Predicting and adapting to biome-scale marine resource changes in the North Pacific

PICES International Symposium
Understanding Changes in Transitional Areas of the Pacific

April 25, 2018

Presented by: Charles Stock
(with contributions from many)

A special thanks to:

Dr. Desiree Tommasi, now a research scientist with NOAA's Cooperative Institute for Marine Ecosystems and Climate; based at the Southwest Fisheries Science Center in La Jolla

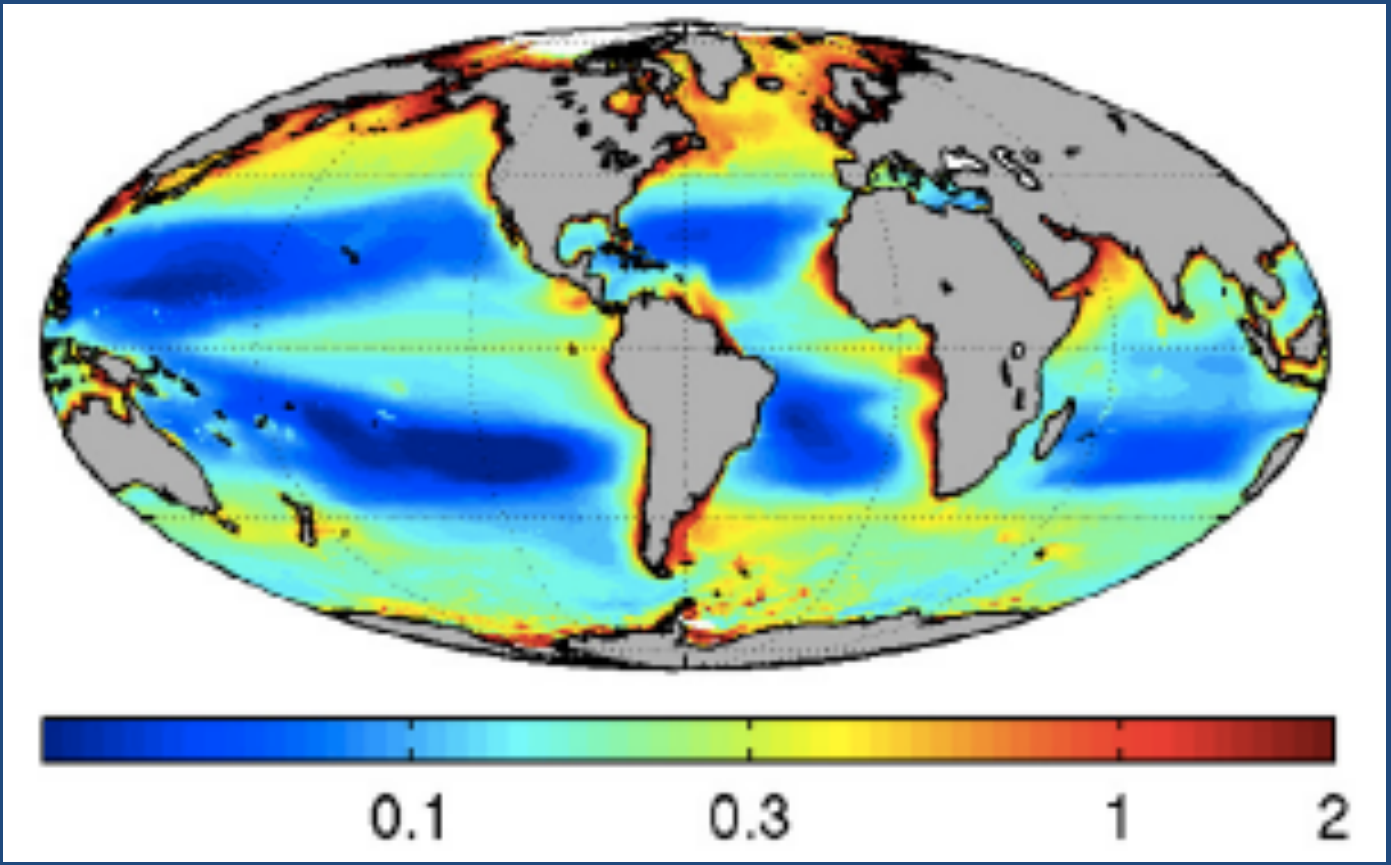
Dr. Jong-Yeon Park, a visiting scientist at GFDL funded by NOAA/OAR's Marine Ecosystem Tipping Points Initiative

Spoilers….

