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From models to assessment: Some present capabilities and challenges for the next decades

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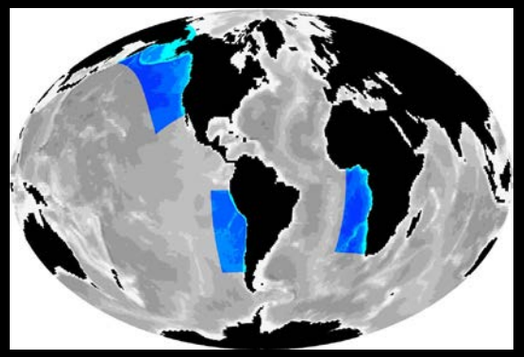
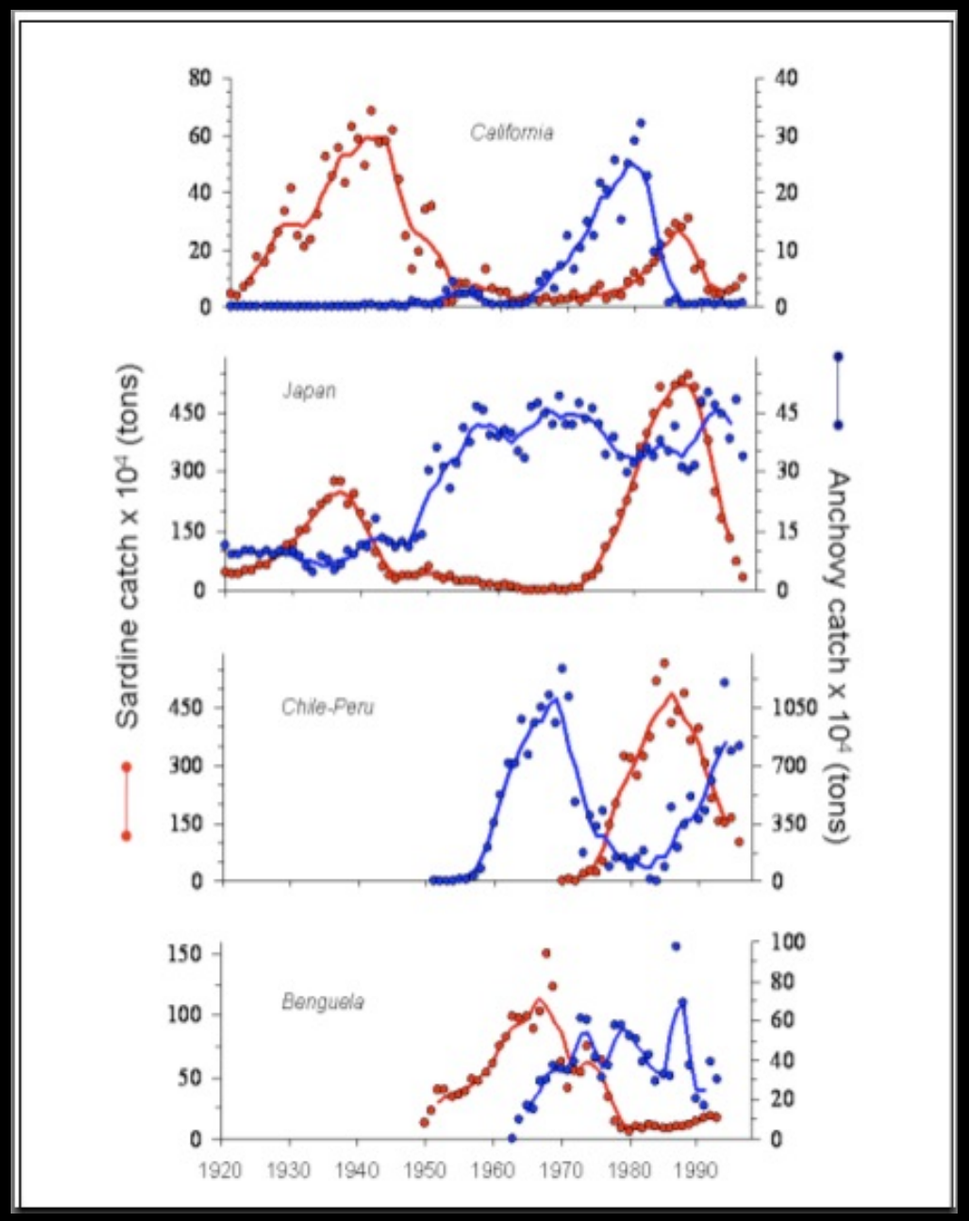
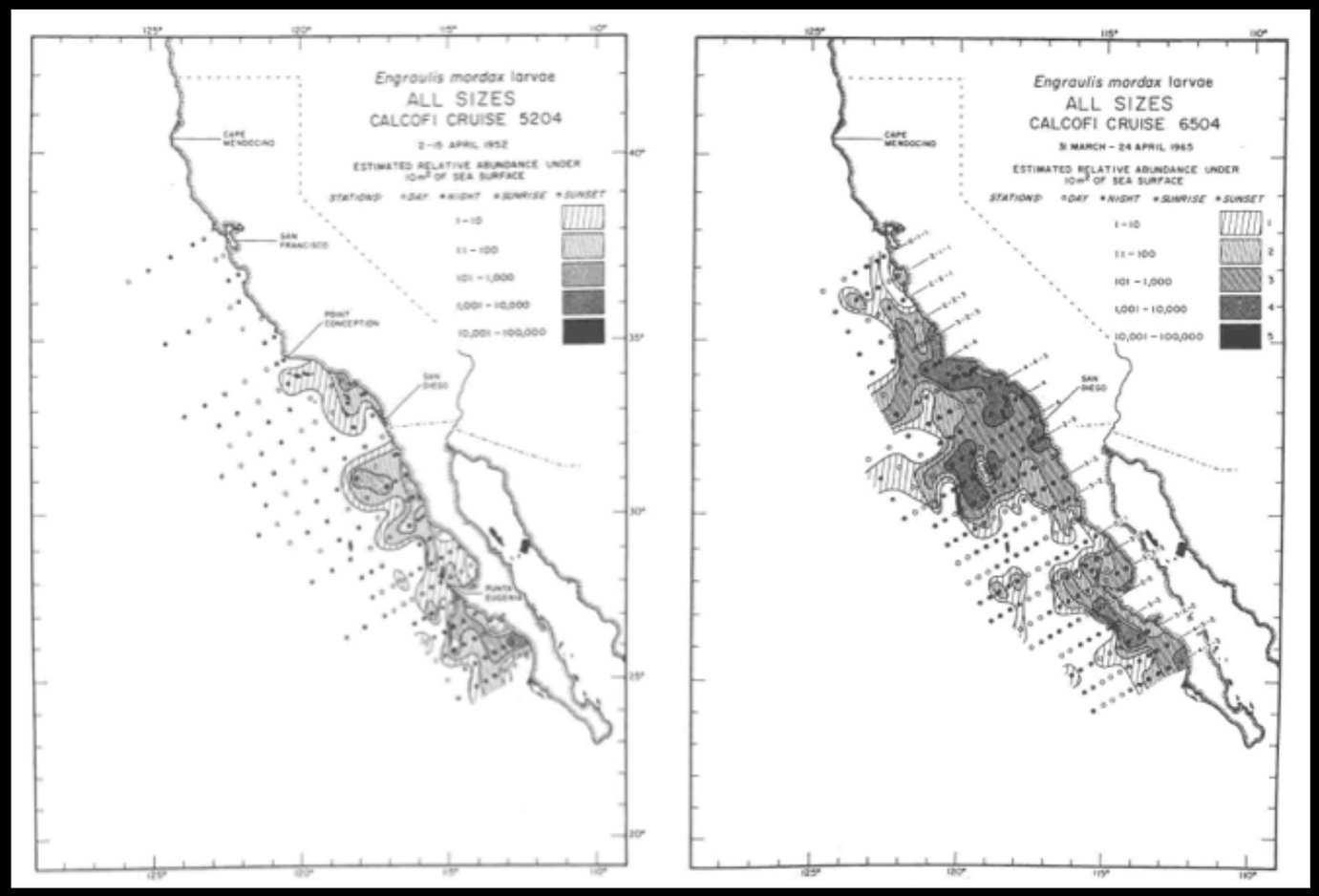


