Modeling the California Current and its Ecosystem: Advances and (some) Promising Results

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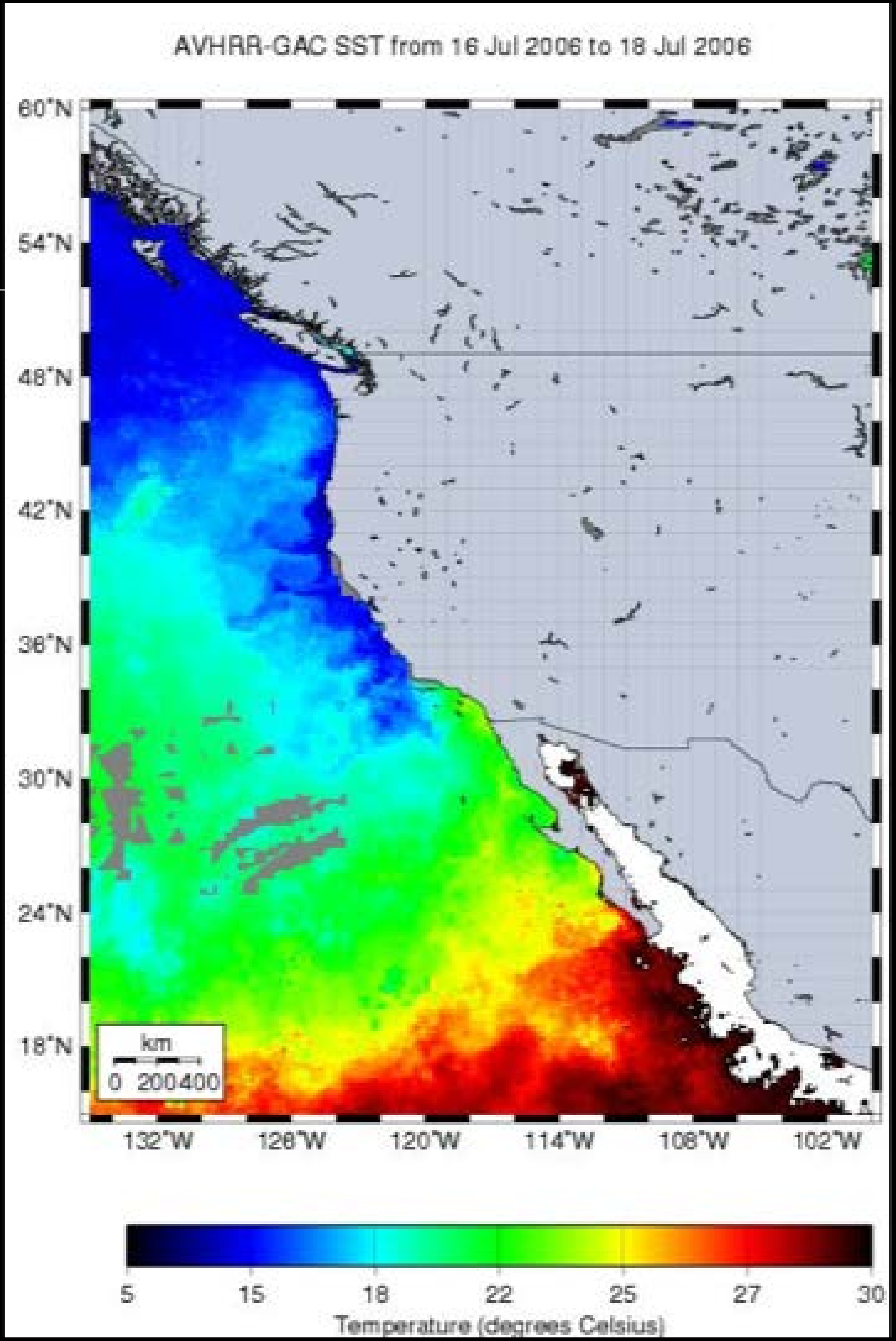
Case Studies

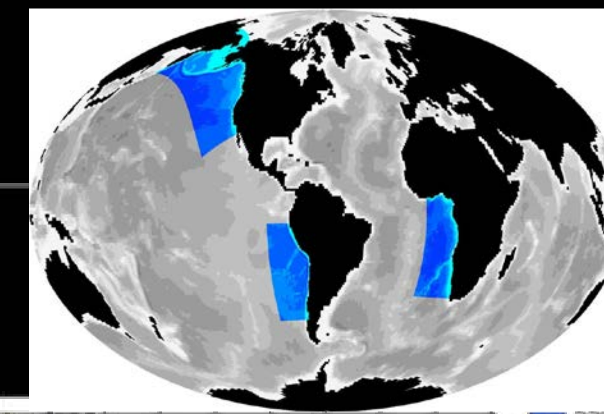
- Future California Current Ecosystem (CCE) conditions (forced by an IPCC scenario)
- Hindcast of the CCE from lower trophic levels to sardines, anchovy and fleets.