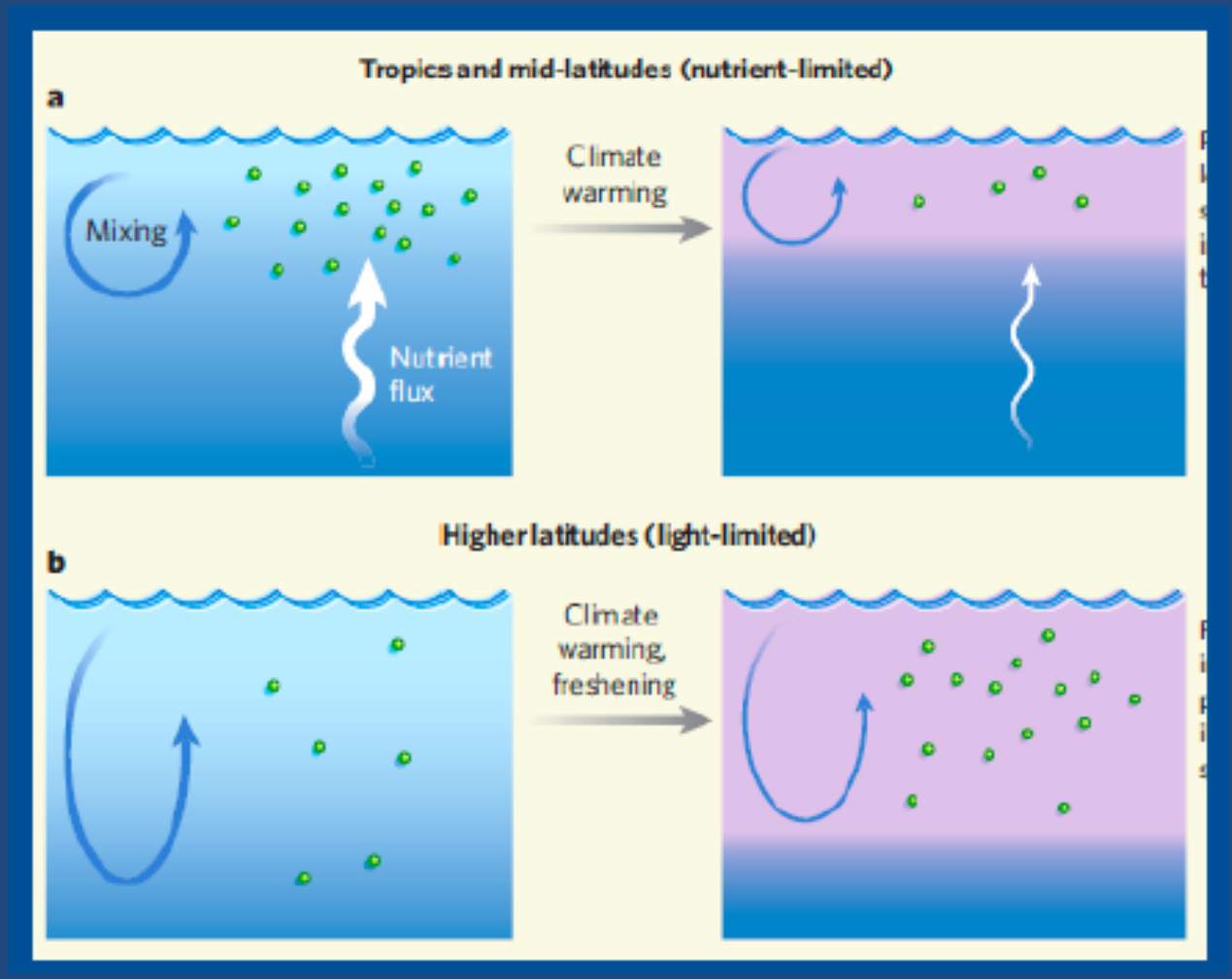
- The potential for large regional and biome-scale trends in fisheries catch under climate change is a natural consequence of basic food web theory and is supported by observed spatial catch gradients in the contemporary ocean.
- Anticipatory consideration of climate/ecosystem fluctuations on seasonal to multiannual time scales may help maximize fisheries benefits in the face of rapidly changing baselines: improve short-term decisions for long-term resilience.