The problem: Sardine and anchovy: Temporal and spatial variability

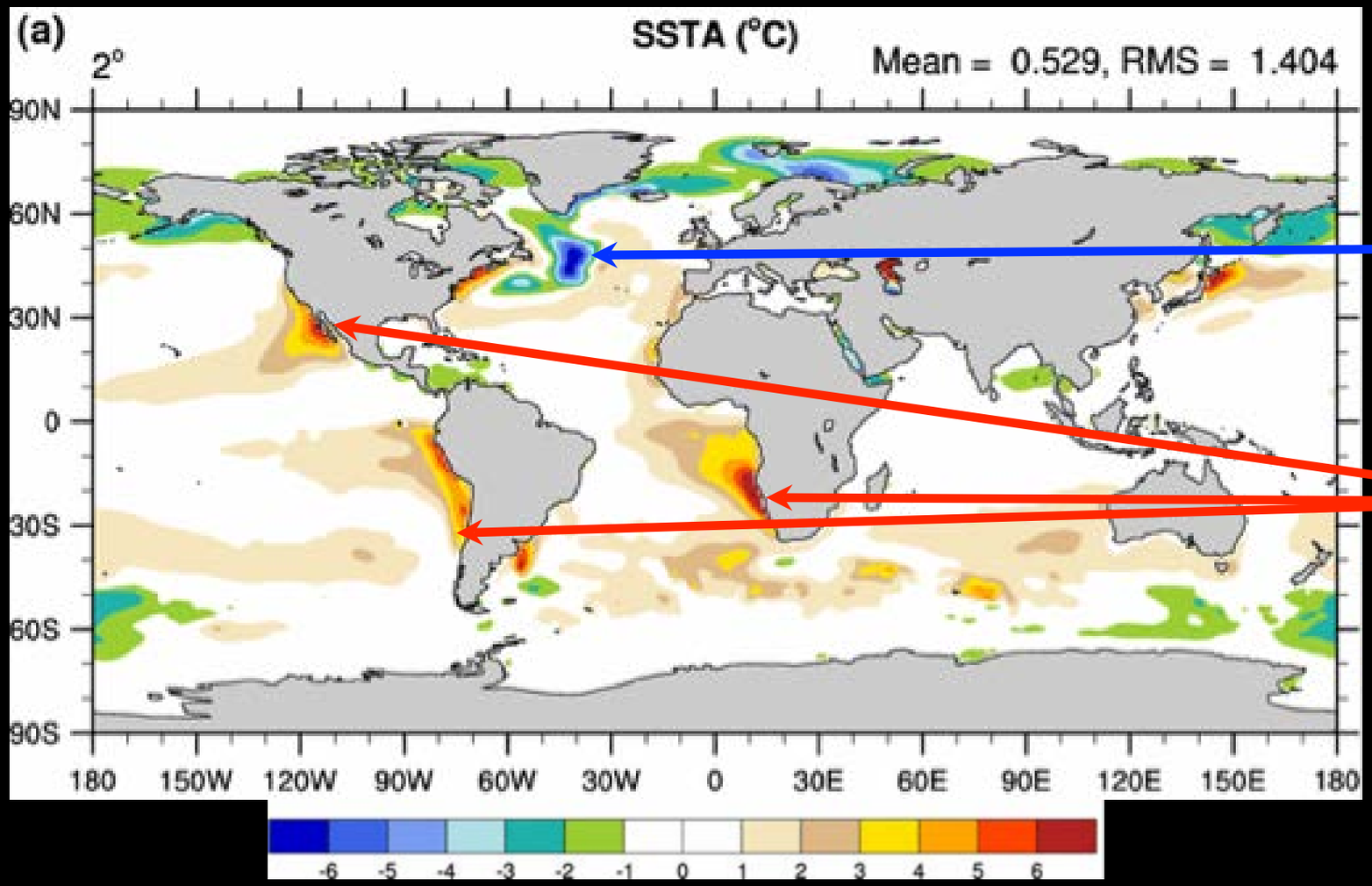




McCall, 1990

Time series of sardine (red) and anchovy (blue) landings since the 1920's. Data from Schwartzlose et al. (1999).

Challenge: Climate model biases
(Model minus Observations of mean SST)



