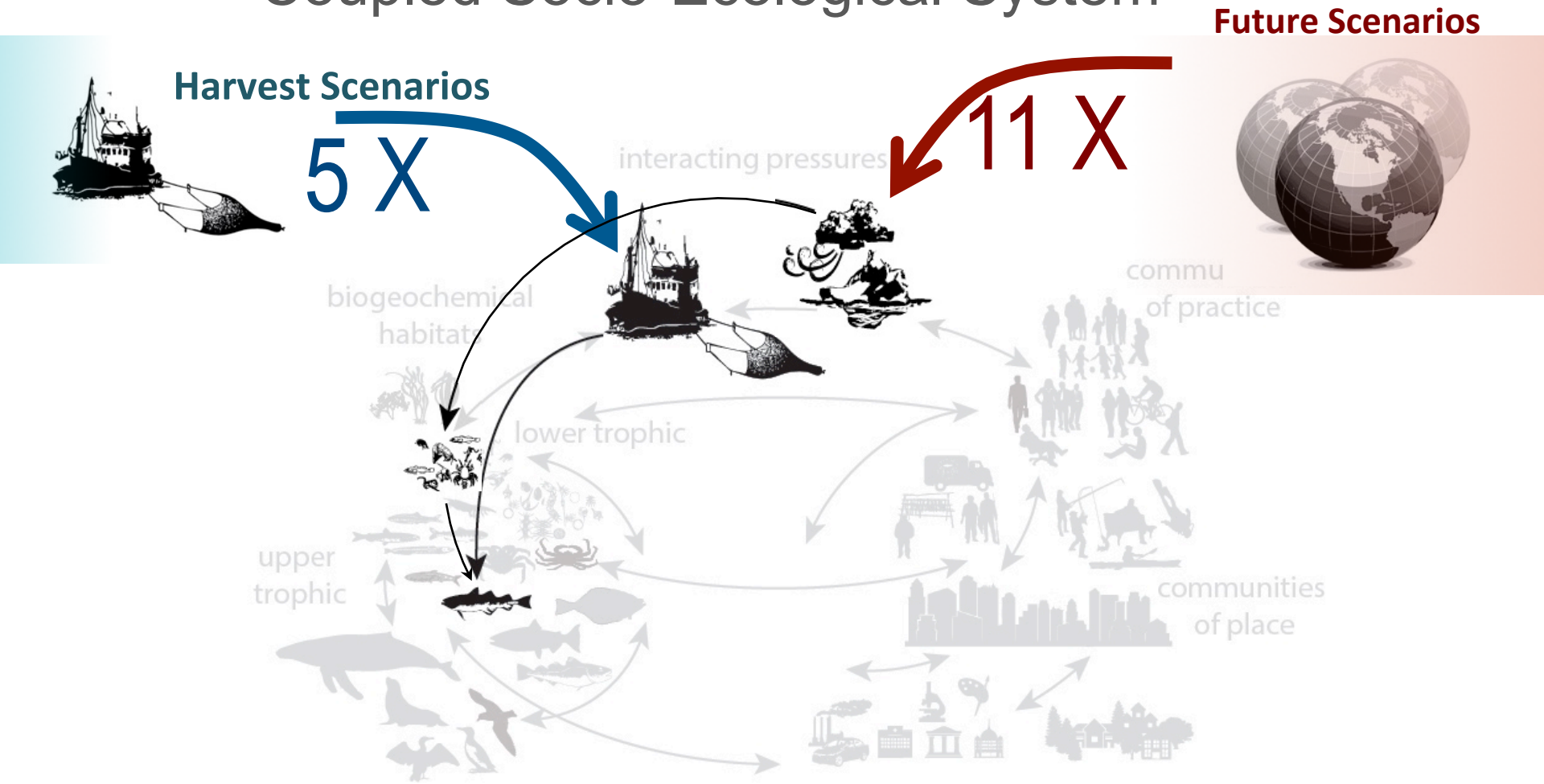
Multiple Interacting (non-linear) Pressures

