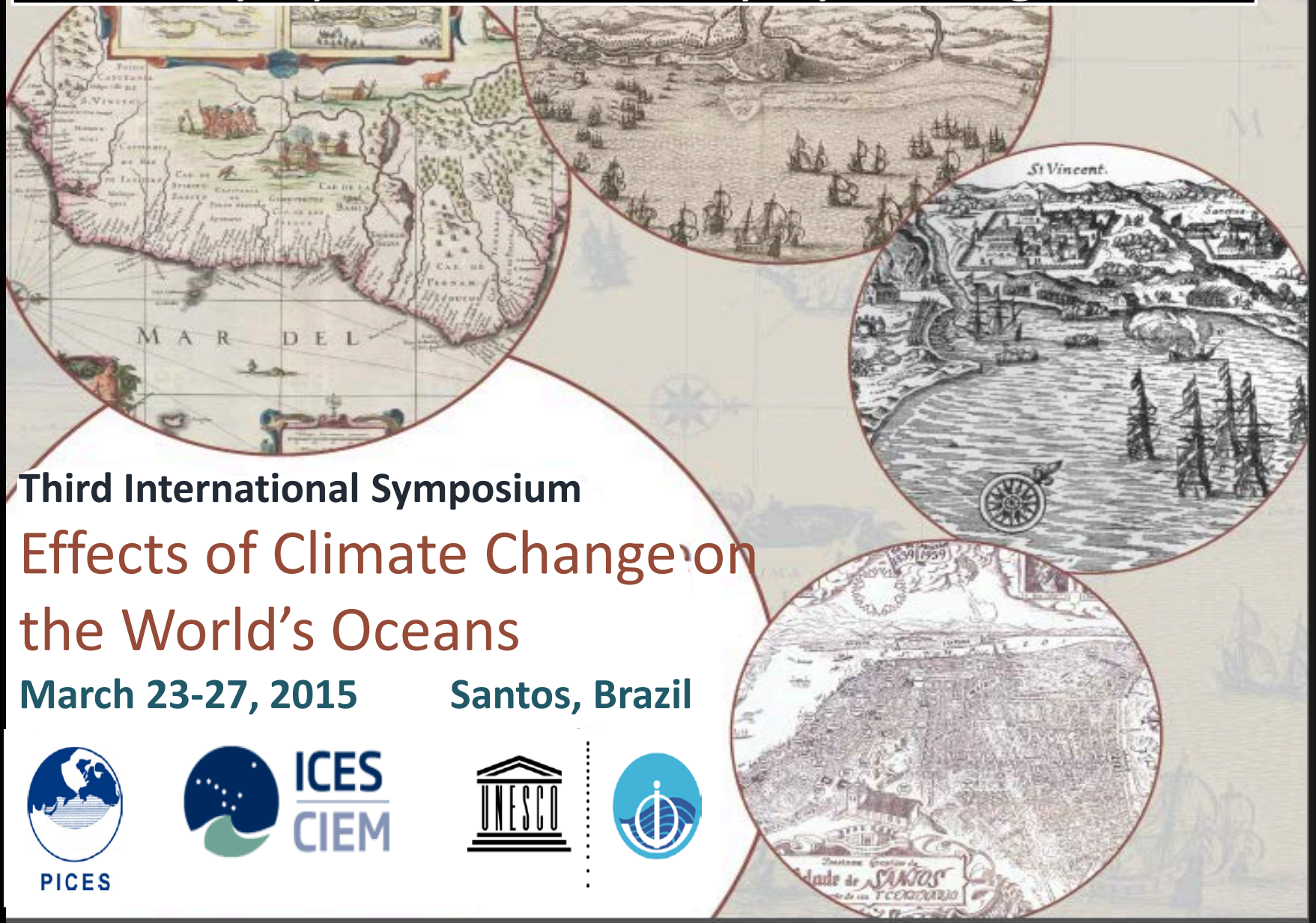
Biological Perspectives

3rd Meeting of Scientific Experts on Fish Stocks in Central Arctic Ocean, April 2015

ANNE HOLLOWED, ALASKA FISHERIES SCIENCE CENTER

SELECTED PRESENTATIONS FROM 3RD EFFECTS OF CLIMATE CHANGE ON THE WORLD'S OCEANS SYMPOSIUM, SANTOS, BRAZIL

RESEARCH HIGHLIGHTS – Adapted from Symposium Summary by Barange



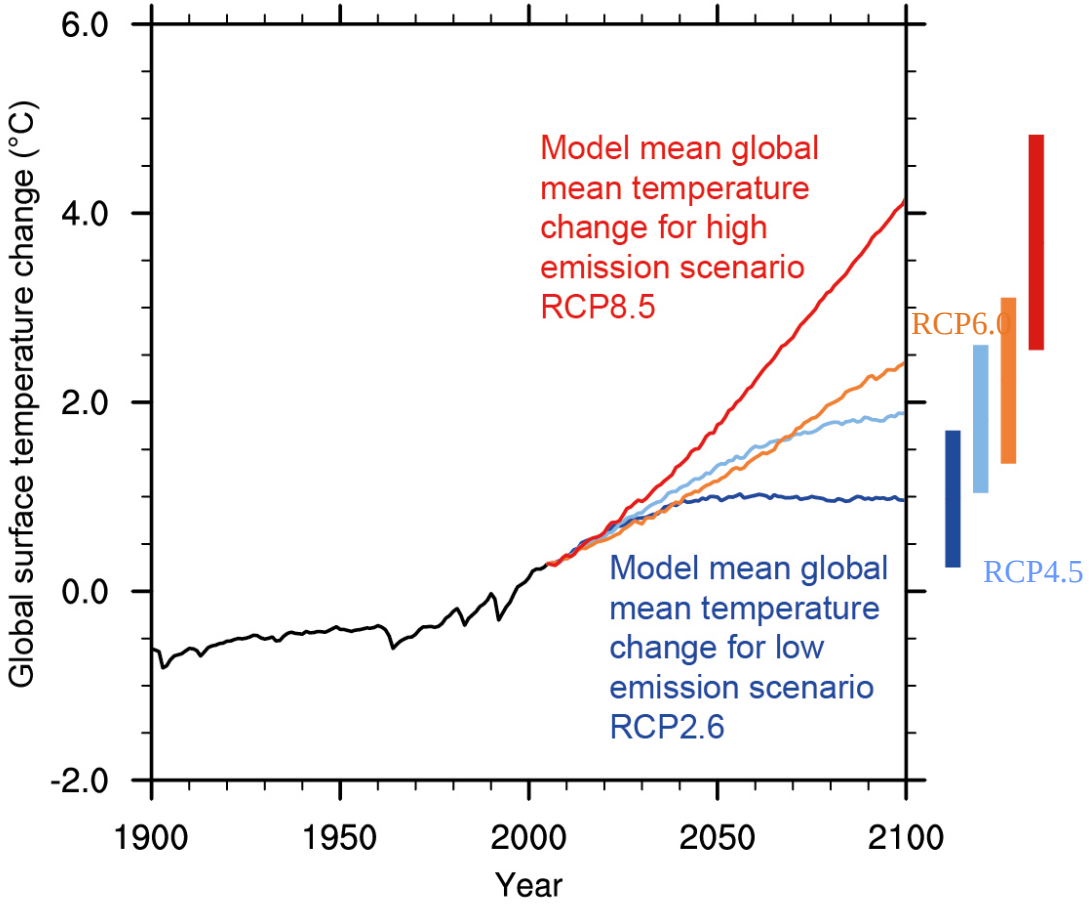
Third International Symposium

Effects of Climate Change on the World's Oceans

March 23-27, 2015 **Santos, Brazil**

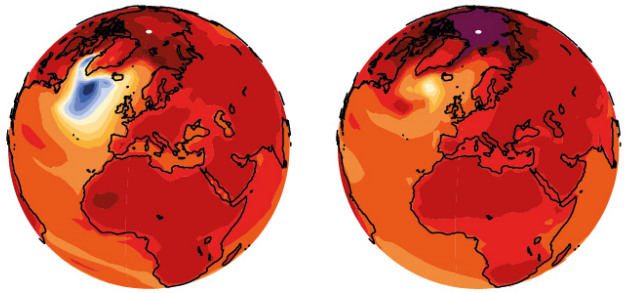
PICES ICES CIEM UNESCO

Reasonable Concentration Pathway emission scenarios of global mean temperature change (relative to 1986-2005)