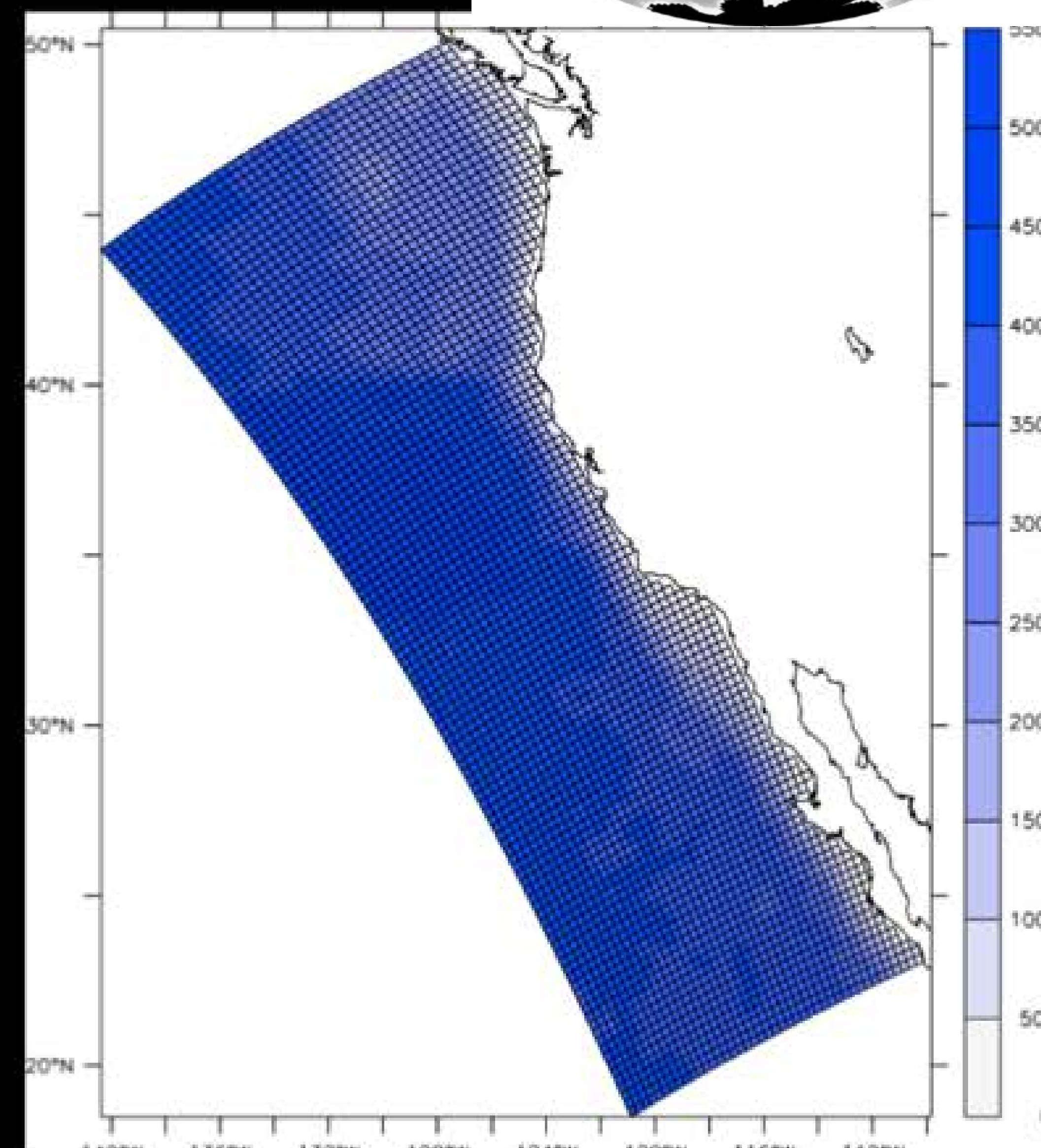
Case 1: California Current

A future scenario

California Current Integrated Ecosystem Assessment (CC-IEA) simulation

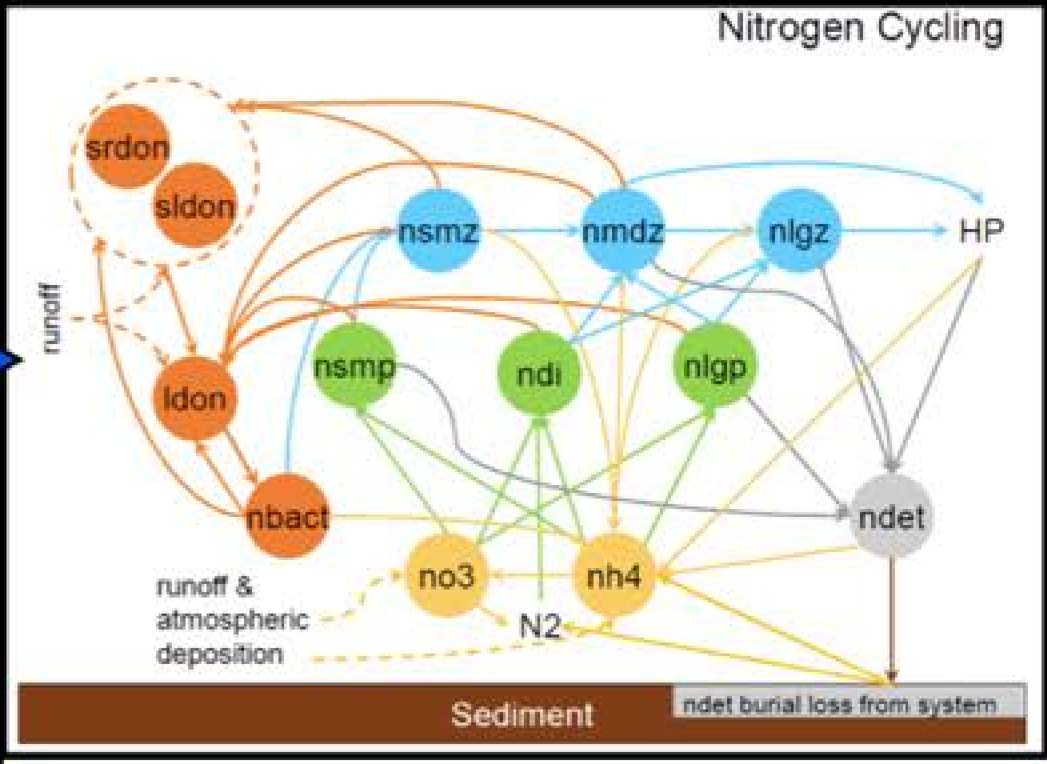


- Simulation
  - 1970-2050 using 20th century climate (emissions) transitioning to RCP8.5
  - One way physical and BGC downscaling of CCS
  - Global to regional boundary conditions for both physics and BGC.