Increasing model complexity

Faster

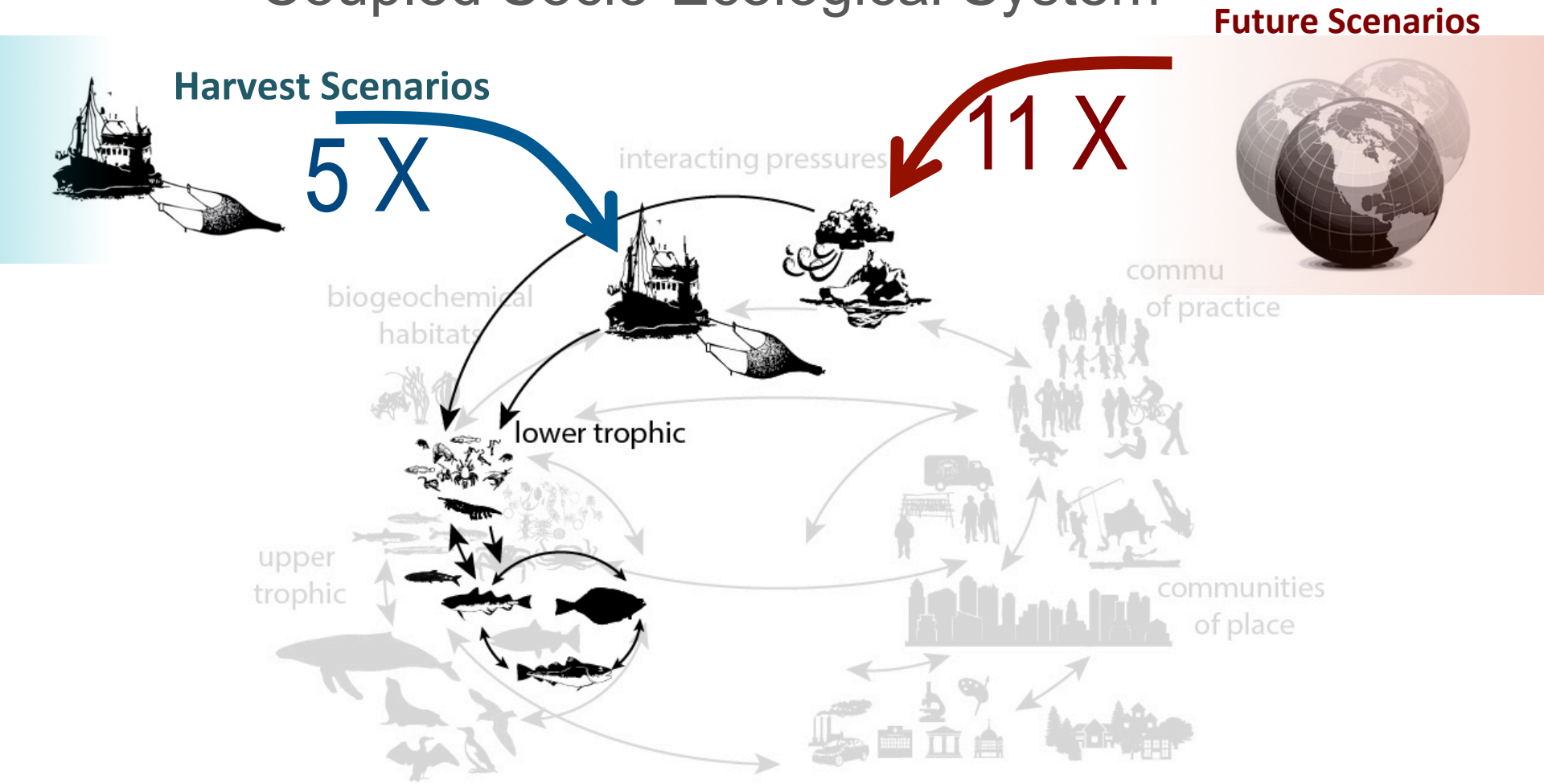
Coupled Socio-Ecological System



Climate-enhanced Multi-species Assessment Model

ACLIM: *Alaska Climate-change Integrated Modeling project*