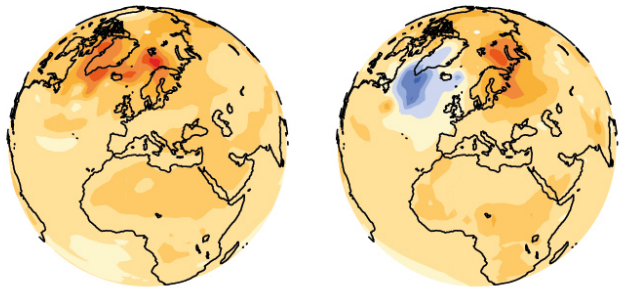


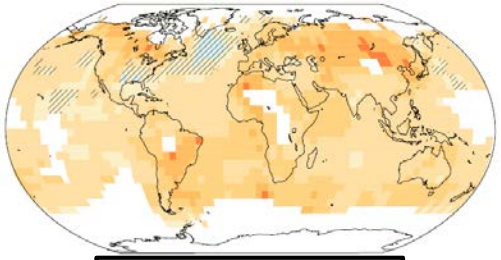
IPCC WGI Chp12

Possible temperature responses in 2081-2100 to high emission scenario RCP8.5



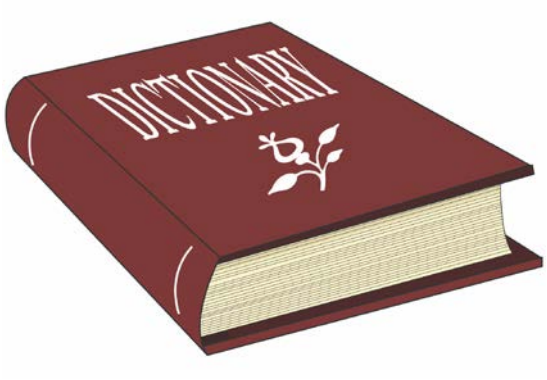
Possible temperature responses in 2081-2100 to low emission scenario RCP2.6





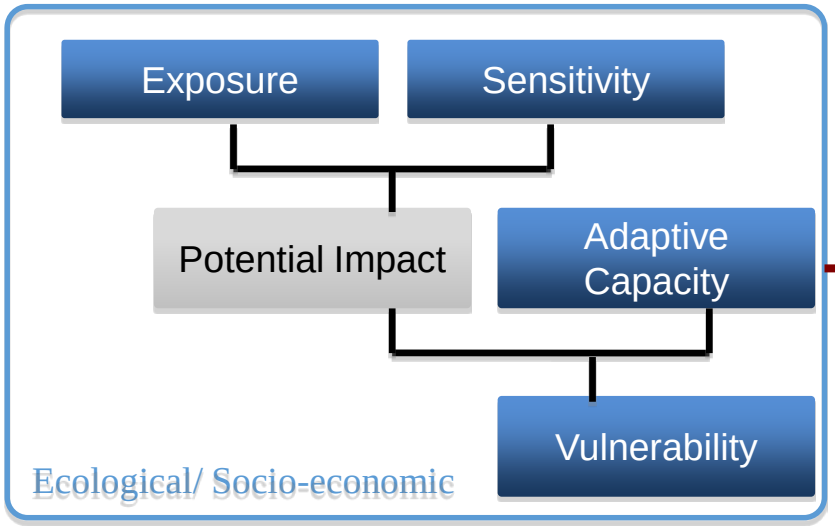
1901-2012

Chris Field (Keynote) - "Mapping the problem space and the opportunity space"

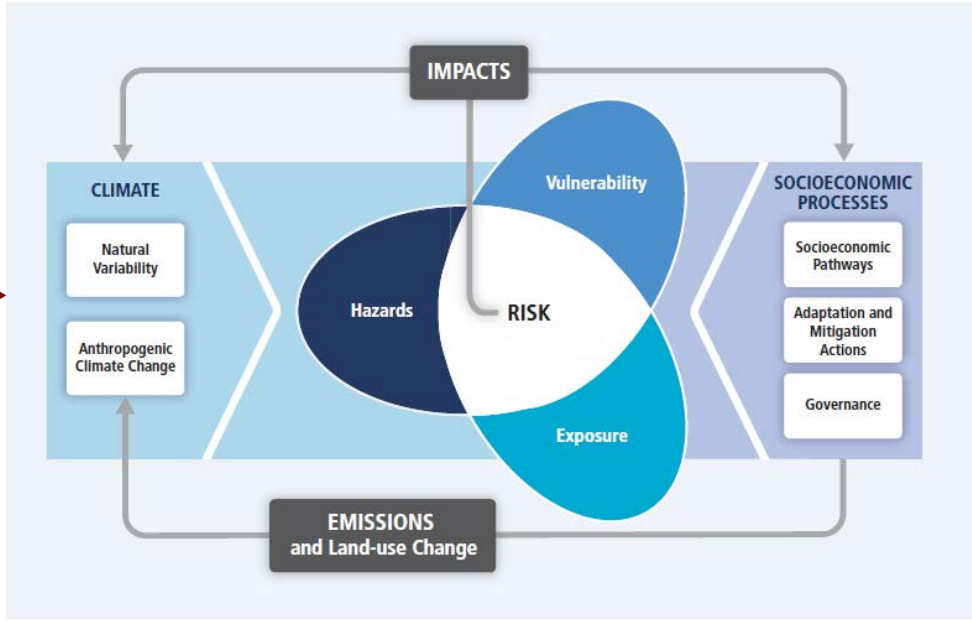


Chris Field (Keynote) - "Mapping the problem space and the opportunity space"

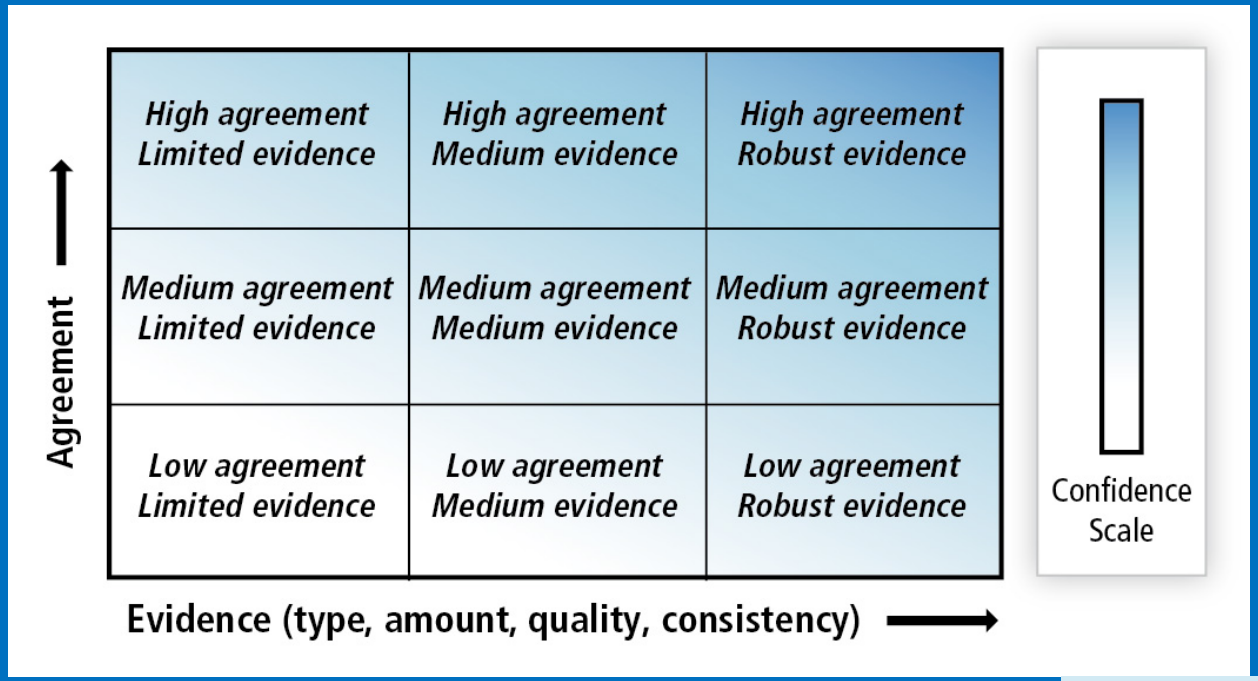
Intergovernmental Panel on Climate Change 4th Assessment Report (2007)