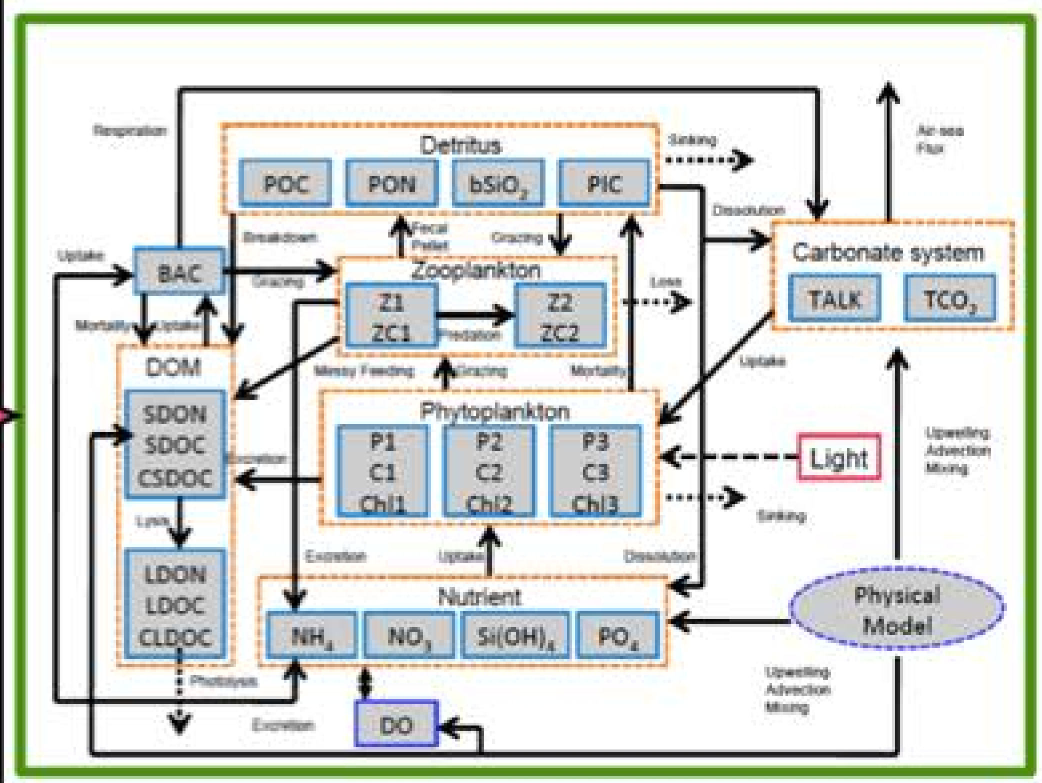


CC-IEA (one way downscale) simulation

- Global model: GFDL **CM2.1mESM**
  - Atmosphere at 1°, ocean (MOM) at 1°
  - BGC is **COBALT** (Carbon, Ocean Biogeochemistry And Lower Trophics)

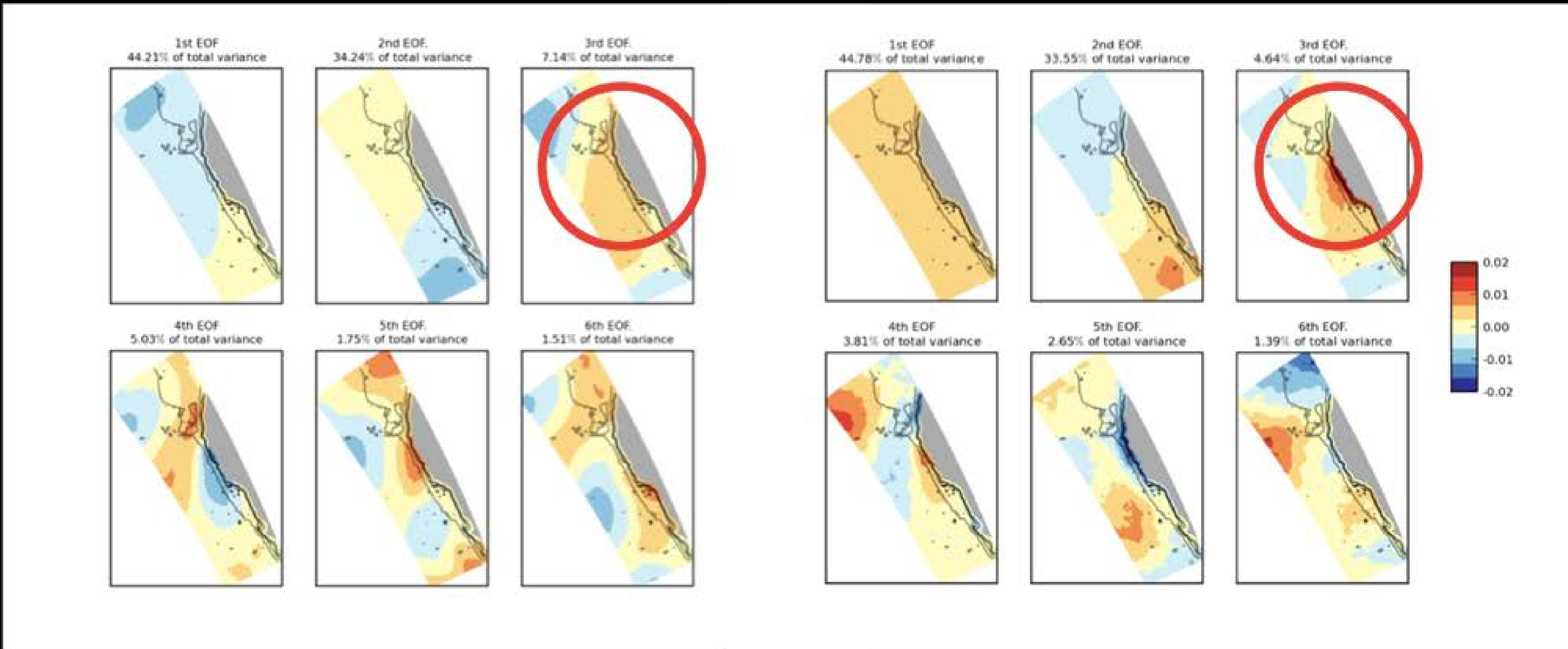


- Regional model:
  - Physics: **ROMS** (7 km or ~1/12th deg), 40 vertical layers)
  - BGC: Enhanced **CoSINE** (C, Si, N Ecosystem model), including oxygen and full carbonate chemistry.