Coupled Socio-Ecological System



Climate-enhanced Multi-species Assessment Model

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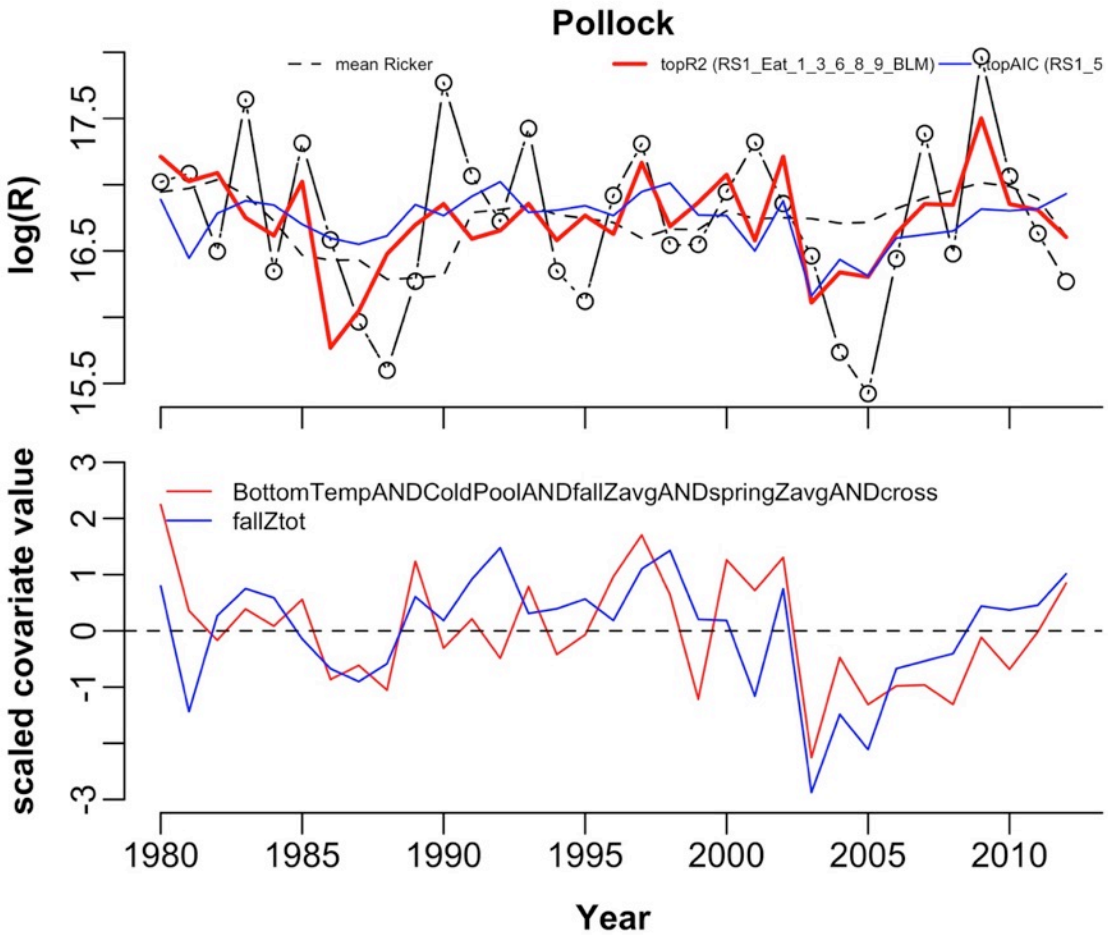
CEATTLE: Recruitment