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



Communication of Uncertainty



Confidence in the validity of a finding

Term*	Likelihood of the outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

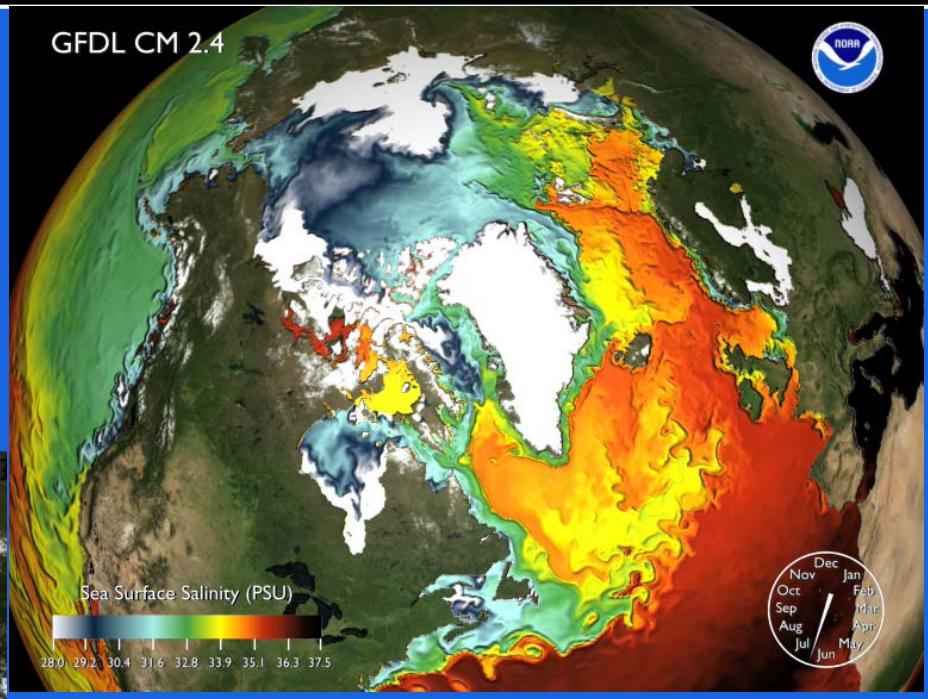
* Additional terms used more occasionally are *extremely likely*: 95–100% probability, *more likely than not*: >50–100% probability, and *extremely unlikely*: 0–5% probability.

Quantified measures of uncertainty in a finding

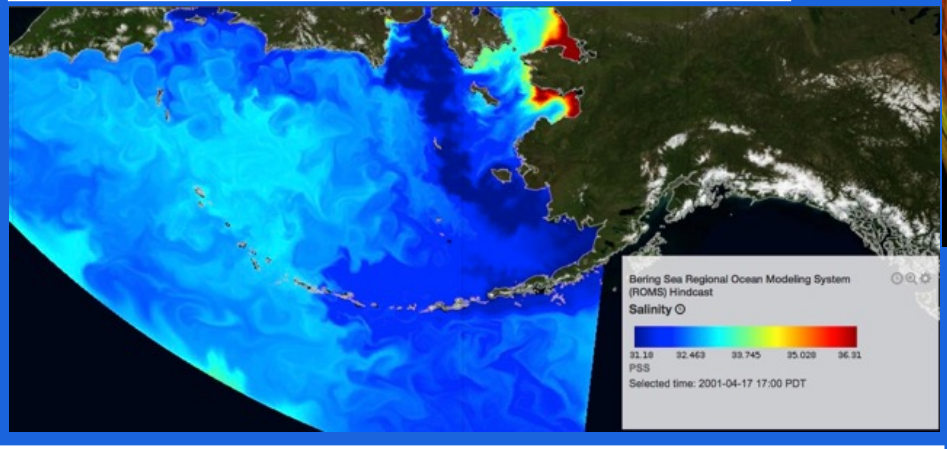
IPCC WGII Chp1

1. While Global Climate Models continue to provide crucial information on CC impacts, we need more regional models of the dynamics of the ocean under climate change

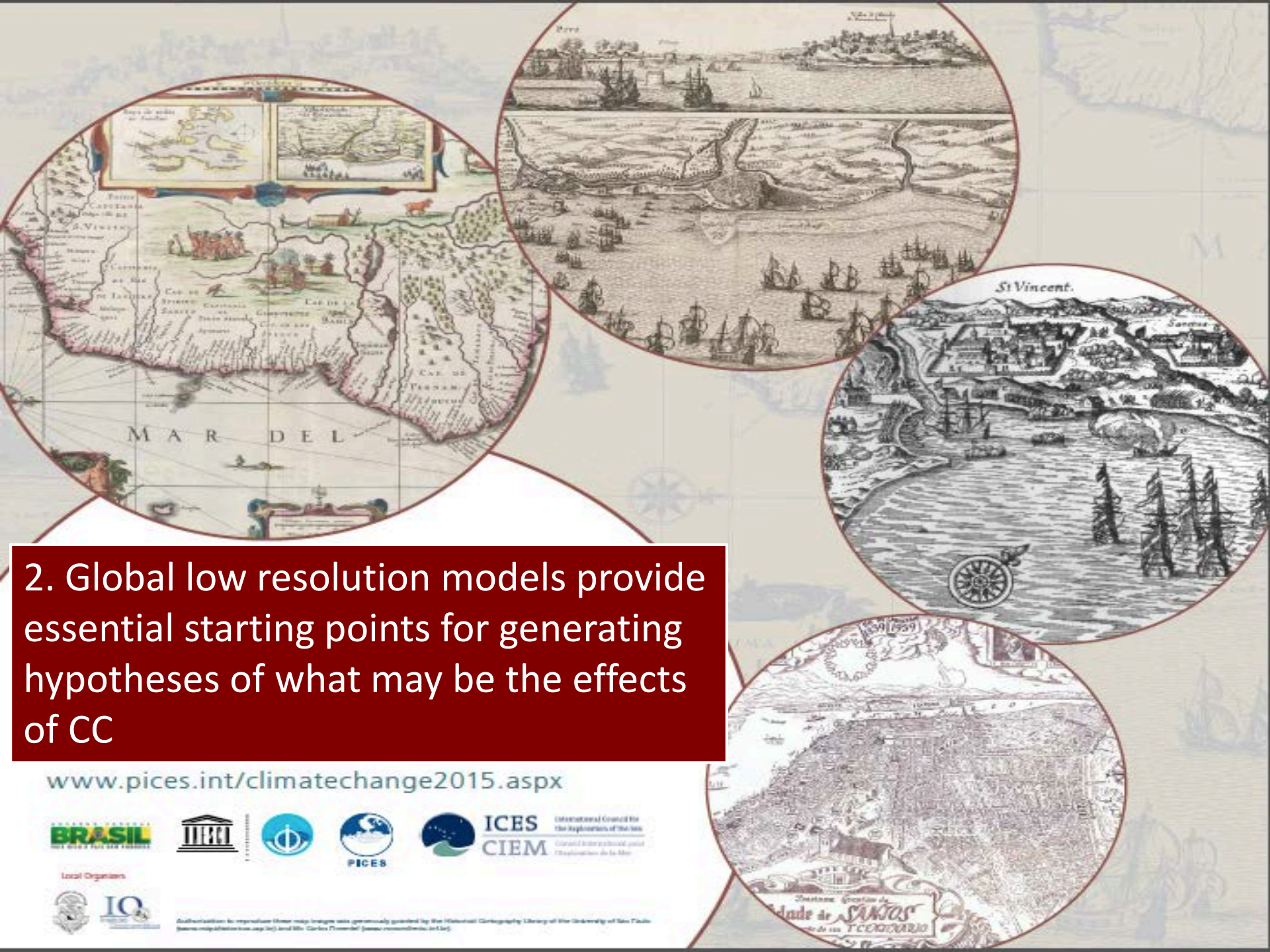
Geophysical Fluid Dynamics Laboratory high resolution coupled model CM 2.4 Arctic Ocean Salinity
http://www.gfdl.noaa.gov/visualizations-oceans



Bering Sea – high resolution Regional Ocean Model



Ortiz (S4) - "Regional models for predictions of climate change impacts: methods, uncertainties and challenges"



2. Global low resolution models provide essential starting points for generating hypotheses of what may be the effects of CC