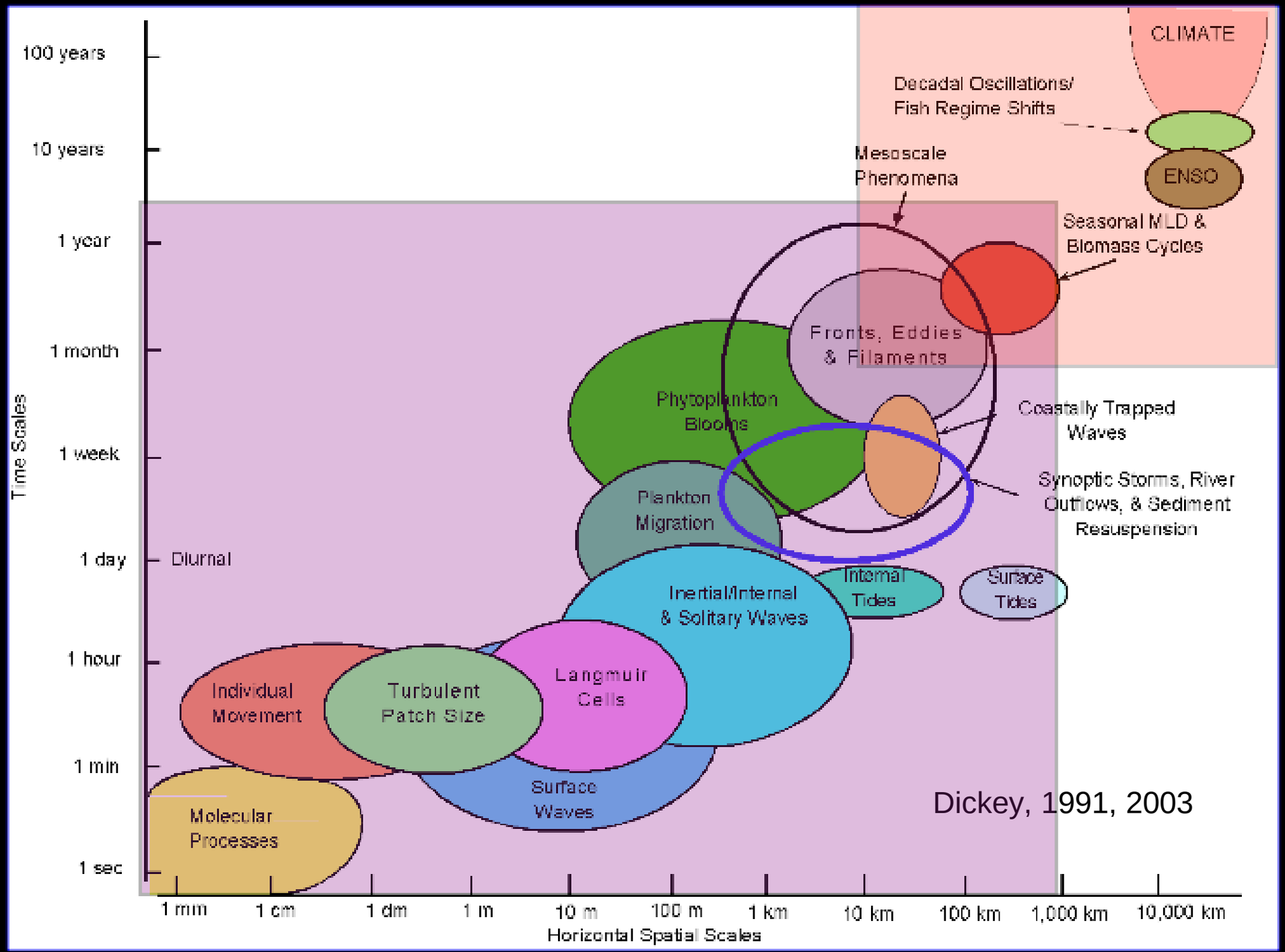
Too cold

Too warm

“Models still show significant errors … The ultimate source of most is that many important small-scale processes are not represented explicitly in models …”

Randal et al., 2007.

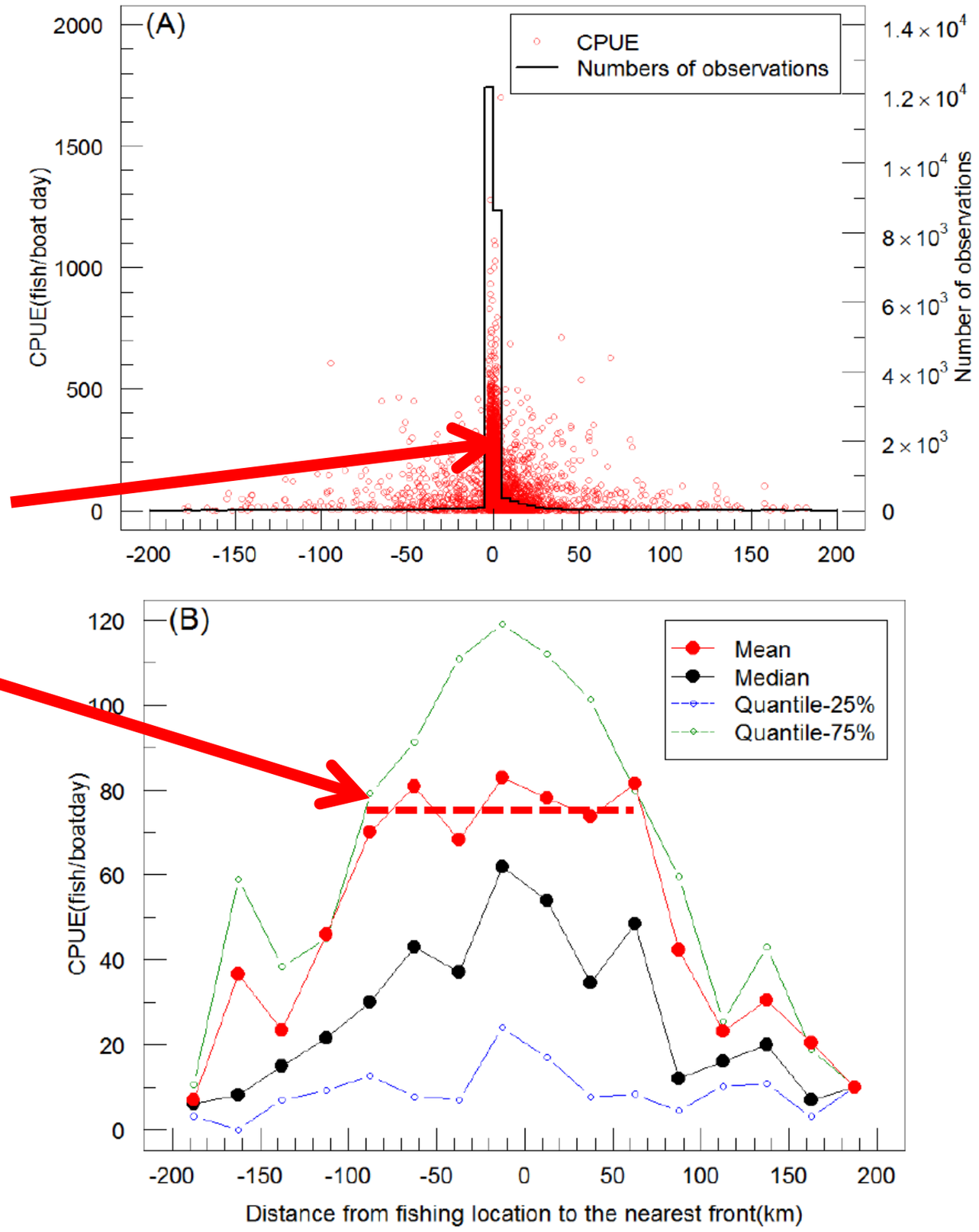
Challenge: Temporal and spatial scales of ocean phenomena



Dickey, 1991, 2003

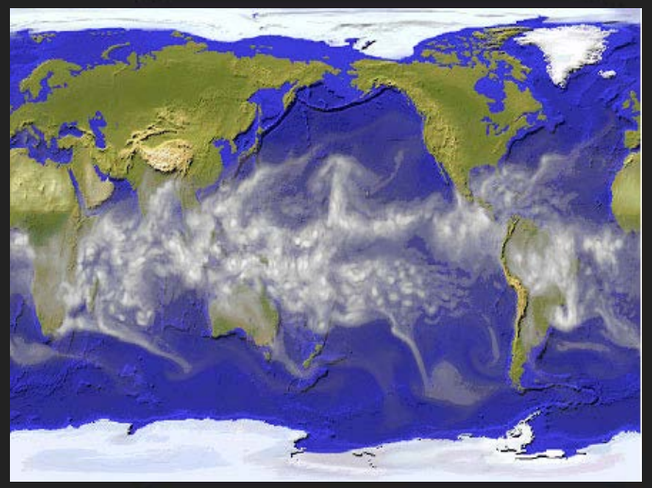
Example: CPUE and Distance to the Front

- Fishermen know that albacore aggregate near fronts and mostly fish (95%) within 5 km of fronts
- Peak CPUE is within 5km of the front
- But mean CPUE remains relatively high within 75 km of the front