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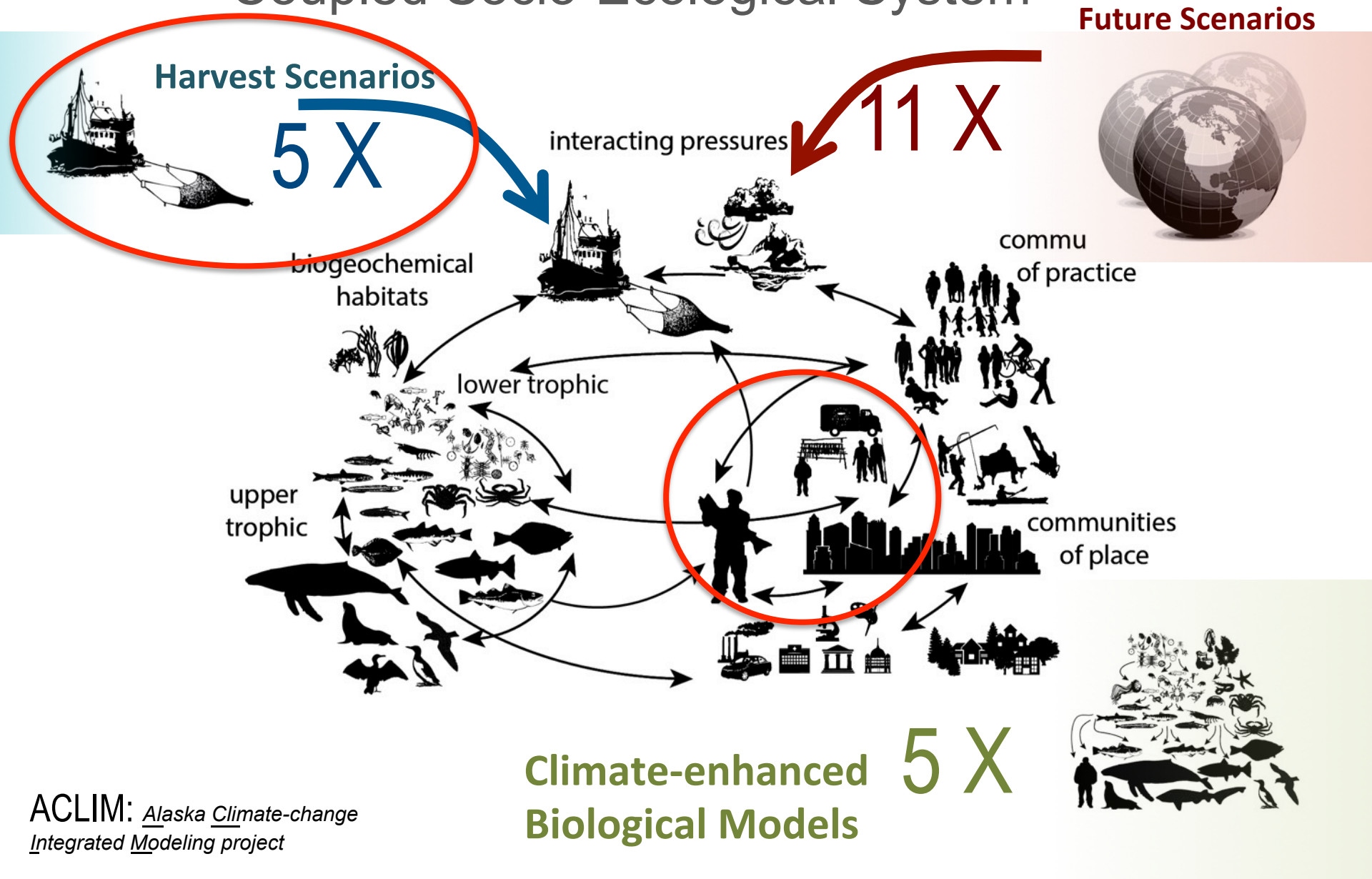