One-way downscaling: Physics and biology

GFDL GFDL-->ROMS



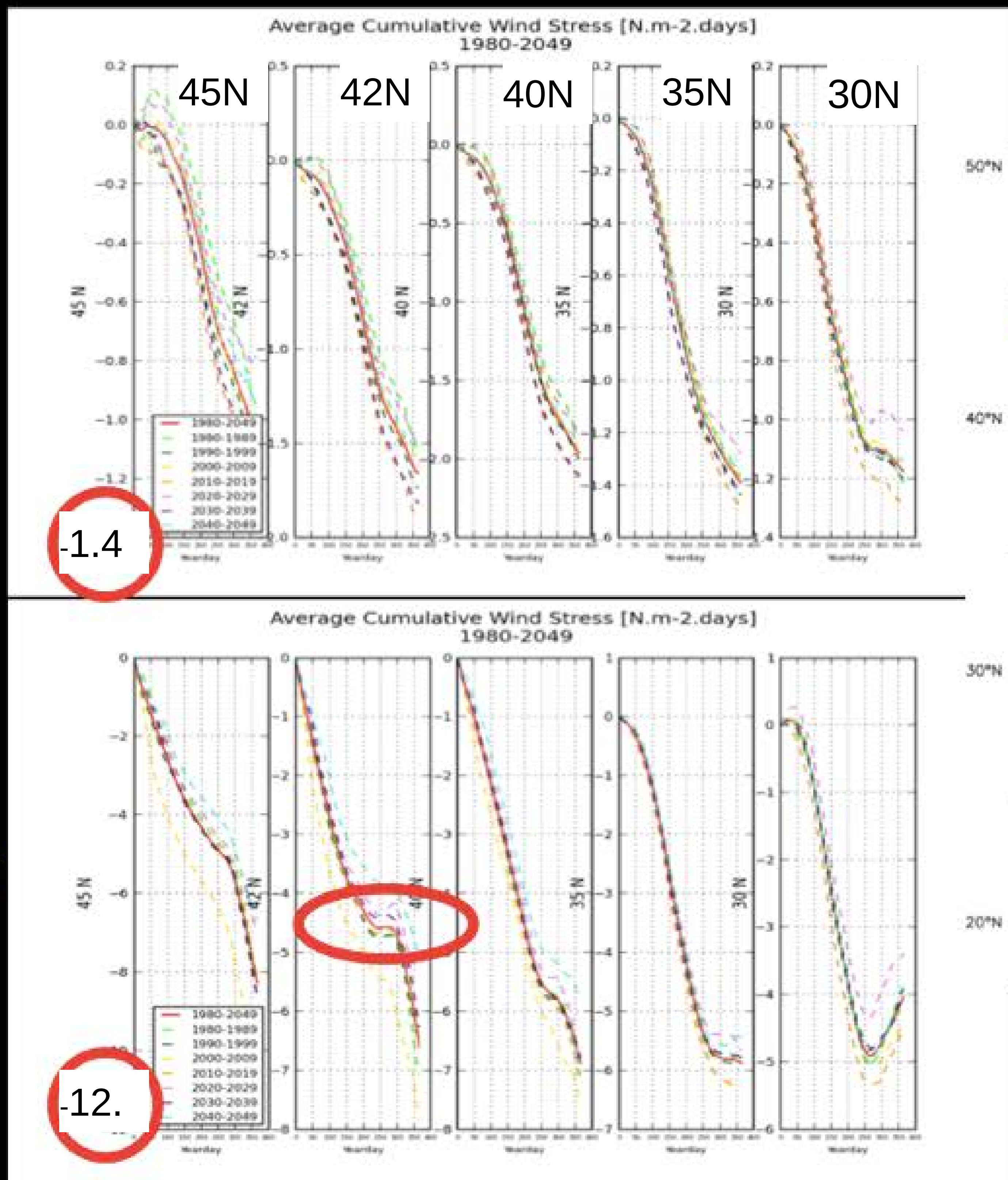
EOFs of summer SSTs

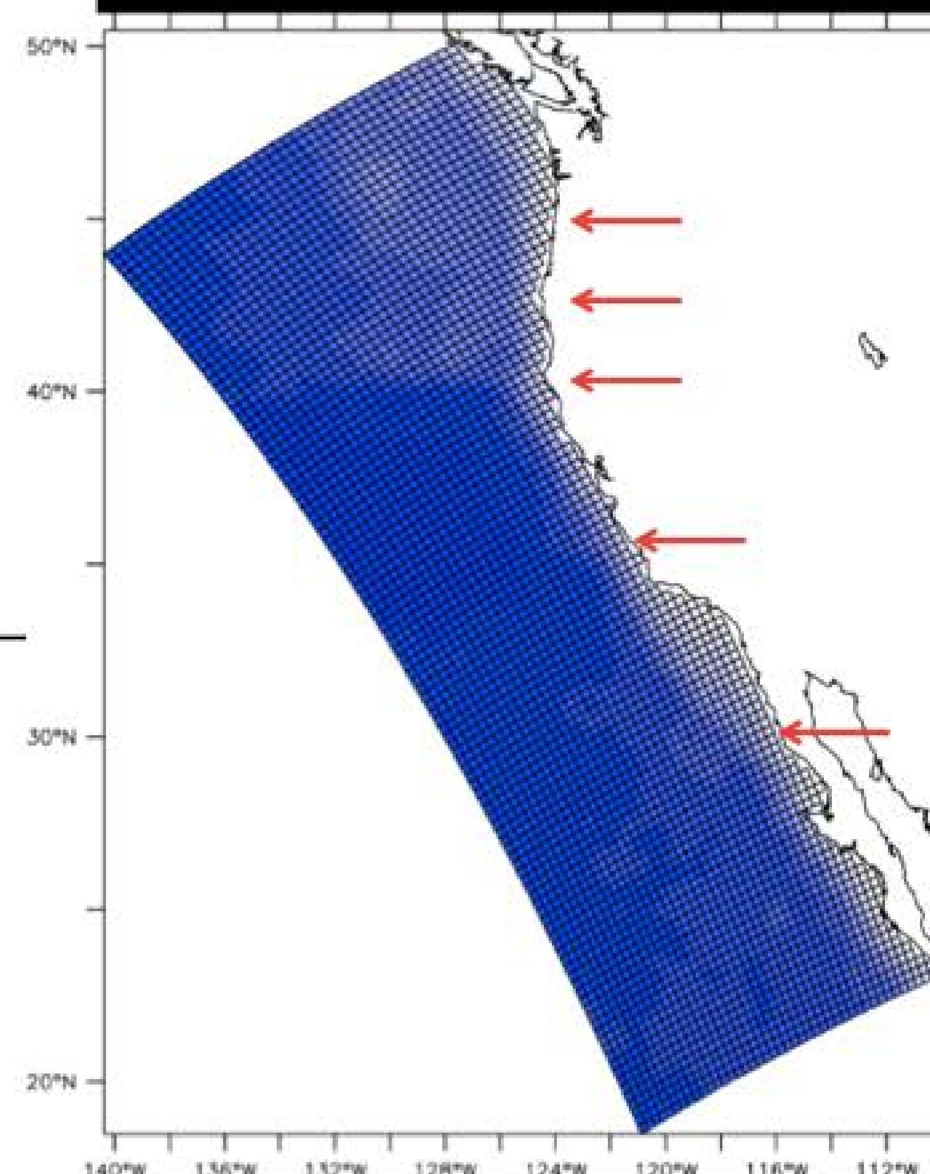
Cumulative wind stress

Stronger winds in the downscaled solution and greater spatial structure

GFDL