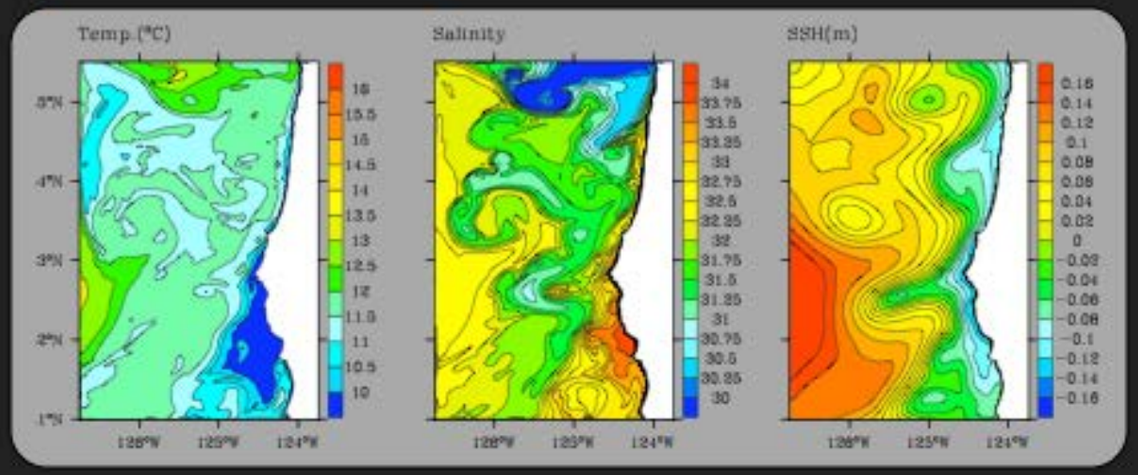
Our approach: Tightly coupled climate-to-fishing model

NCAR-CCSM Global Climate Model



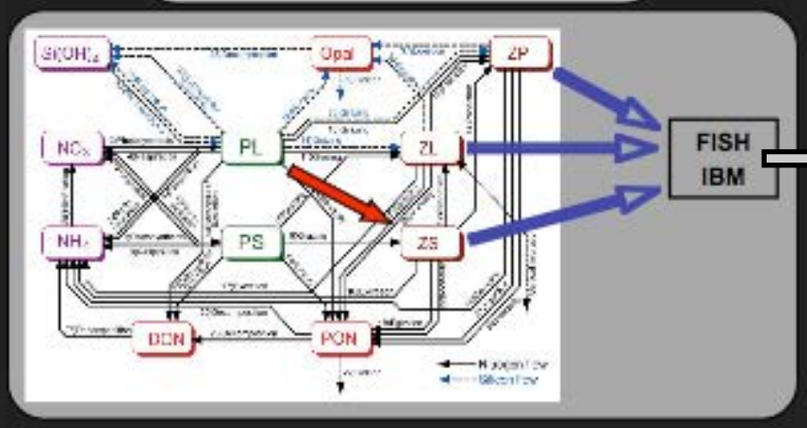
Dynamical two-way downscaling

ROMS regional ocean model



Tightly coupled to lower and upper trophic level models

NEMURO NPZD and Individual Based Model



Growth
Reproduction
Mortality
Movement

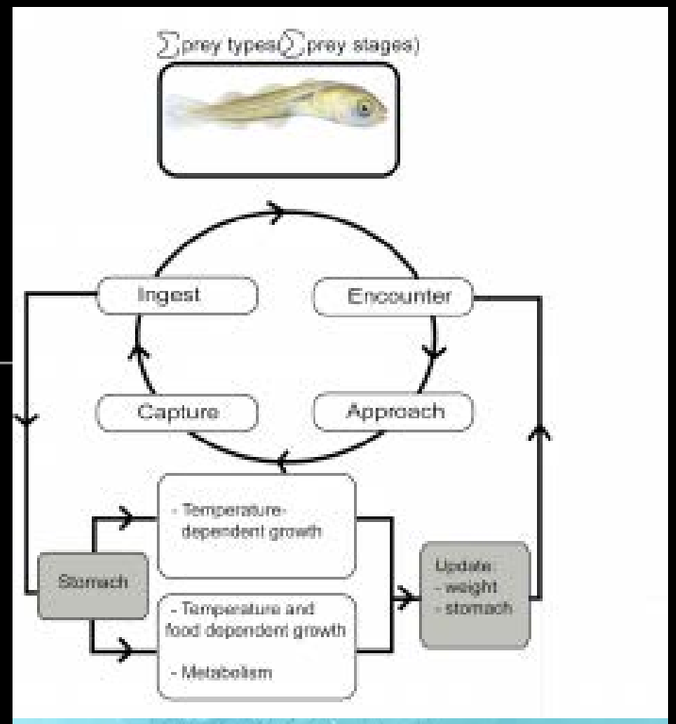
Fishing fleet

Climate-to-fishing: Multi-species fish model

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

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

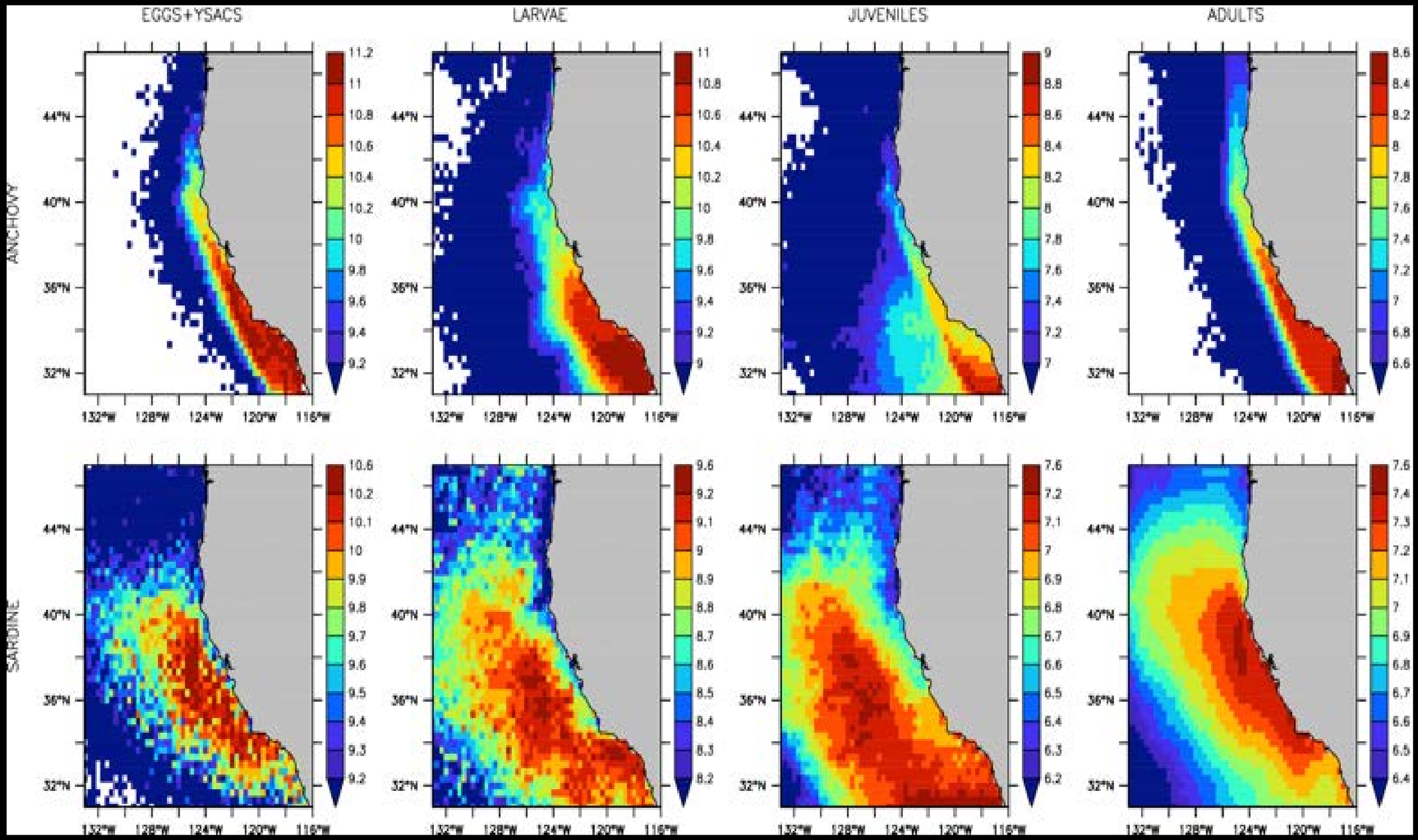
- Natural unit in nature
- Allows for local interactions and complex systems dynamics
- Complicated life histories
- Plasticity and size-based interactions
- Conceptually easier movement