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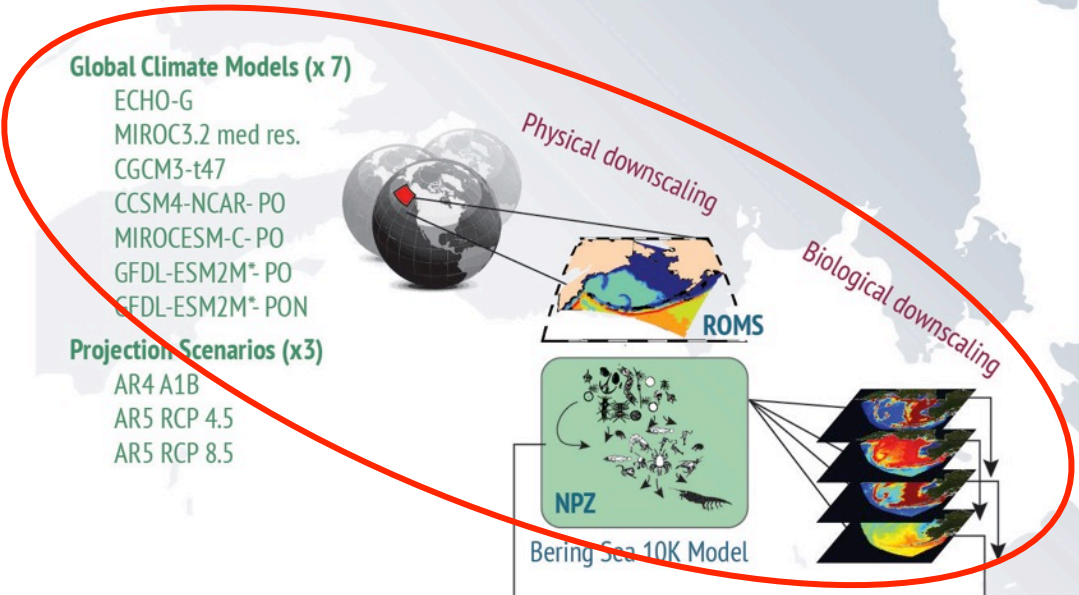