GFDL-->
ROMS

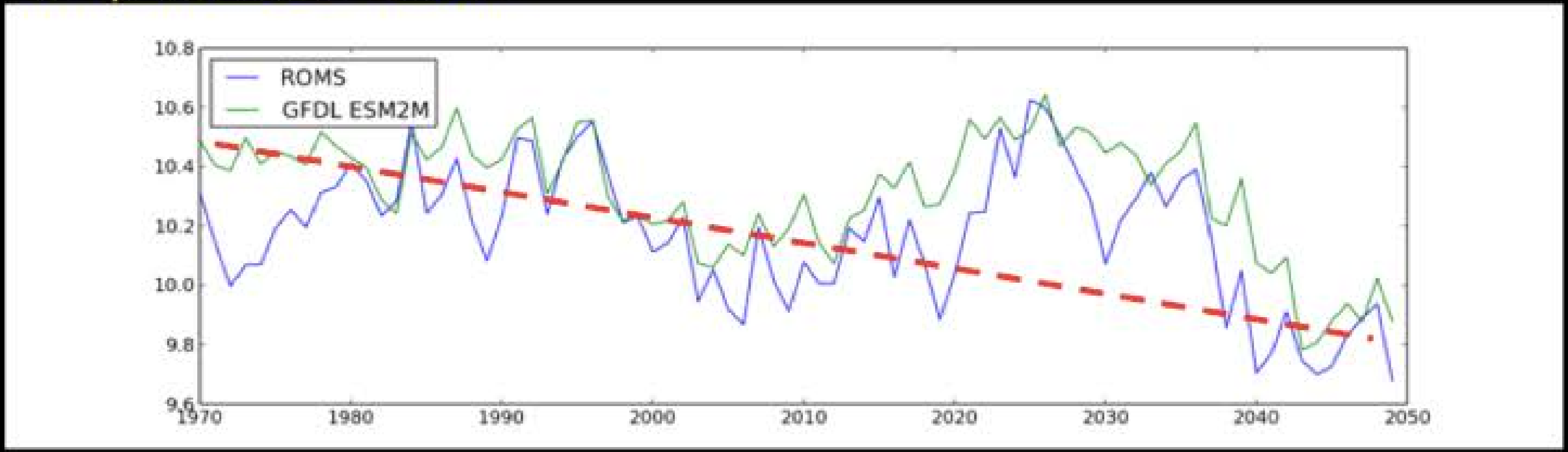




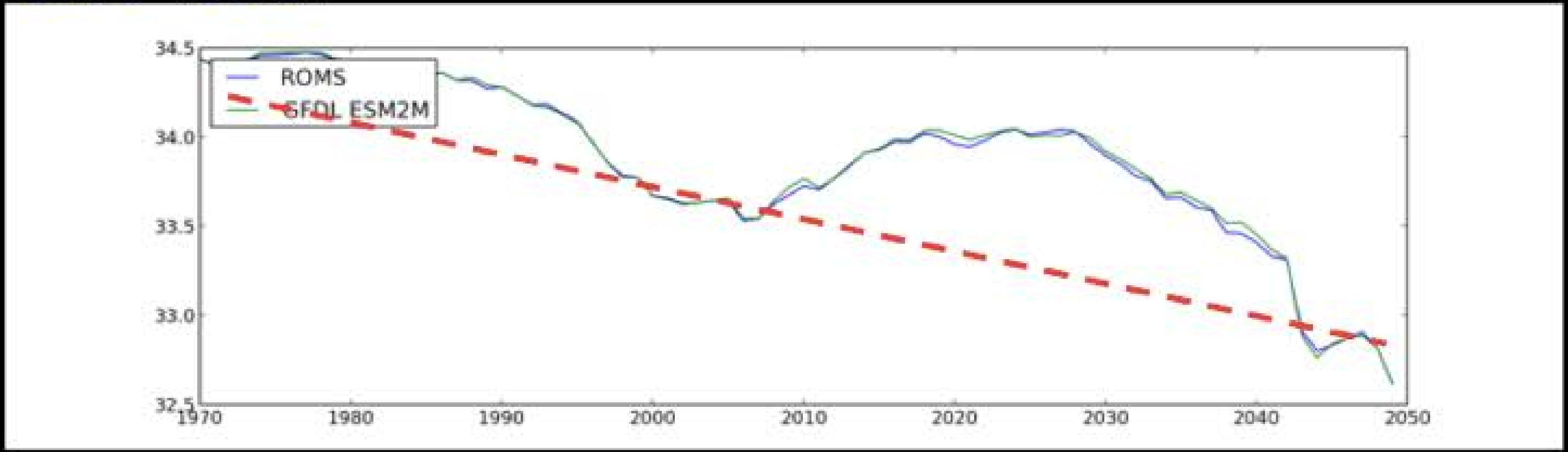
One-way downscaling: Physics (80 year simulation)

conserve heat content and salinity, and
cooling and freshening trend
(southward expansion of Alaskan sub-polar gyre)