Ocean productivity driven by the confluence of nutrients and light

Surface Chlorophyll from SeaWIFS

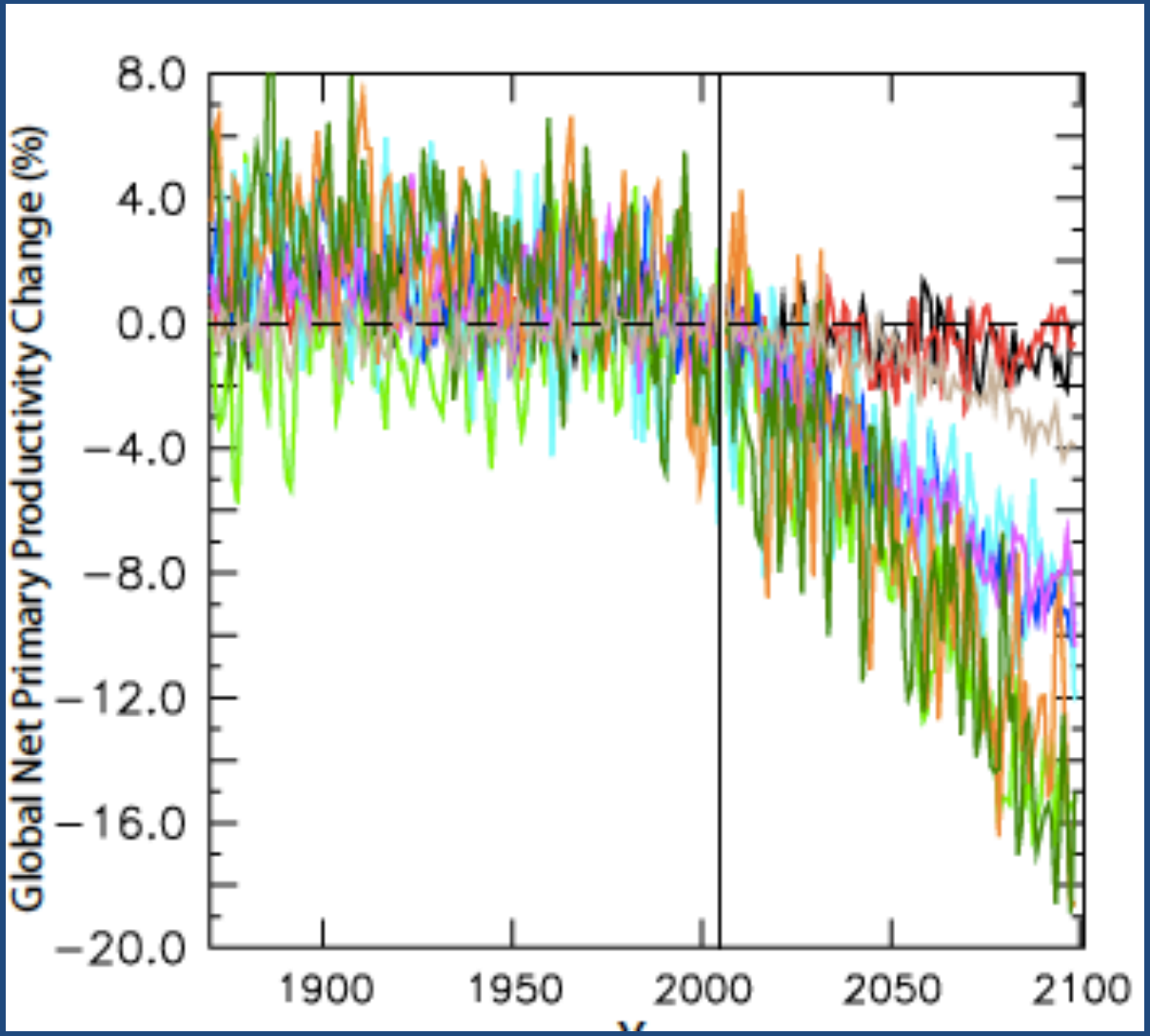


Increasing ocean stratification expected under climate change modulates this confluence



Doney, Nature, 2006; see also Bopp et al., GBC 2001; Sarmiento et al., GBC 2004; Steinacher et al., 2010