www.pices.int/climatechange2015.aspx

BRASIL

PICES

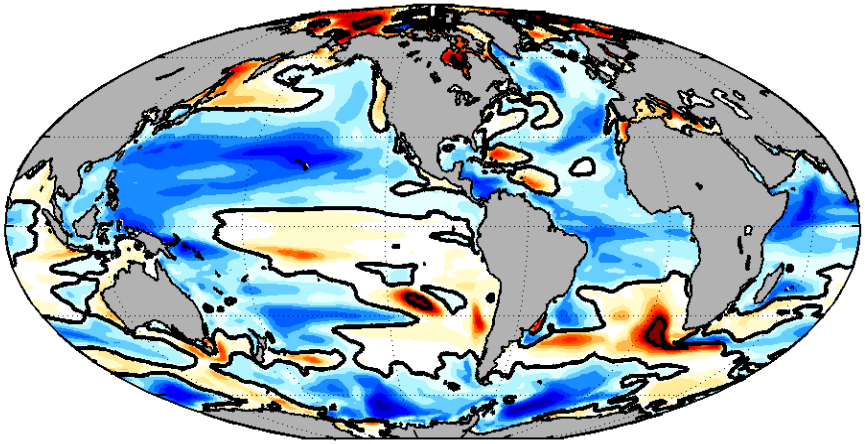
ICES

CIEM

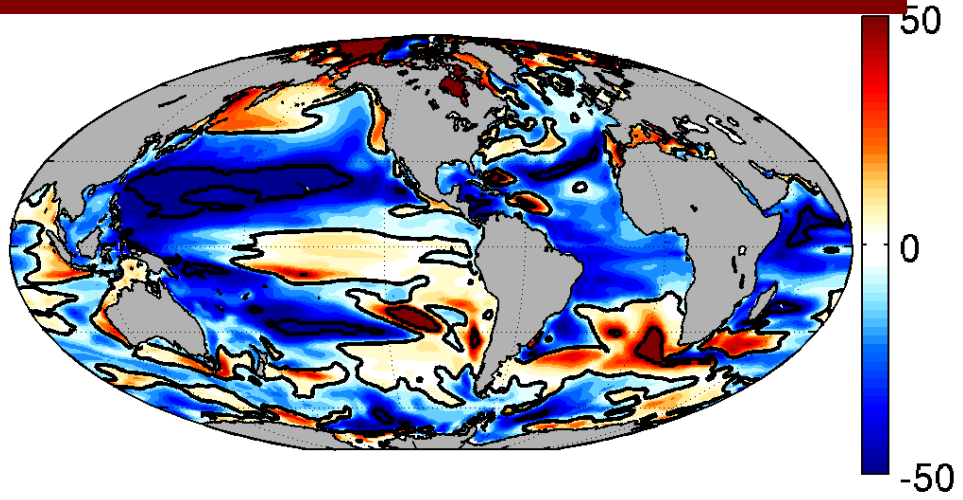
Local Organizers

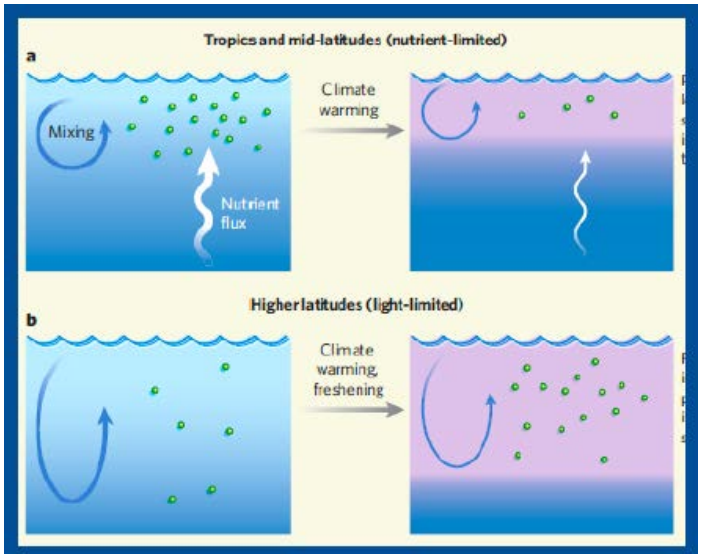
Charlie Stock (S4) - "Trophic amplification of ocean productivity trends in a changing climate"

% NPP Change (-3.6%)

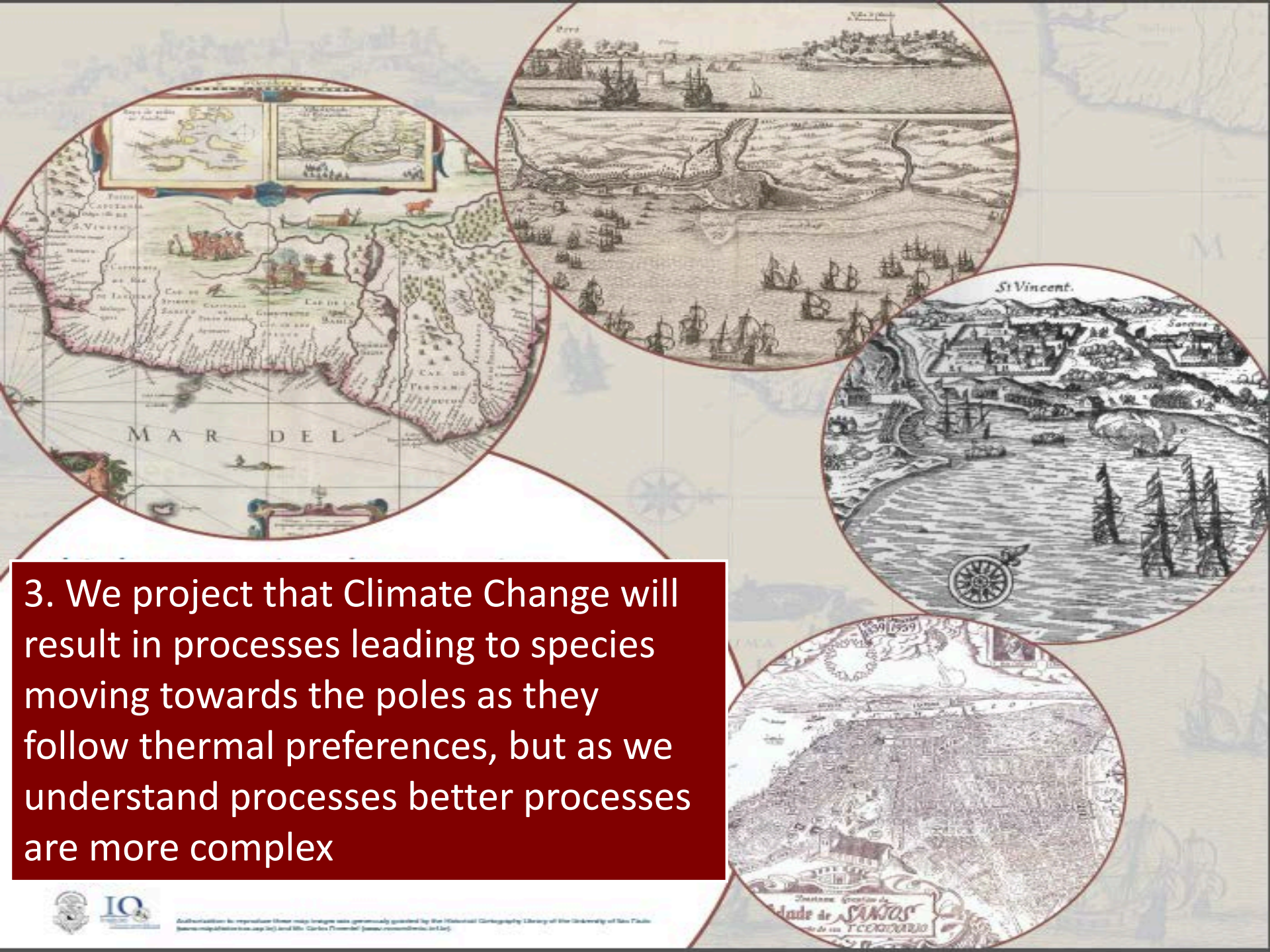


% MESOZP Change (-7.9%)



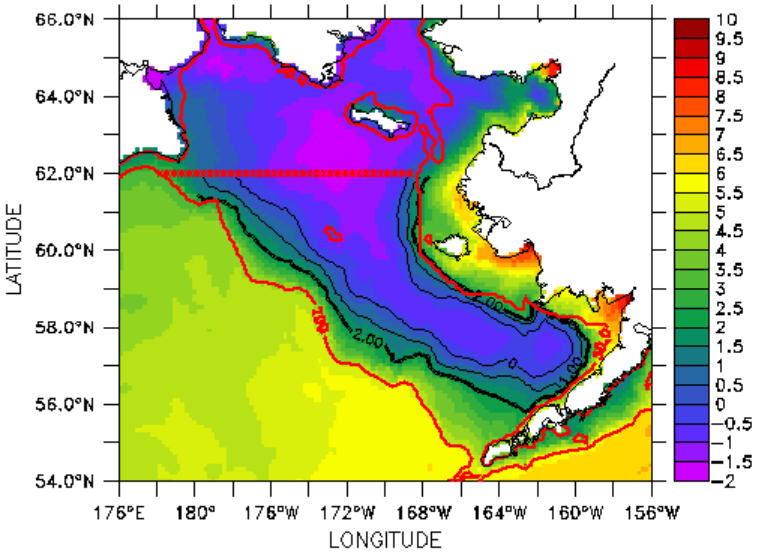


- GFDL's Earth System Model 2M-COBALT Earth System Model, 2050-2099 vs 1950-2000
- MESOZP change attributed to NPP change and three planktonic food web properties - zooplankton growth efficiency (ZGE), and the zooplankton (zooplankton-phytoplankton coupling, ZPC).
- The ZGE results in the amplified drop of the subtropics mesozooplankton production, while ZPC amplifies NPP increase effect in the Arctic