Temperature 0-1000m



Salt 0-1000m



1970 2050

Rich structures yet to be fully explored and uncertainties quantified as we move to "marine ecosystem scenarios"

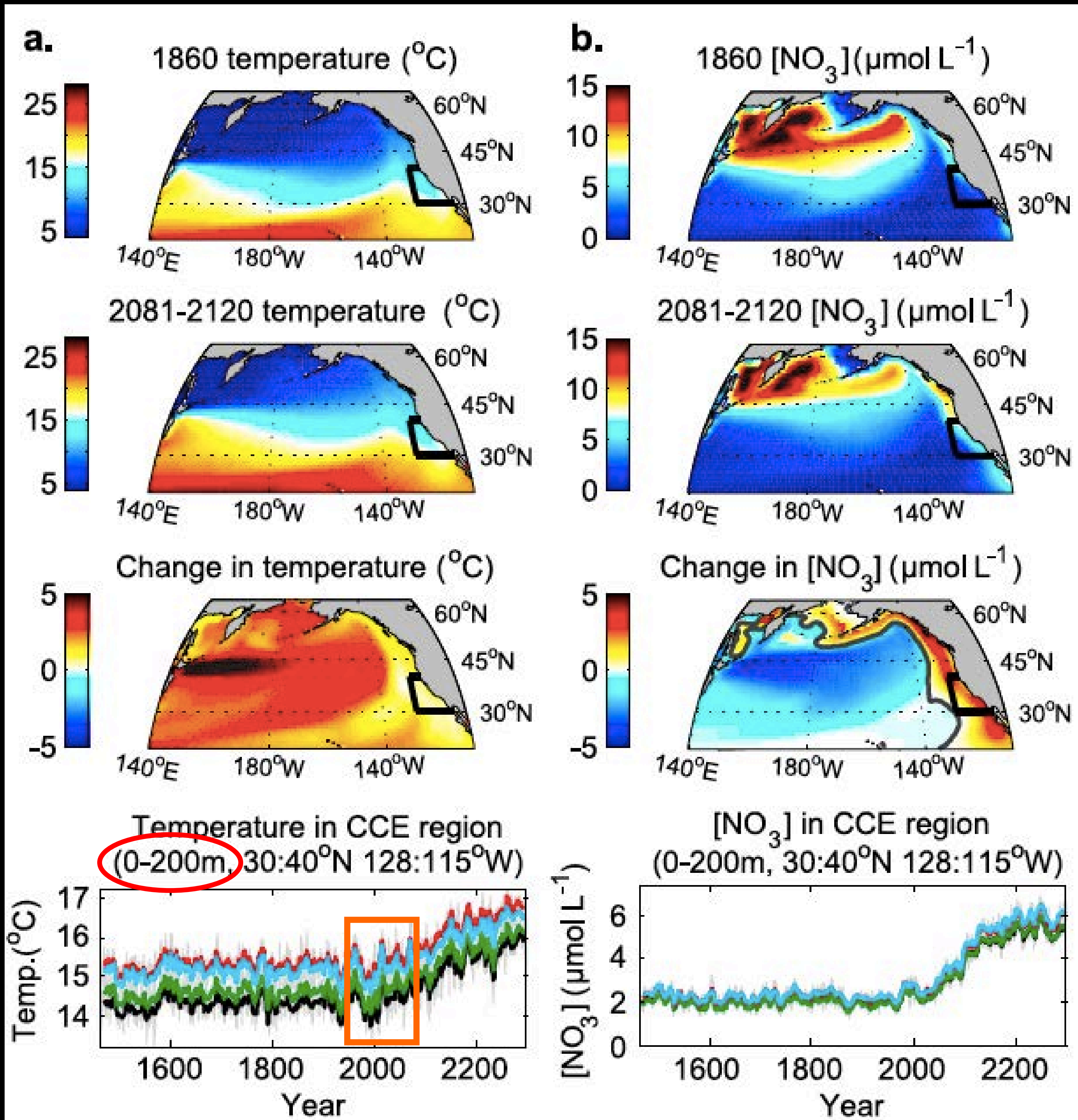


Table 1. Likelihood Scale	
Term*	**Likelihood of the Outcome**
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

Taken from: "Guidance Note for Lead Authors of the IPCC Fifth Assessment Report"