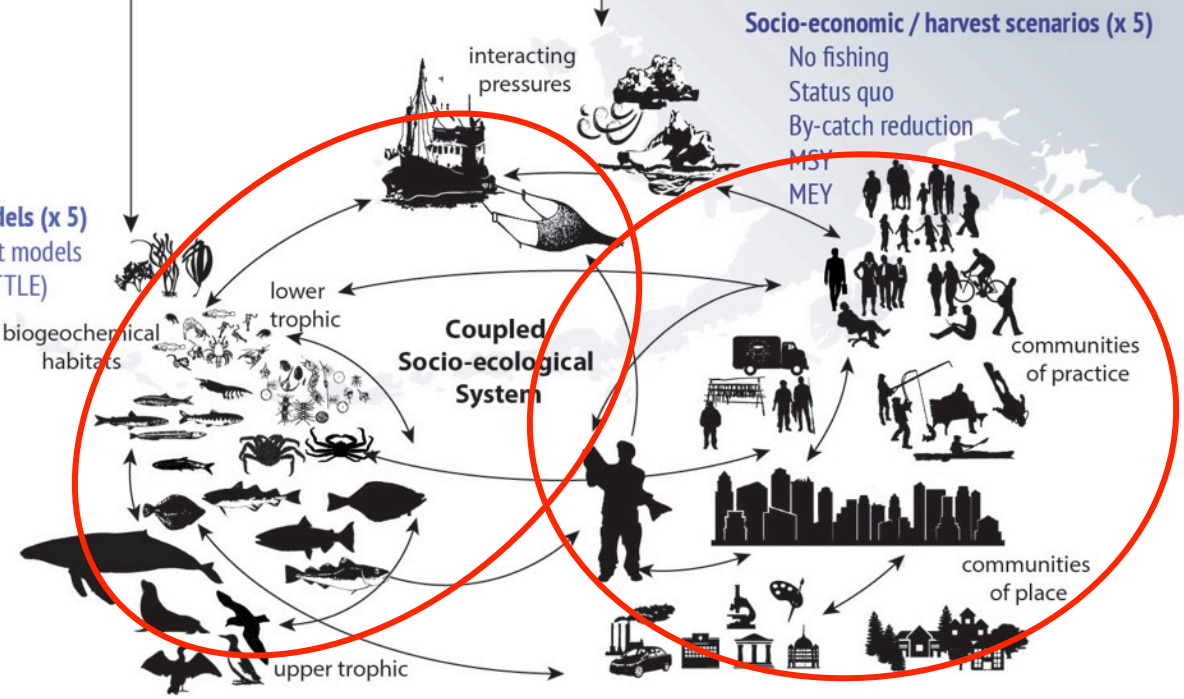

Socioeconomic Team

Stephen Kasperski

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Photo: Mark Holsman

Challenges

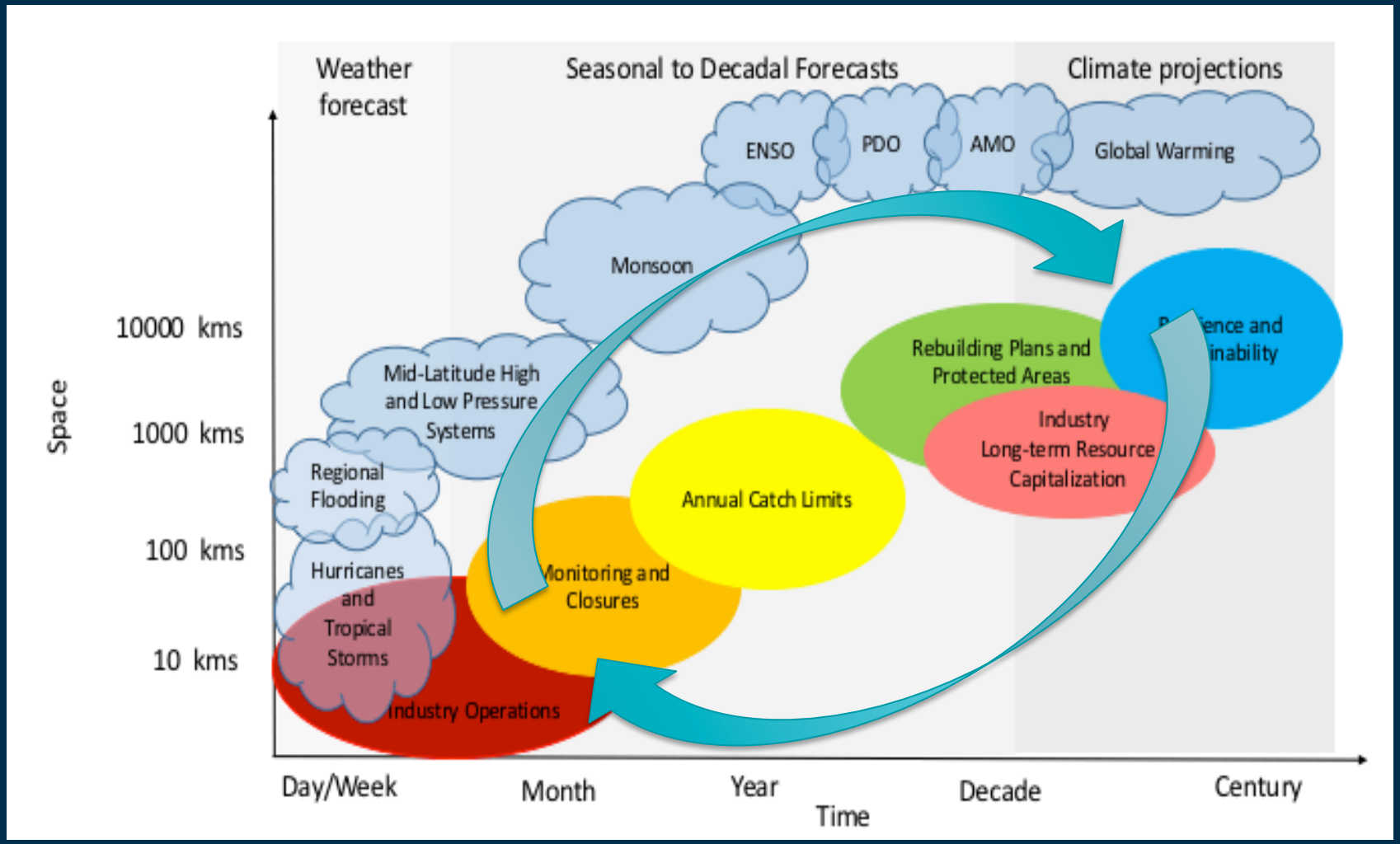
- GCM selection
- Computing capacity limitations
- Data-sharing/Translating model outputs
- Models based on current ecological understanding
- Evolution of models to incorporate nascent science

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

Photo: Mark Holsman

Marine resource management decisions across space and time scales



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Tommasi et al., (in revision)

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!