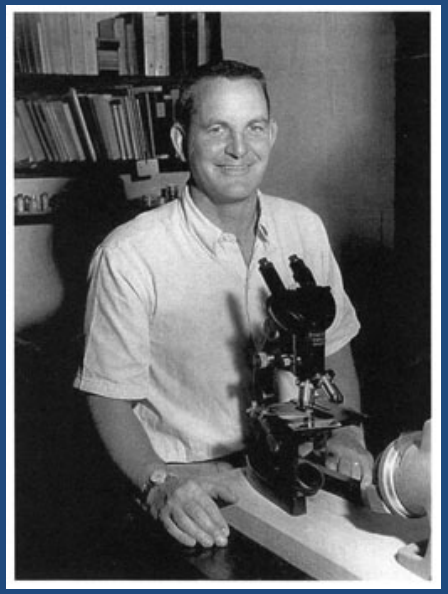
Stable to modest projected global NPP declines = Stable to modest fisheries declines?



Bopp et al., Biogeosciences, 2013

Might fish catch changes be considerably larger than NPP trends?

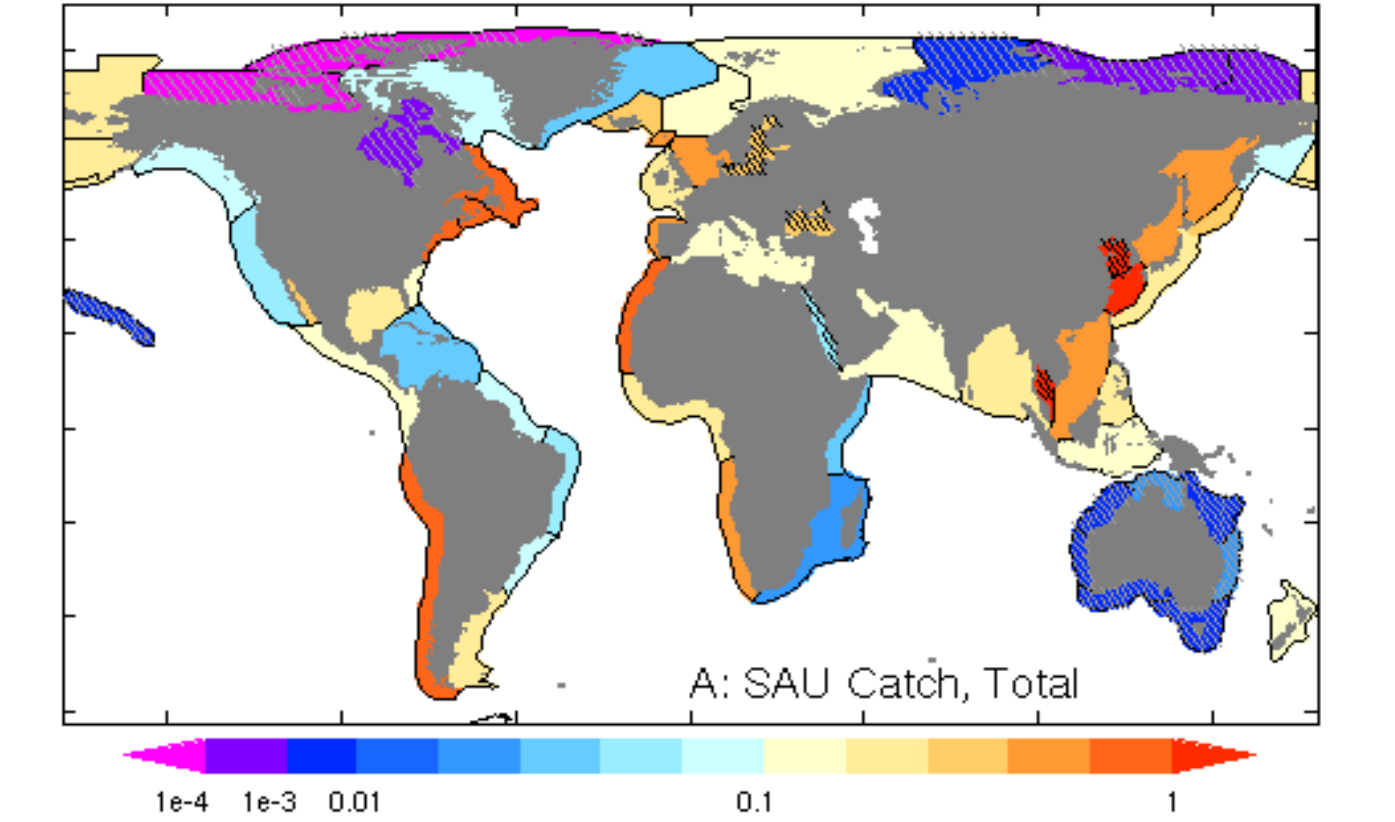
"Primary production and the associated food chain dynamics may act additively to produce differences in fish production which are far more pronounced and dramatic than the observed variability of the individual causative factors". (Ryther, 1969, Science)



- What do modern data and models tell us about Ryther's hypothesis?
- Can the food chain dynamics responsible for creating stark spatial fish catch gradients in the contemporary ocean amplify temporal fish catch trends?