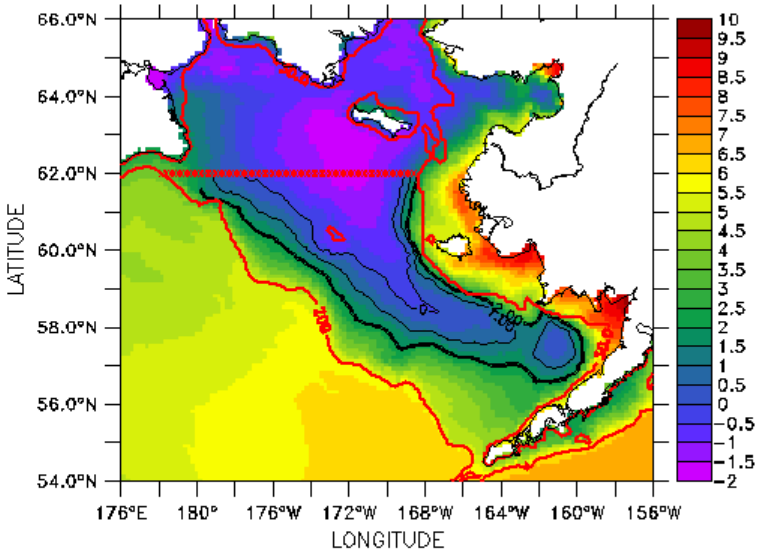


3. We project that Climate Change will result in processes leading to species moving towards the poles as they follow thermal preferences, but as we understand processes better processes are more complex

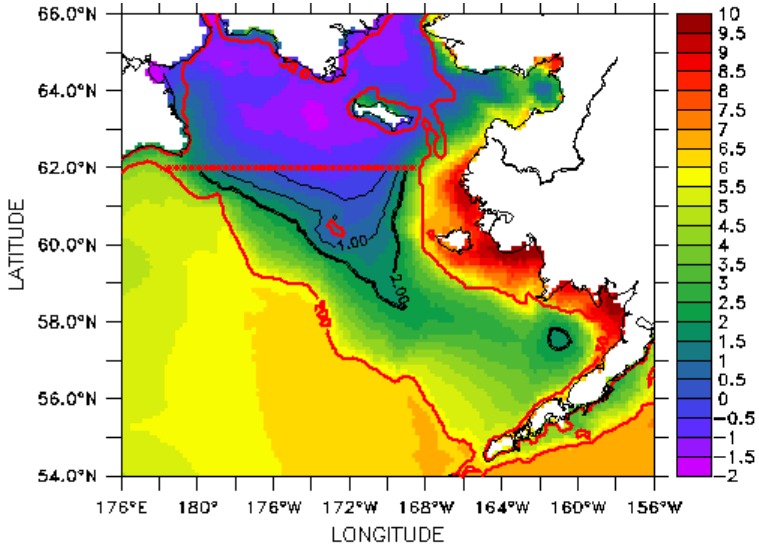
Projected EBS July bottom temperatures in SE Bering Sea (Al Hermann JISAO)



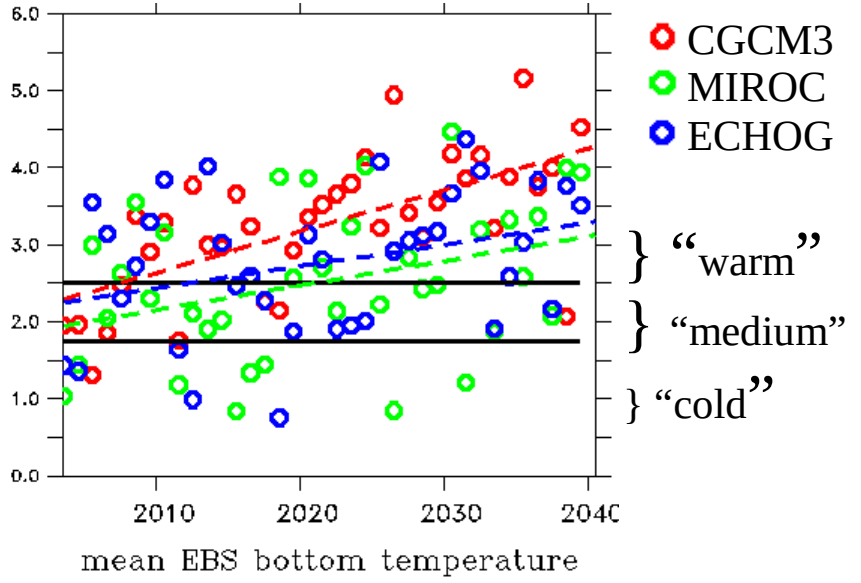
ensemble ave cold year



ensemble ave medium year



ensemble ave warm year

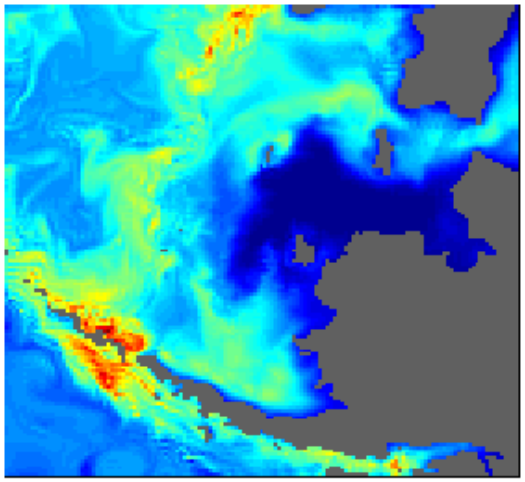


mean EBS bottom temperature

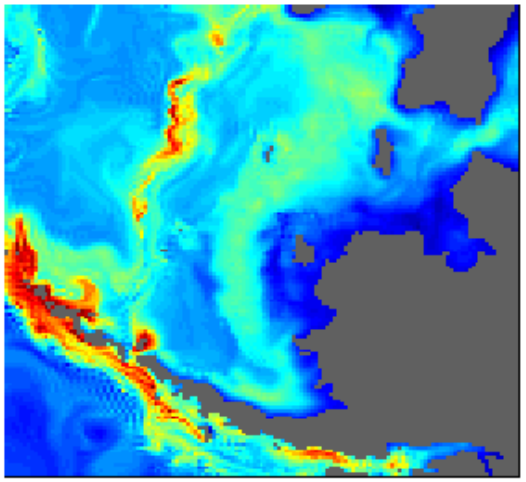
The Foraging Hotspots (Coupled bio-physical model)

Simulated Food supply

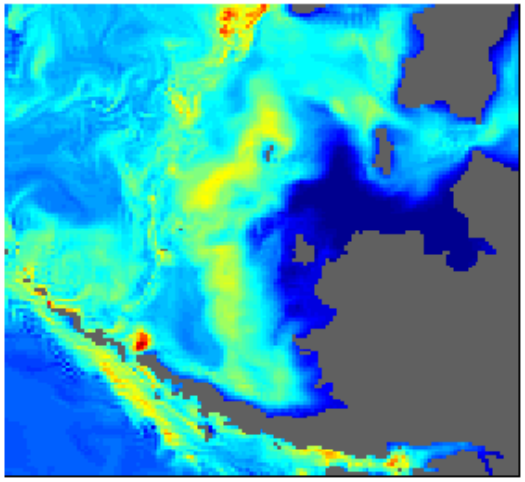
July 1975 (cold)



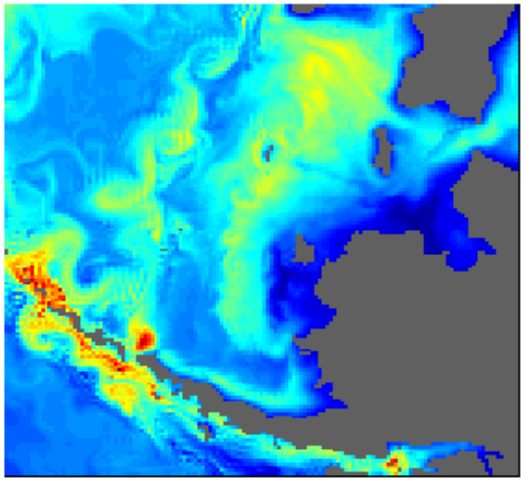
July 2004 (warm)