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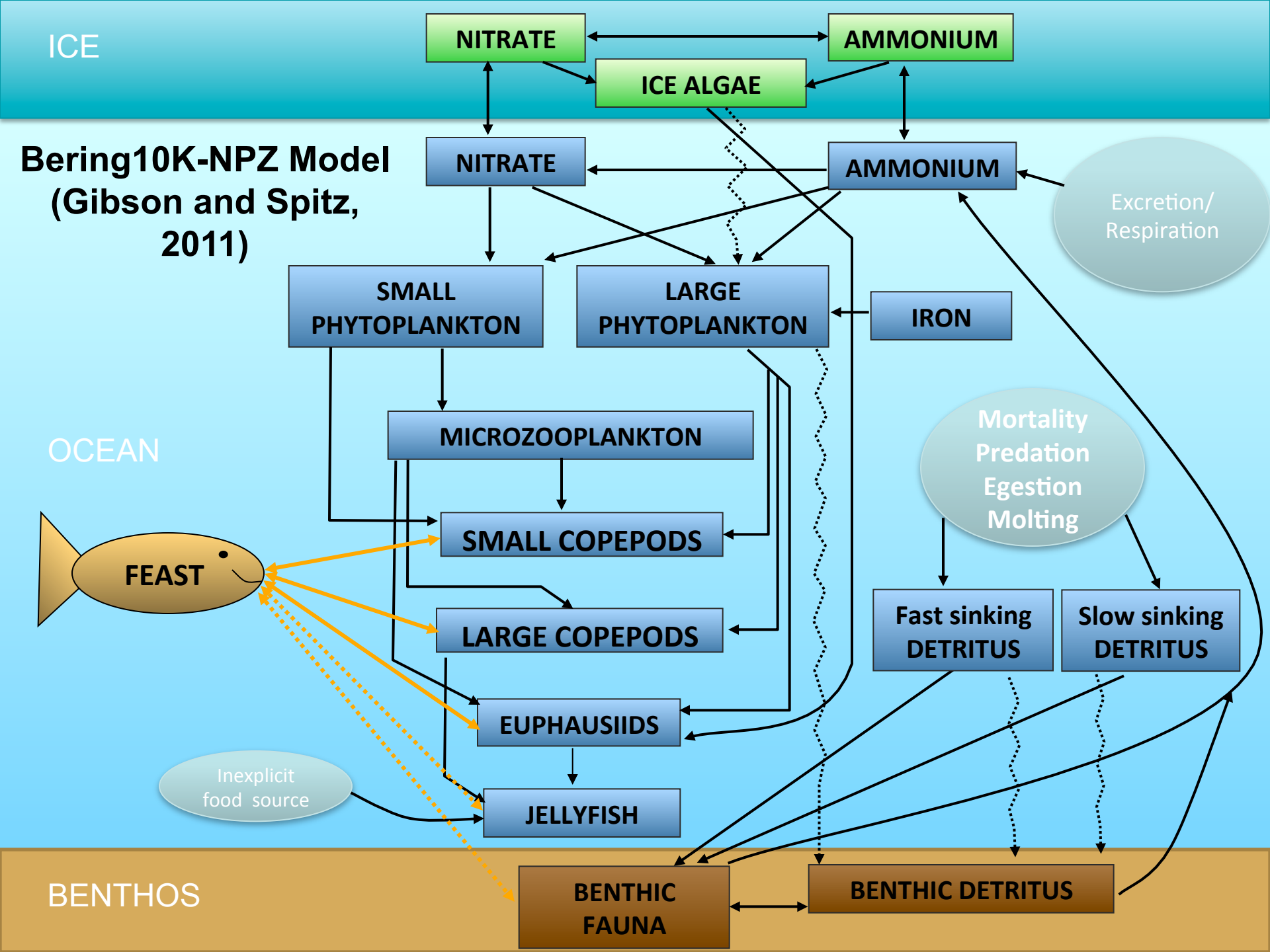
S&T: Climate Regimes & Ecosystem Productivity

NOAA FISHERIES


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
FEAST
SMALL COPEPODS
LARGE COPEPODS
Fast sinking DETRITUS
Slow sinking DETRITUS
EUPHAUSIIDS
Inexplicit food source
JELLYFISH
BENTHOS
BENTHIC FAUNA
BENTHIC DETRITUS