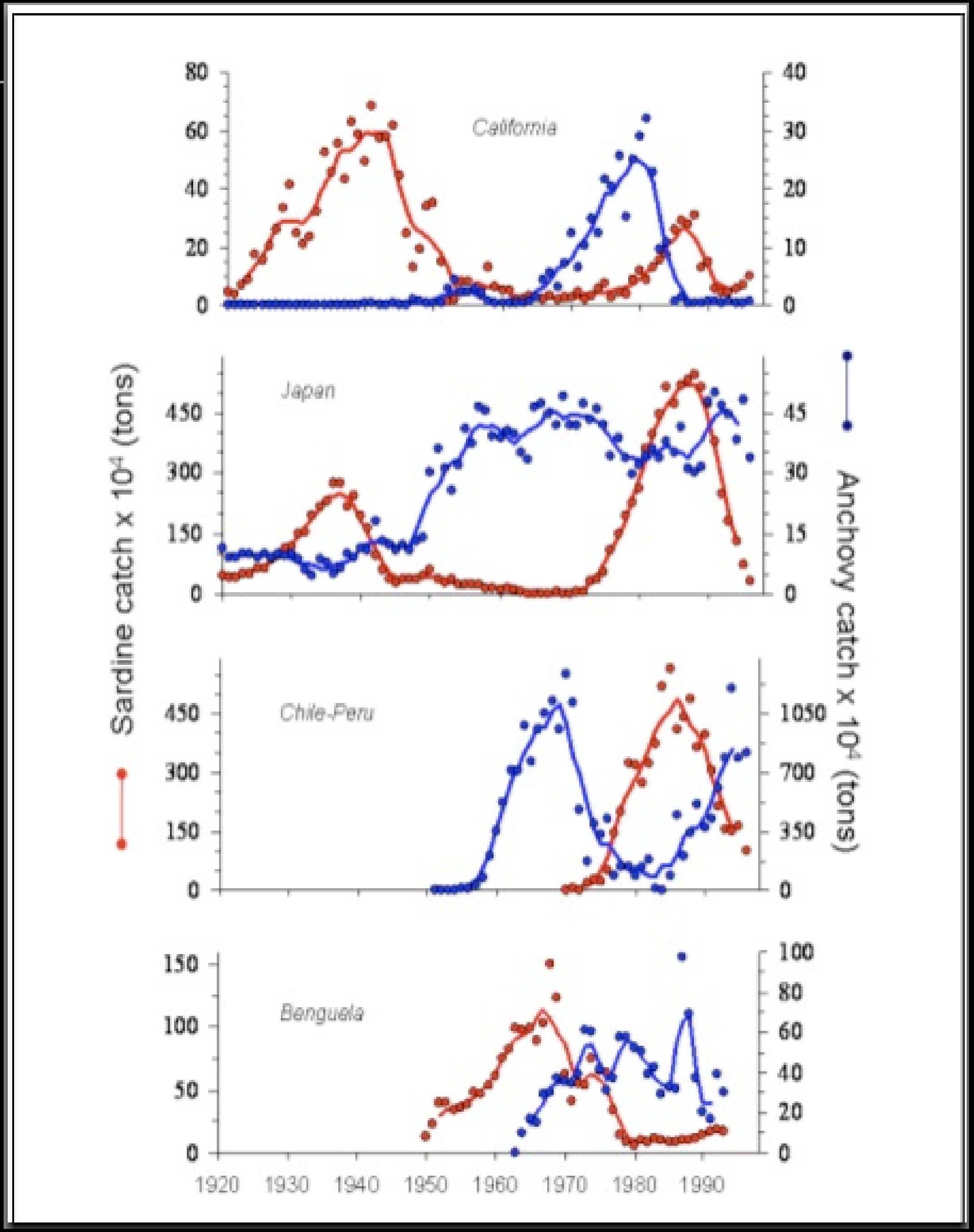
Rykaczewski and Dunne (2010)

Case 2: California Current

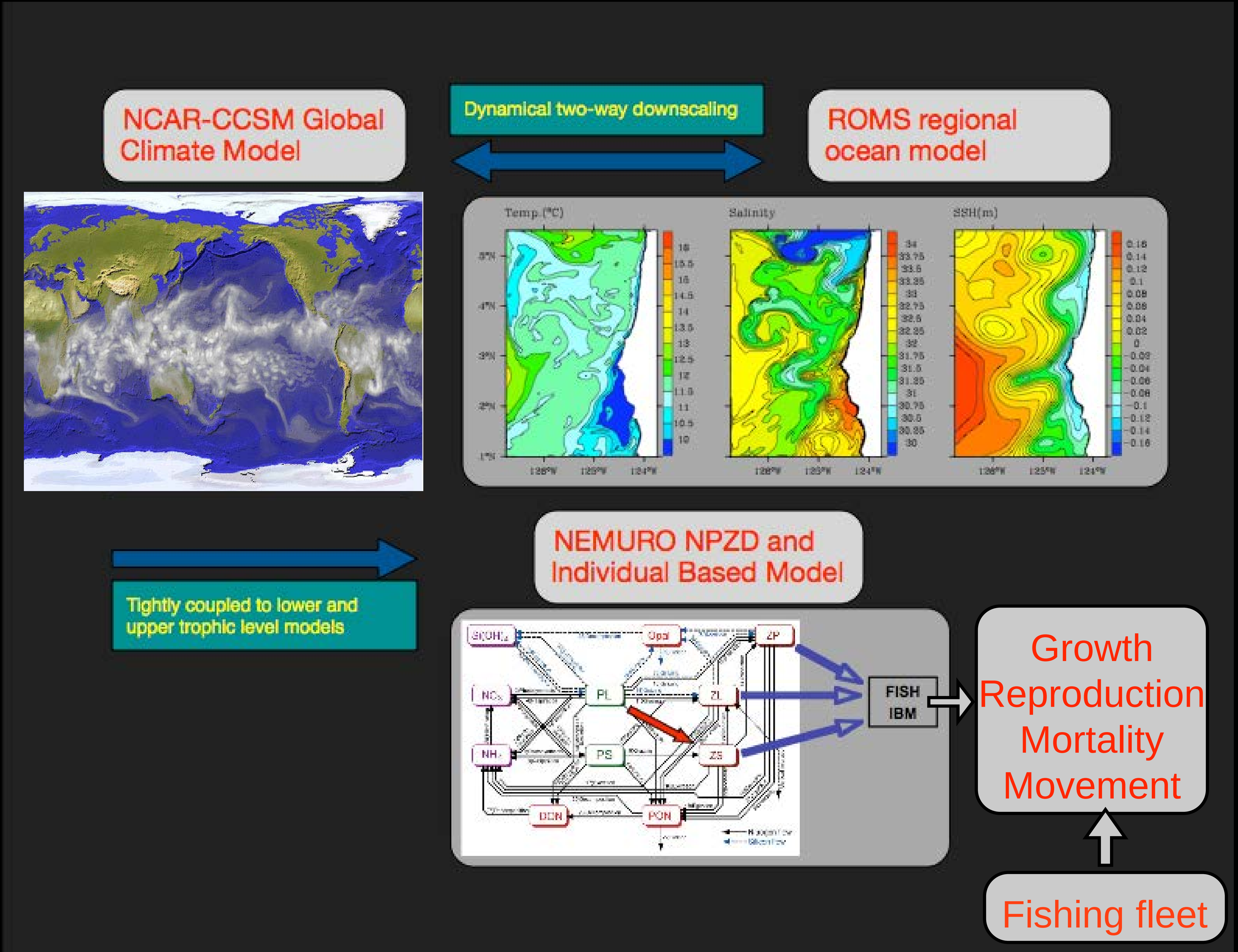
From physics and lower trophic levels
to sardine, anchovies and fishing fleets