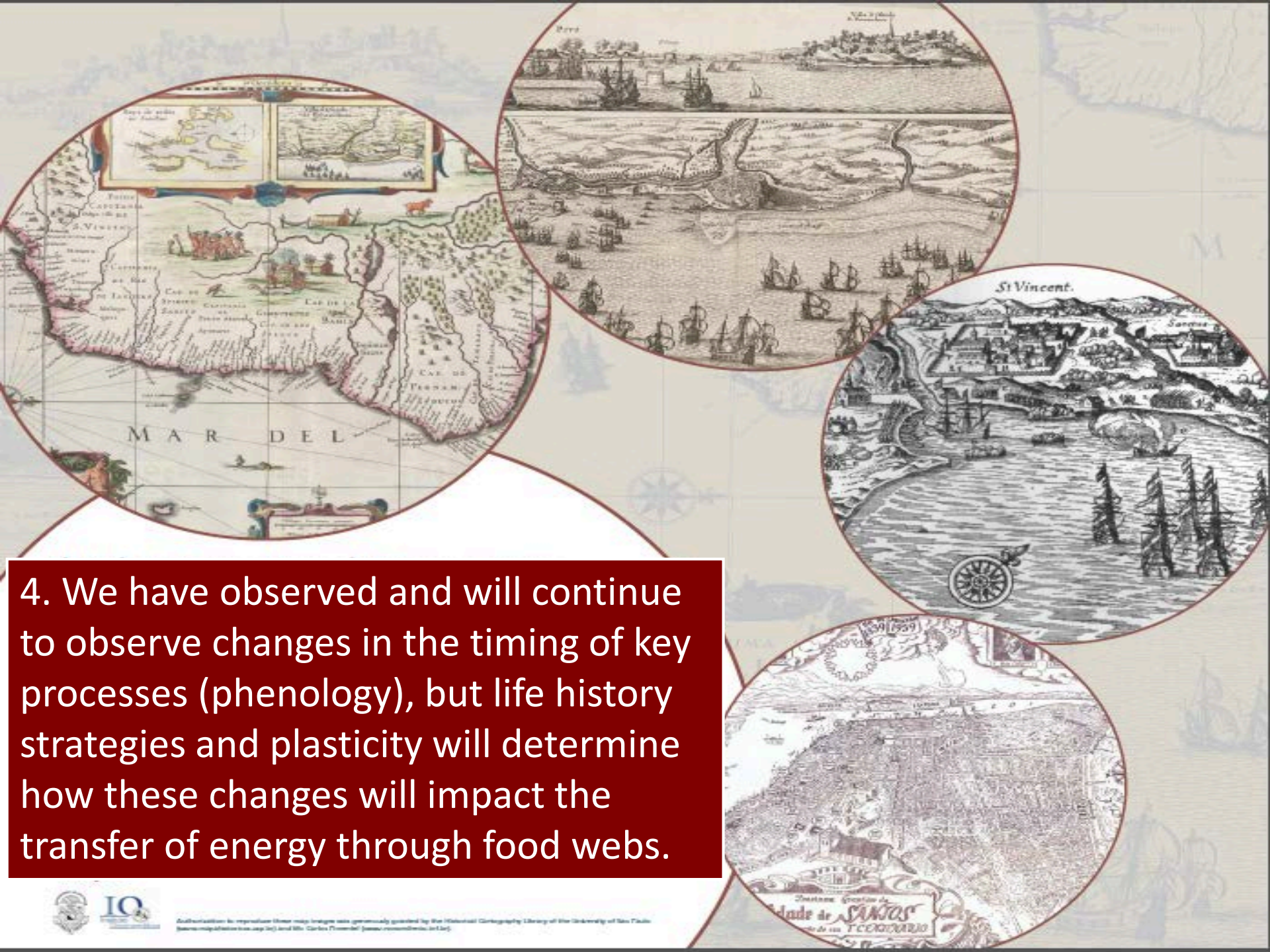
July 2008 (cold)



July 2040 (warm)



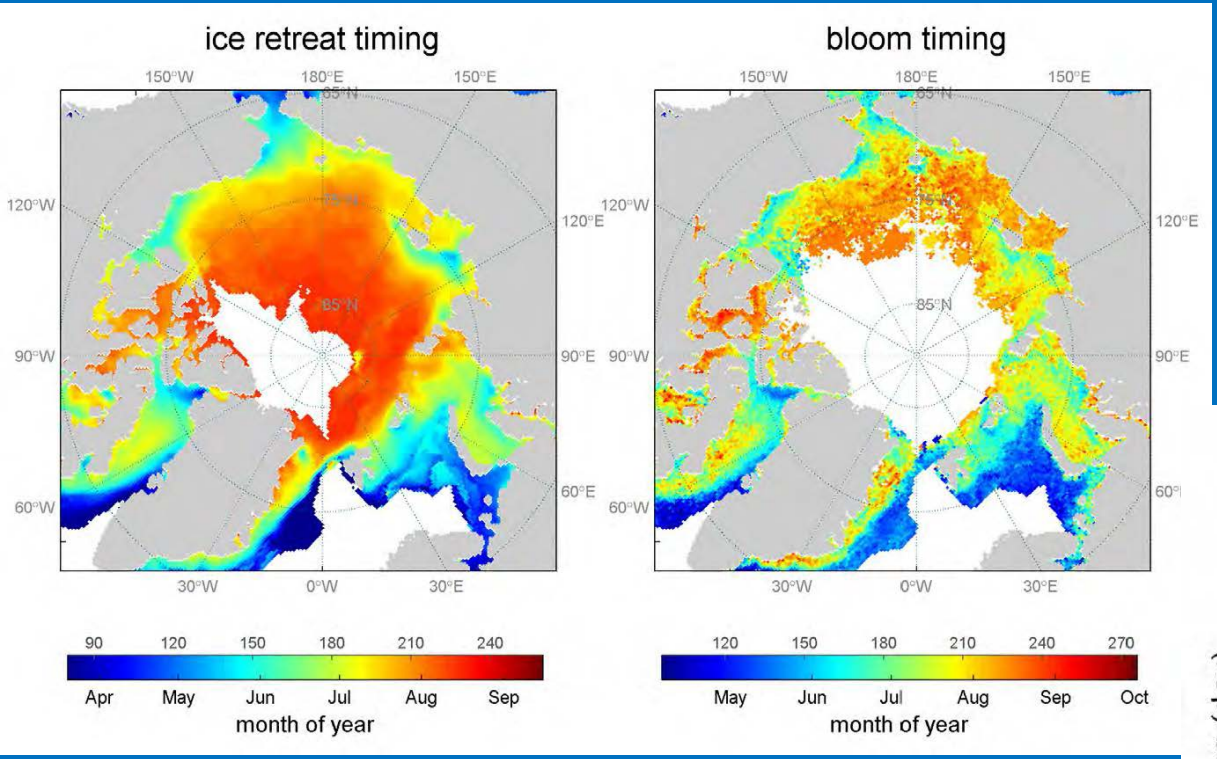
Aydin et al.



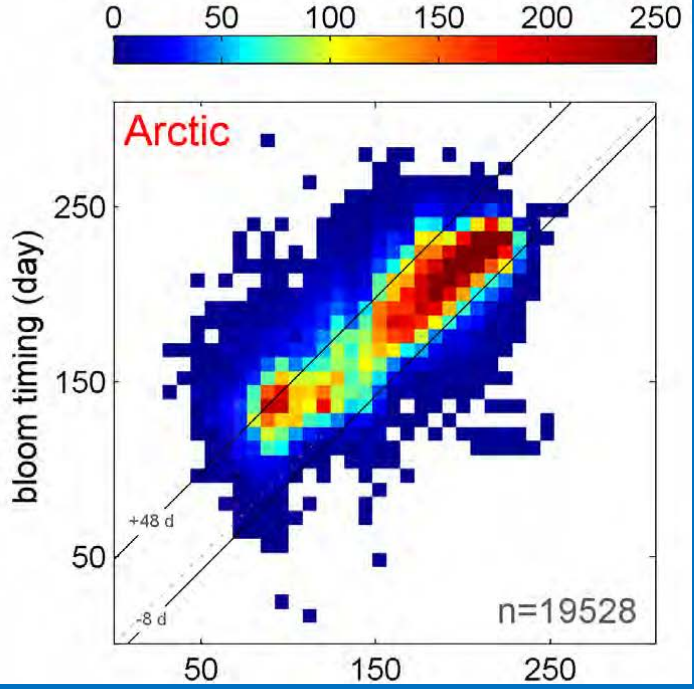
4. We have observed and will continue to observe changes in the timing of key processes (phenology), but life history strategies and plasticity will determine how these changes will impact the transfer of energy through food webs.