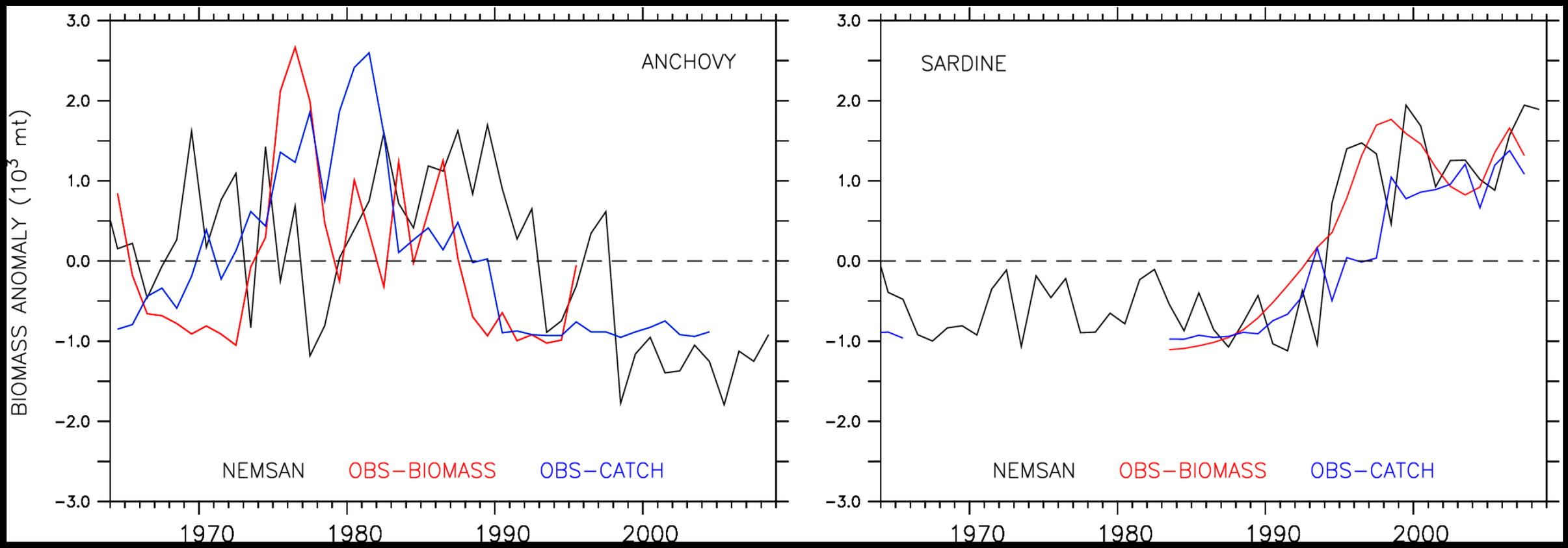
Climate-to-fish-to-fishing

Movie director: *J. Fiechter*

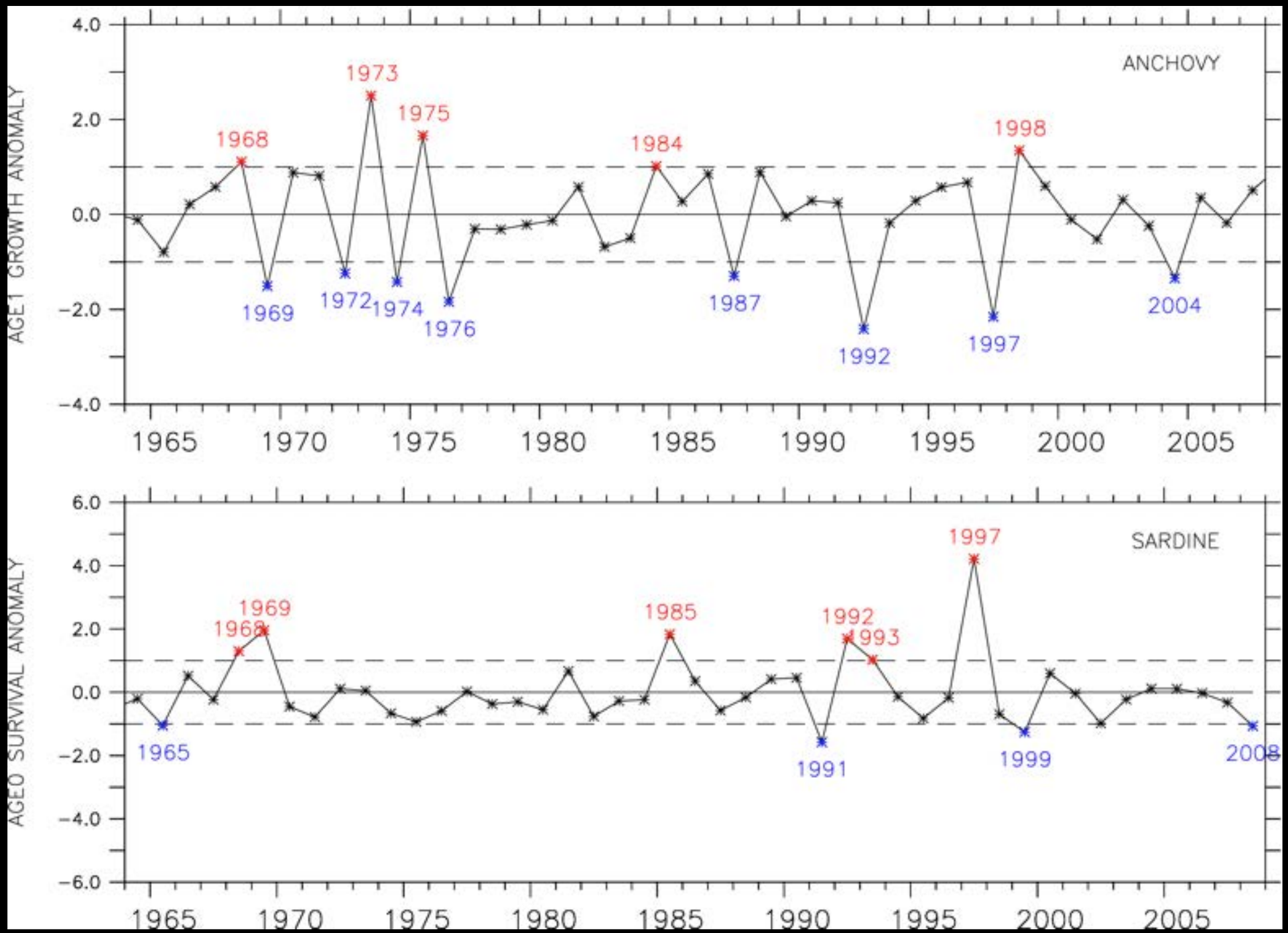
Mean (1964-2008) abundance by life stage (log_{10} of individuals); Anchovy (top) and sardine (bot.)