Hypotheses for low-frequency variability

- **Environmental conditions (bottom up)**
  - Temperature controls population expansions and contractions via spawning behavior (e.g., Lluch-Belda et al., 1991).
  - Reproduction success linked to mesoscale features (MacCall, 2002).
  - Food availability and composition determines population success (e.g., Van der Lingen et al., 2001).
- **Fishing pressure (top down)**
  - Affects longevity--affects survival in adverse conditions.
  - Differentially preserve more fecund older fish and their migratory behavior.
  - Productivity depends on learned migratory behavior (Petigas et al., 2006).



Our approach: coupled climate-to-fishers model

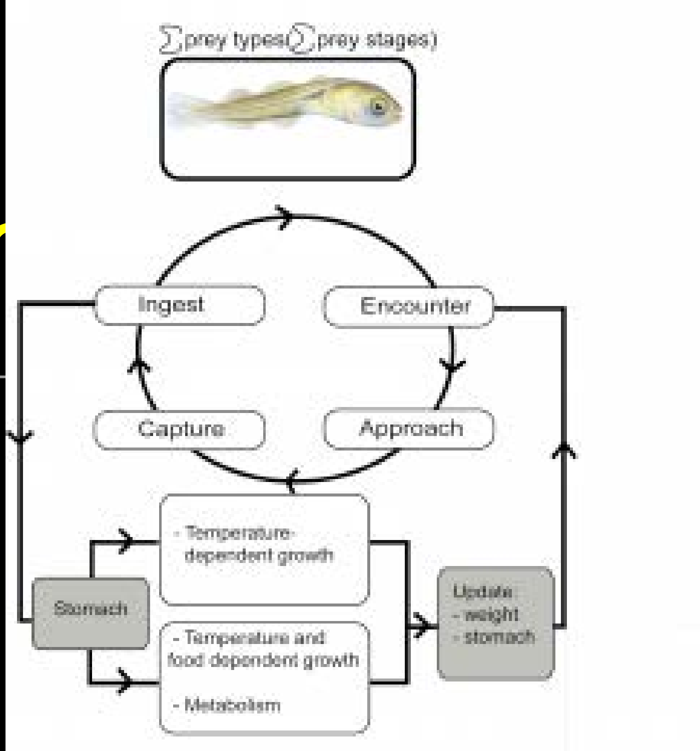


Climate-to-fishers: Multi-species fish model

- Simulate 5-6 species with an *individual based modeling* approach.
- General food web: Species can compete for common prey and eat each other.
- Explicitly model *growth, mortality, reproduction and movement.*
- One species can represent a *fishing fleet* as individuals.

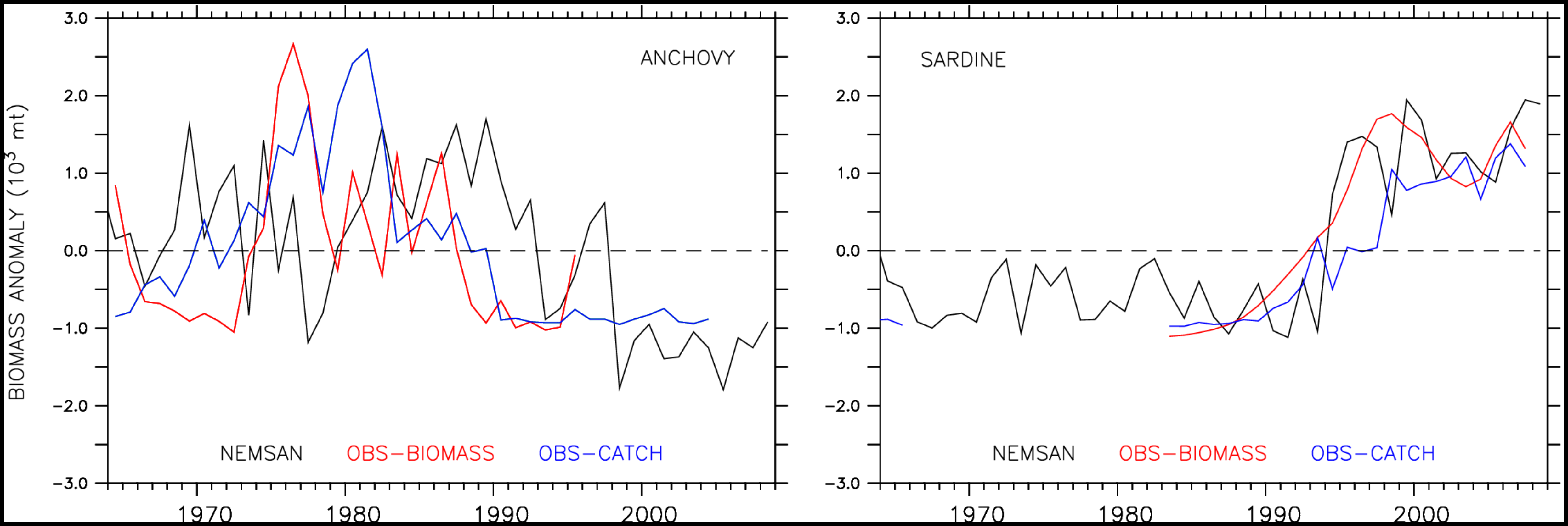
Climate-to-fishers:
Why an IBM (Individual Based Model)?

- Natural unit in nature
- Allows for local interactions and complex systems dynamics
- Complicated life histories
- Plasticity and size-based interactions
- Conceptually easier movement



Climate-to-fish-to-fishers

...almost there - fluctuations captured (but not yet explained in space and time)



Rose *et al*. and Fiechter *et al*.

(in preparation, to be submitted to
Prog. in Oceanography Special Issue)