Climatology: Arctic

Rubau Ji (S6) - "Spatio-temporal variability of synchronicity between ice retreat and phytoplankton blooms in the polar regions"



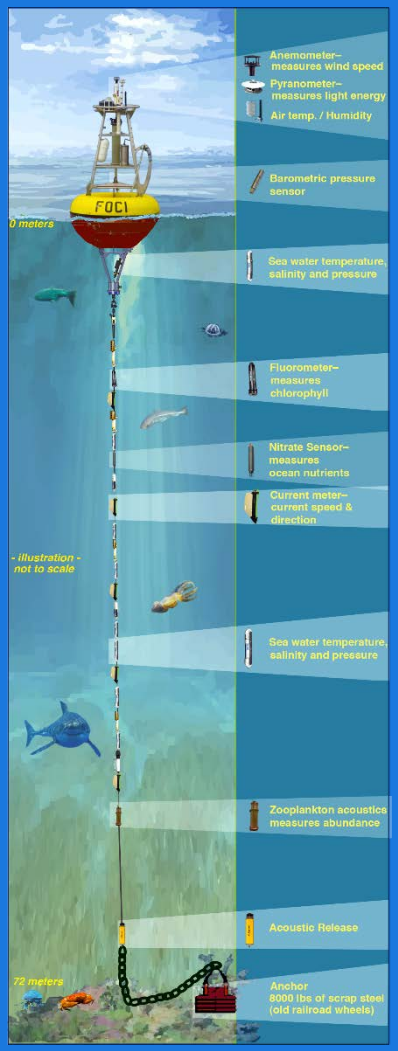
data points in 8x8 day bins



ice retreat timing (day)

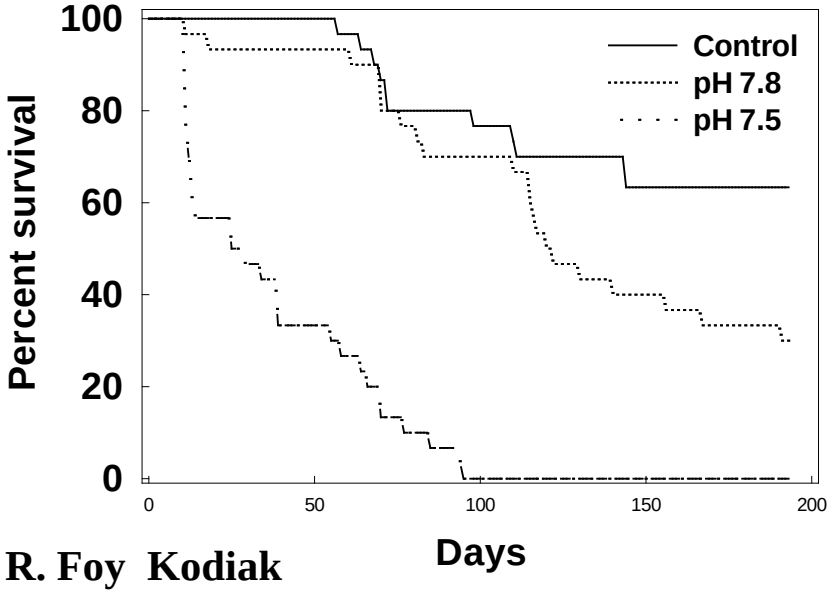
Utilize Advanced Technology

- Acoustic Moorings
- Sail drones
- Ice hardened ships
- Leverage existing monitoring platforms (underway acoustic)



5. The field of acclimation and genetic adaptation to reduced pH, de-O_2 and warming is offering some of the most exciting avenues of ecological research.

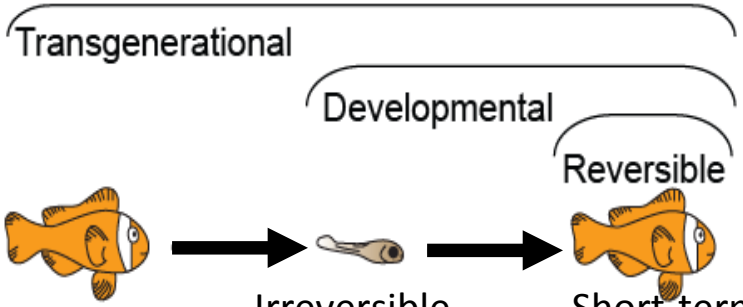
Red King Crab Juveniles



R. Foy Kodiak

Philip Munday (S7) - "Predicting evolutionary responses to climate change in the sea: progress and challenges"

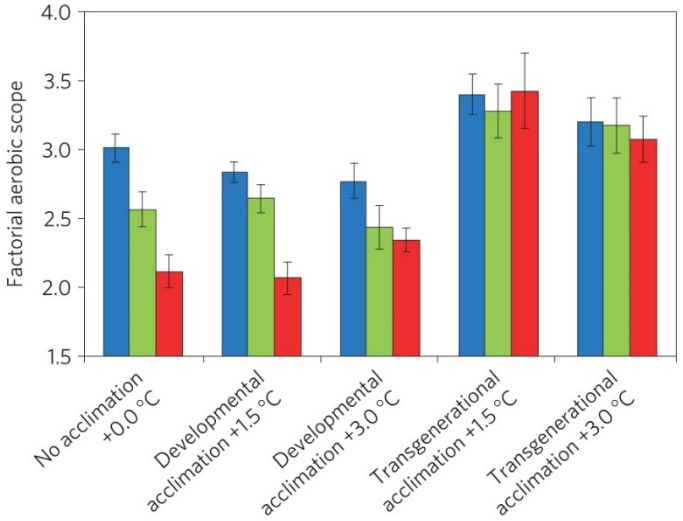
Acclimation



Environment experienced by parents influences offsprings' responses

Irreversible response experienced during ontogeny. Influences later life stages

Short-term regulated responses



Future Fisheries

- **Demand for protein**
- **World markets**
- **Range expansion to north uncertain**
- **Infra-structure**
- **Bio-economic considerations (fuel, risk)**
- **Sustainable fisheries – Ecosystem Based Fisheries Management**
- **International cooperation**

Photo Credit: Sam Zmolek, NOAA Fisheries. Photo of Dutch Harbor, Alaska

6. Global Environmental Change research in the oceans needs to increasingly consider a range of man-made impacts like land-use change and population growth.

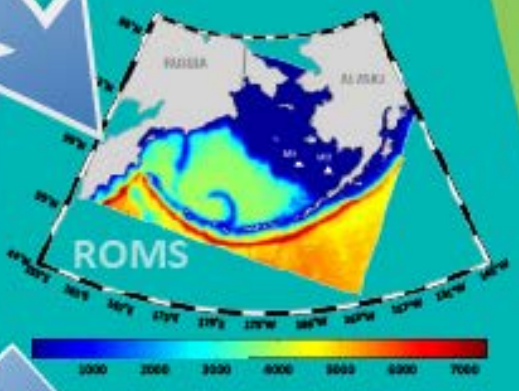
FUTURE MODELING ENTERPRISE

Earth System Models

Regional Models

Dynamic Downscaling

Other Stressors



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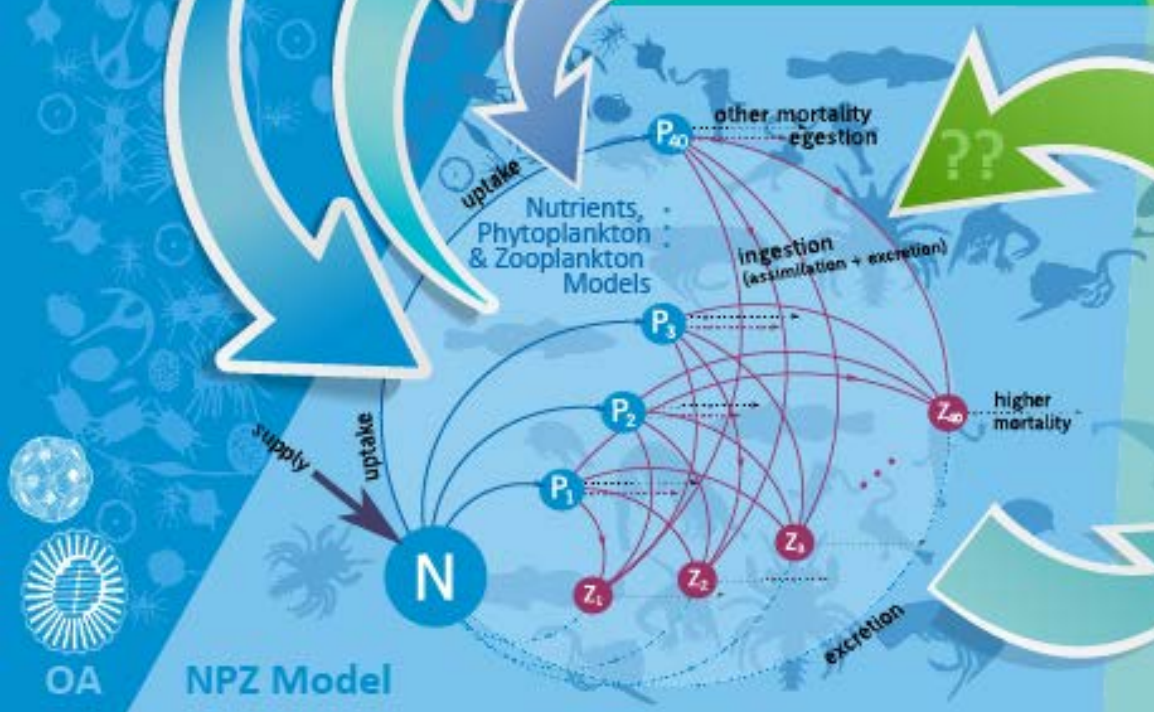