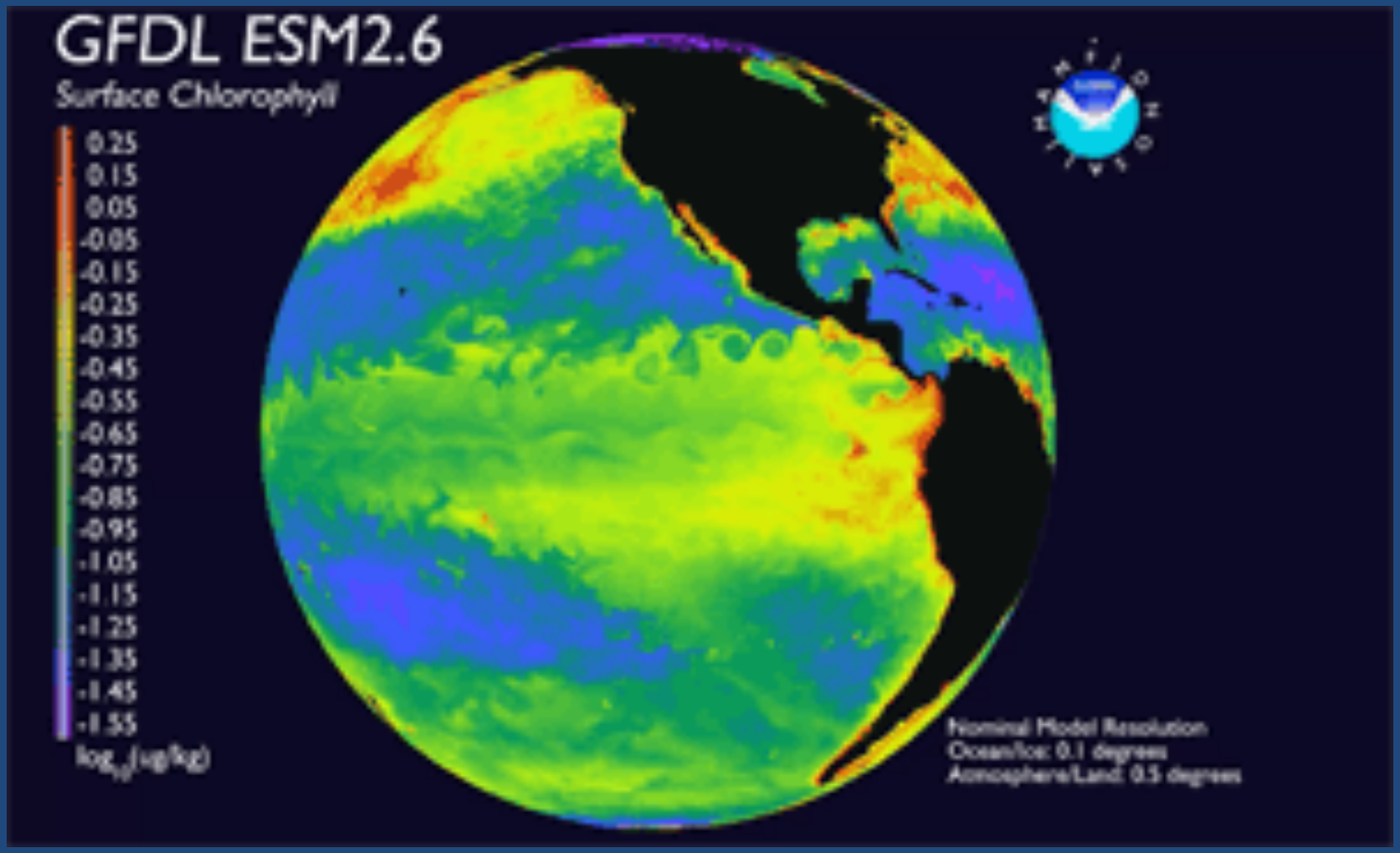
Stark contrasts in fish catch across marine ecosystems