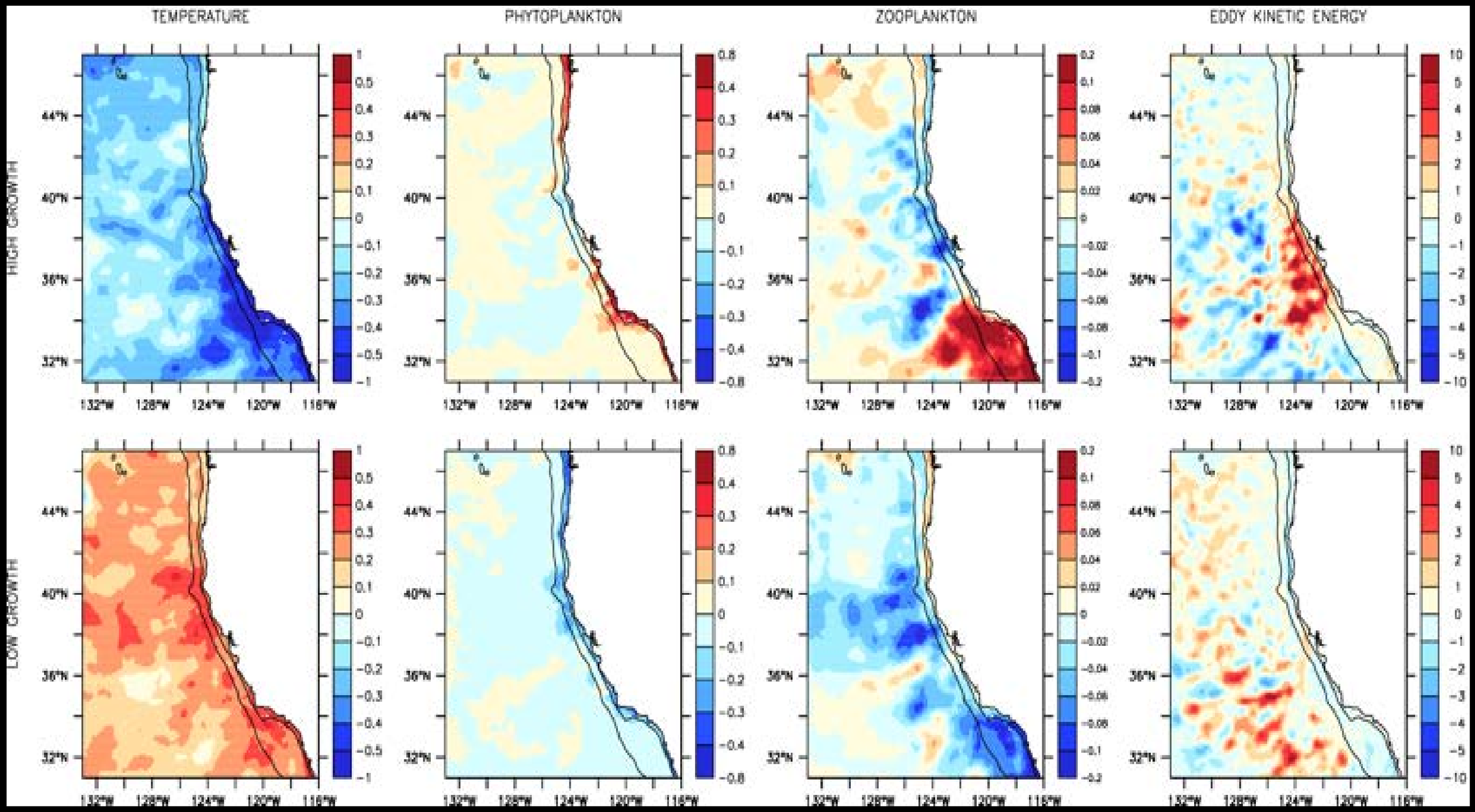
Population biomass



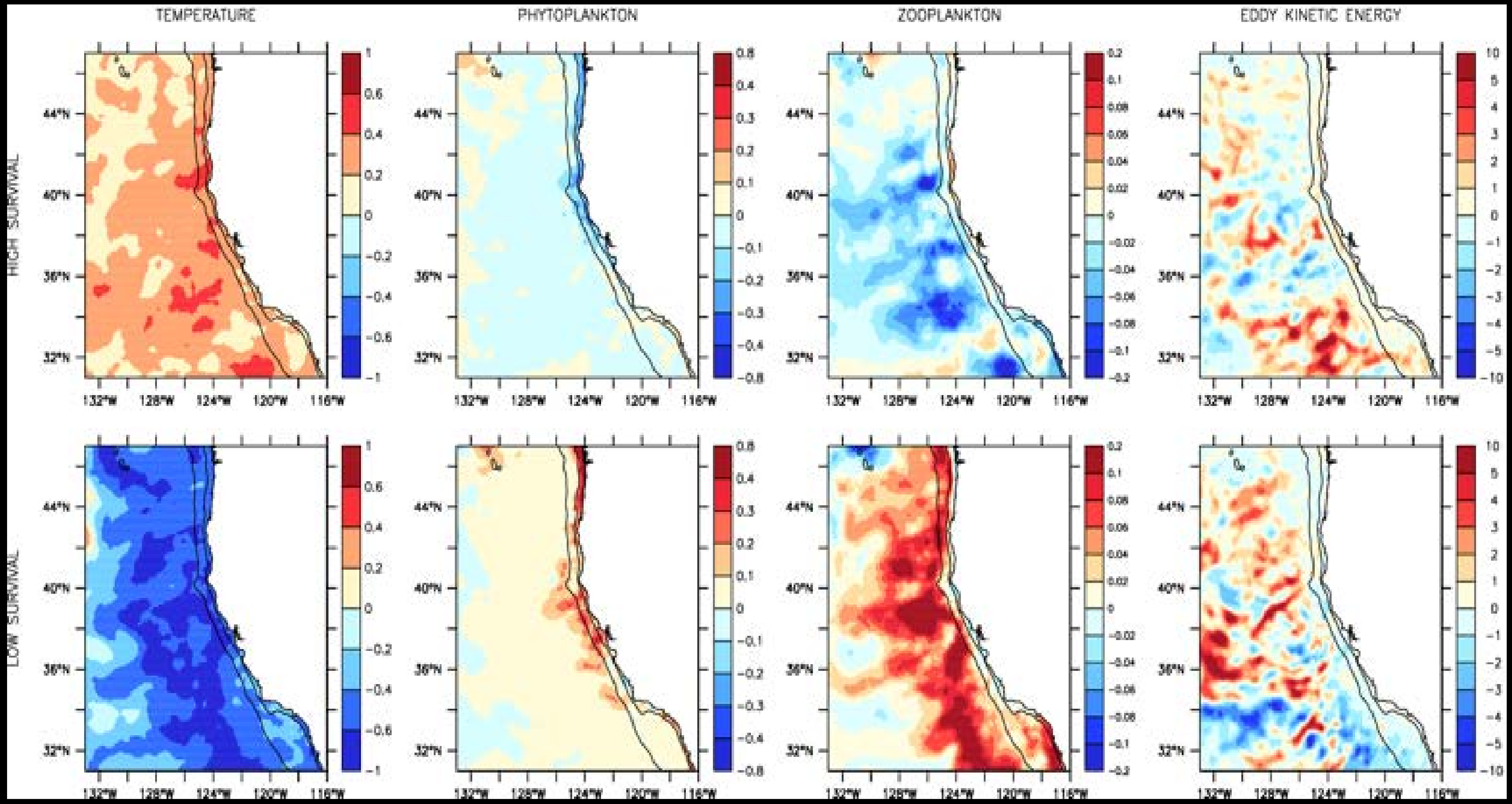
Annual anomalies
Top: Age-1 growth. Bot.: Age-0 survival



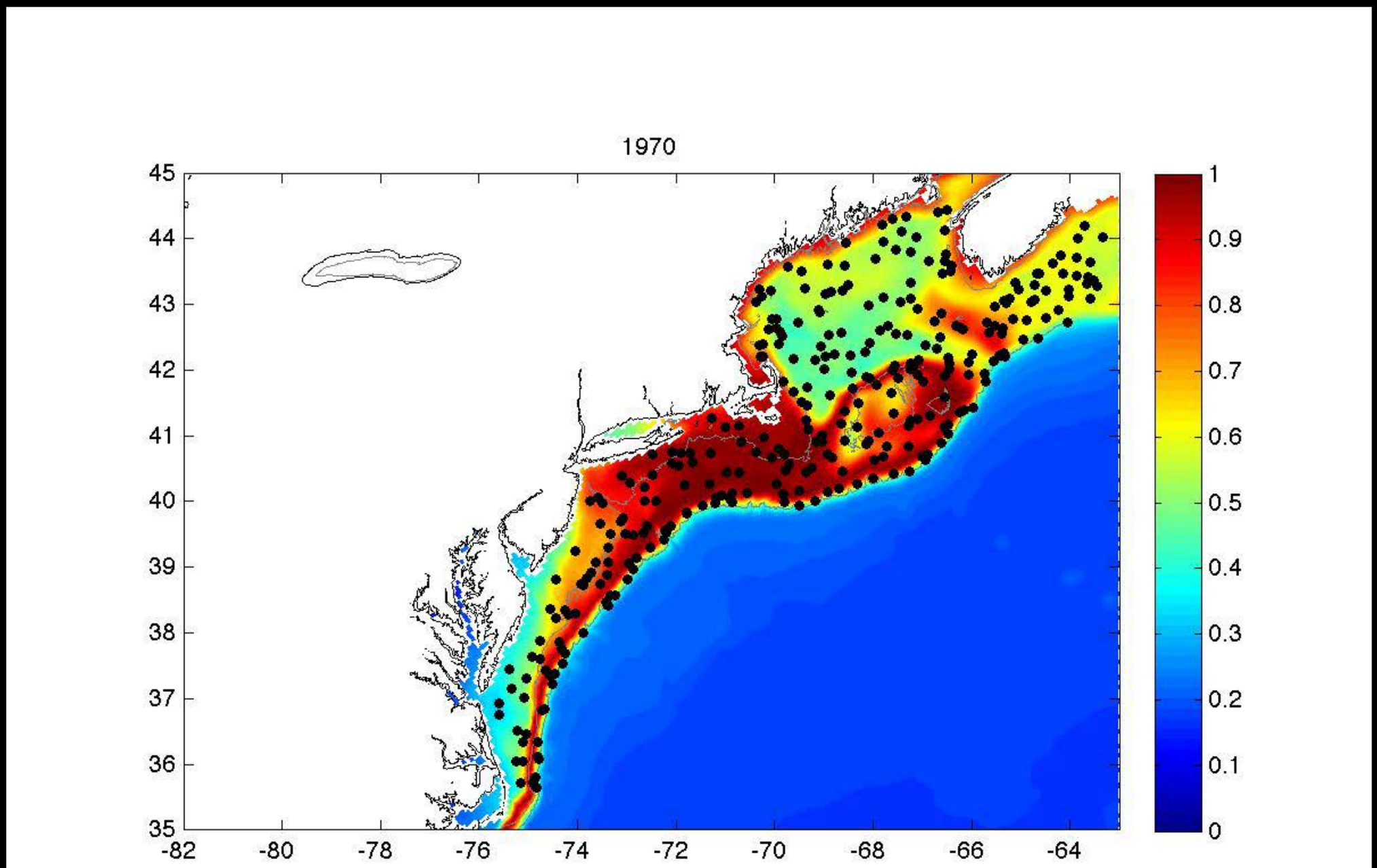
Environmental drivers: Anomalies for high- and low-years of anchovy age-1 growth



Environmental drivers: Anomalies for high- and low-years of sardine age-0 survival