Multispecies projection model

Spatial Ecosystem Models

Spatially Explicit Stock Projection Models

Food-web models

Single species projection model

Size Spectra Models

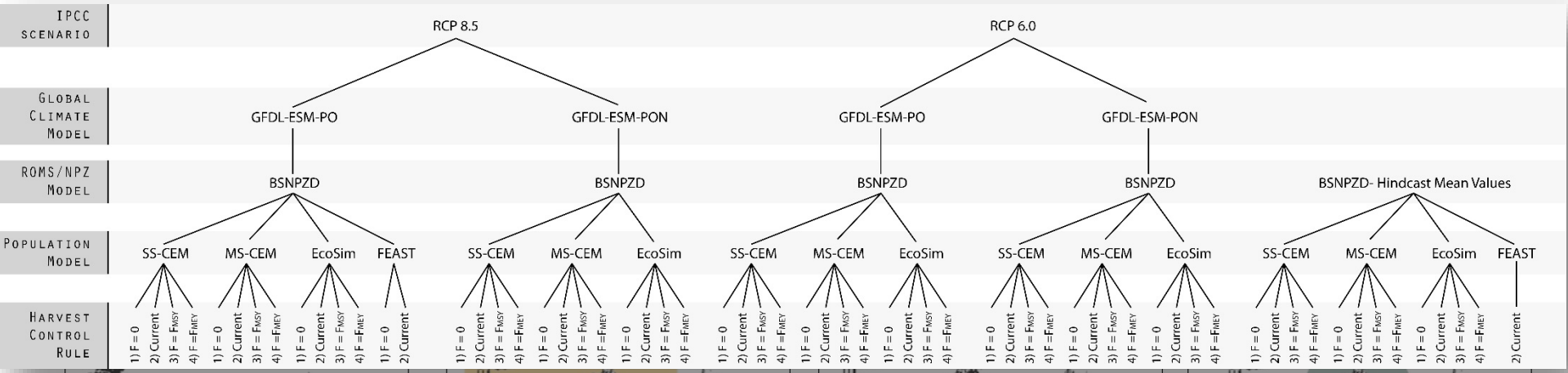
Individual Based Models

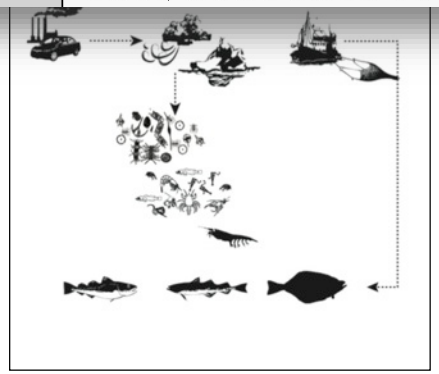
OA

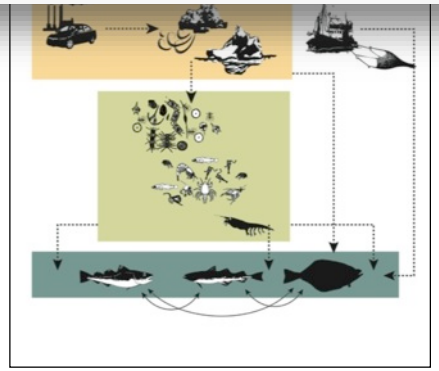
NPZ Model

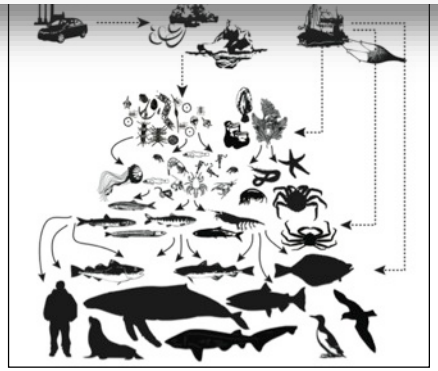
Stock Projection Ensemble

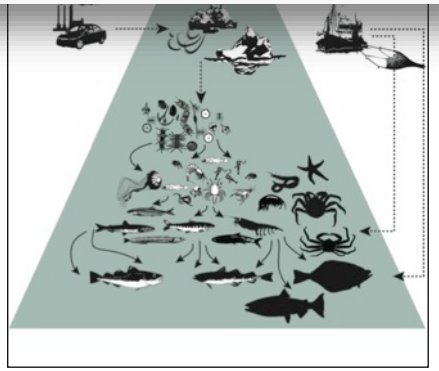
(FATE-SAAM)ACLIM: Bering Sea Models











Single Species | CEATTLE | Ecosim | FEAST

Additive Pressures

Multiple Interacting (non-linear) Pressures

Non-linear Species Interactions; Non-linear Cumulative Effects

Estimation of Error/ multiple random iterations

Our World Opportunity Space Possible Futures

- We can explain the need for change.”
- We can develop scenarios of the types of things that are expected to happen.
- We cannot answer questions about exactly what will change by how much and when.
- Seek to identify strategies that will incorporate transition and adaptive response

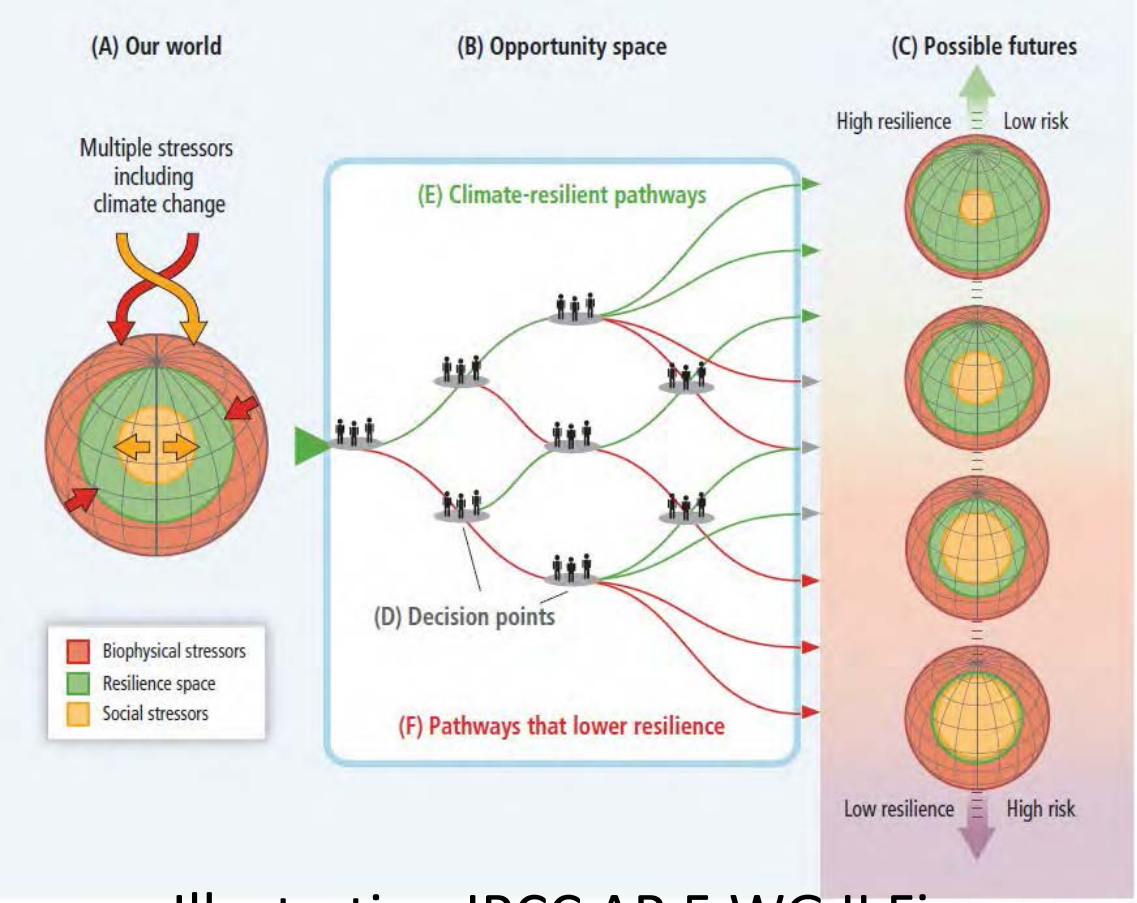


Illustration IPCC AR 5 WG II Figure 1.5

Summary with respect to Central Arctic

- Arctic is a vulnerable region for fish, fisheries and fishery dependent communities.
- Environmental modeling capabilities are emerging quickly, biological models lagging behind.
- Baseline research on adaptive response in Central Arctic is critical.
- Seasonal monitoring needed to capture phenology.
- Adaptive capacity studies needed on species vulnerable to OA
- Target – 2019 for scenarios for fish and fisheries under changing climate