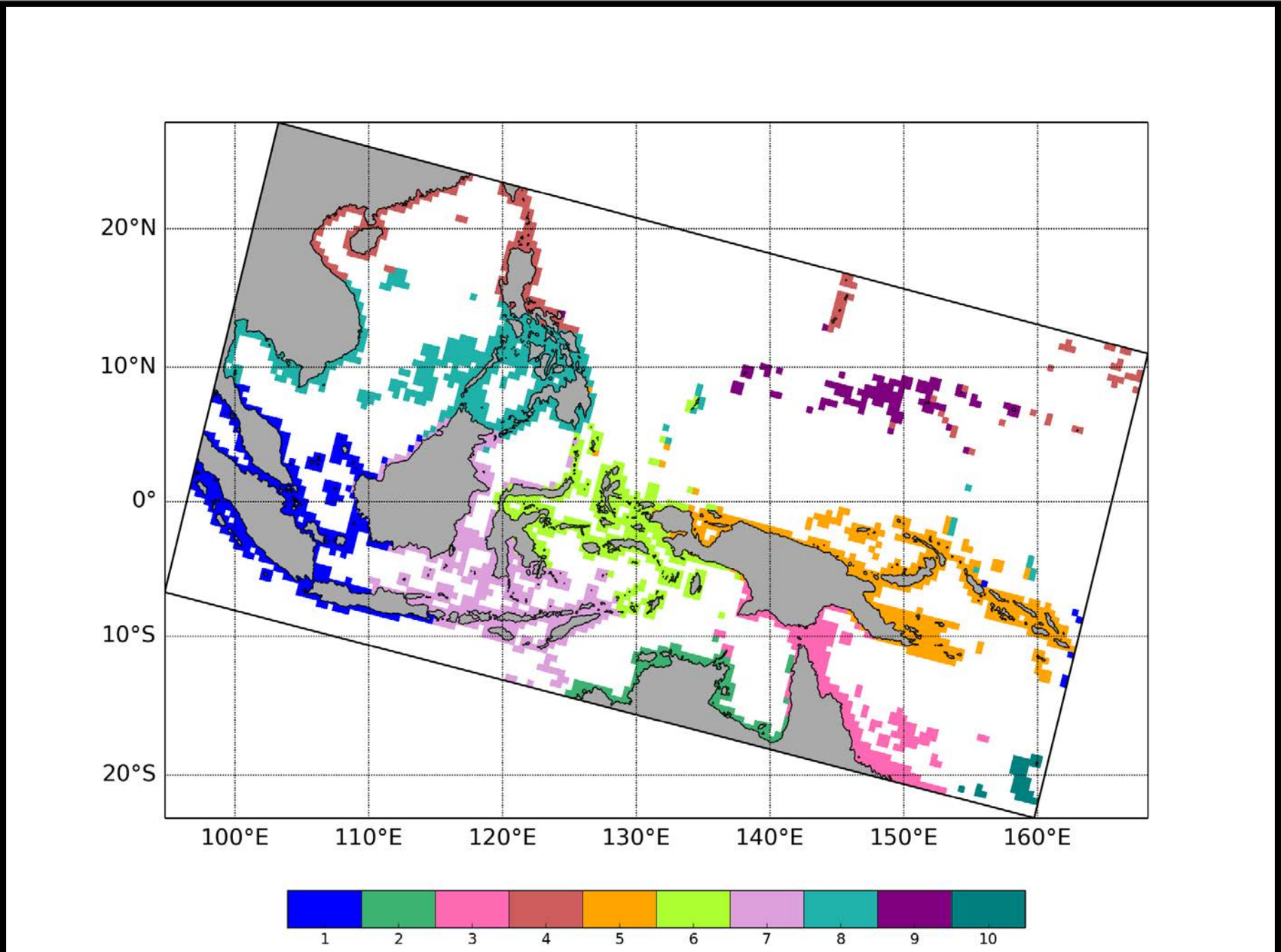


And now for something different:
Habitat modeling: Atlantic butterfish



A Lagrangian perspective

Connectivity



Lessons for tuna?

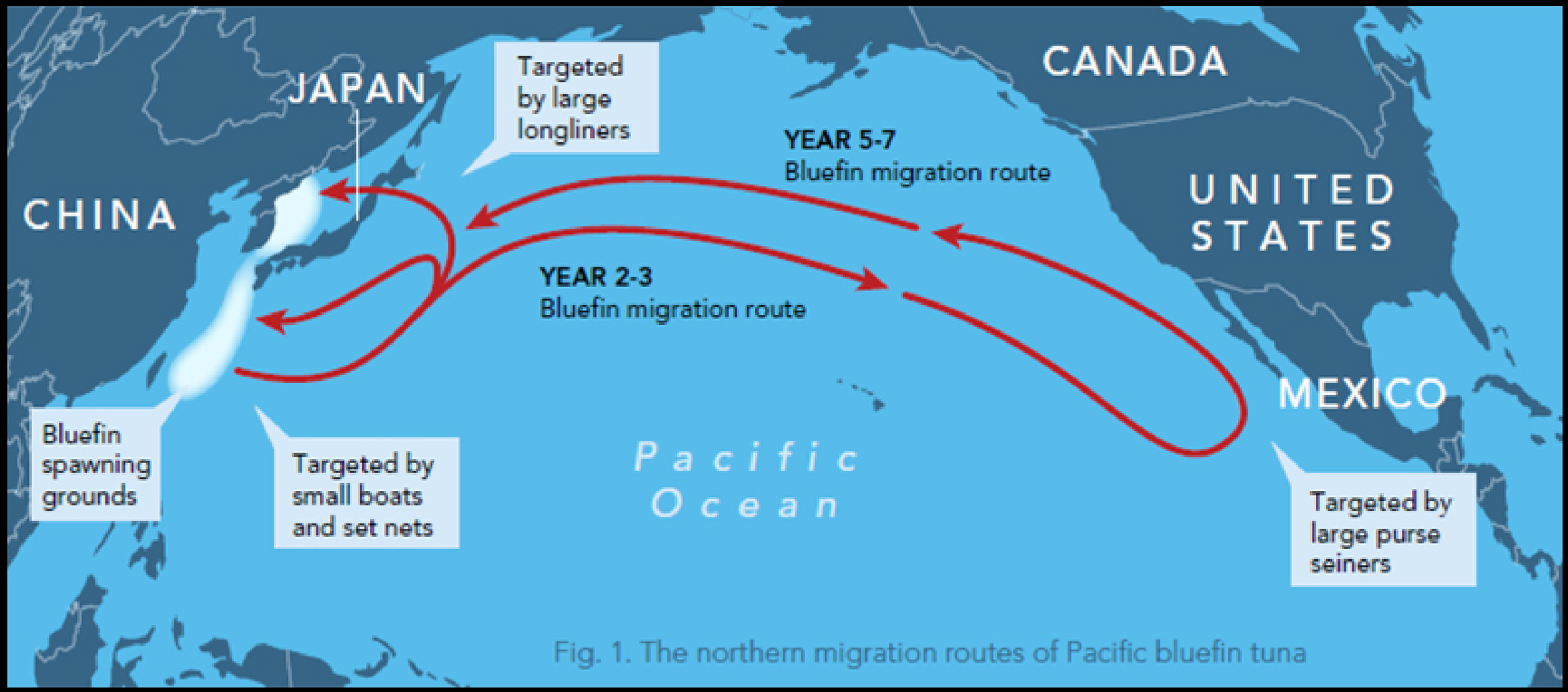


Fig. 1. The northern migration routes of Pacific bluefin tuna

Fish-for-thought

- Climate-to-fishing: Yes we can! –Downscaled climate, spatially explicit, multi-species, full life cycle…

- Our results hint at potential linkages to known modes of climate variability, with anchovy responding to ENSO and sardine to the PDO (in the CCS).

- Slightly different temperature and diet preferences can lead to significantly different responses to environmental variability—biology matters!

- Coupled models inherently different from forced (hindcasts) models. Need to think about how best to apply climate projections to fisheries.