Mean of top 10 catch years, g C m^{-2} day^{-1}

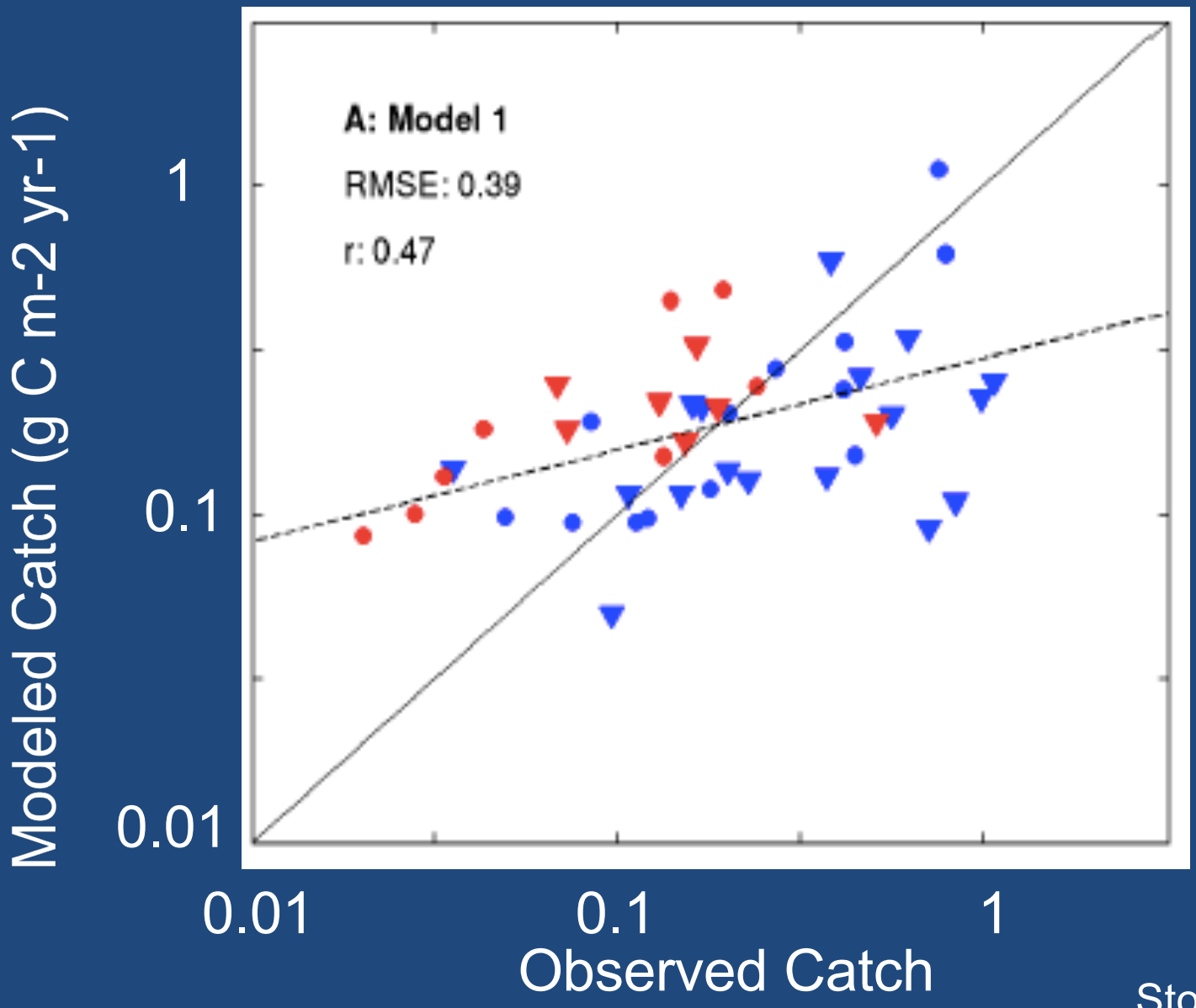


Pauly and Zeller (2016) Nature Communications, 7; Stock et al., in review

GFDL ESM2.6 Surface Chlorophyll



Primary production alone is a poor predictor of fisheries catch



Stock et al., PNAS, 2017

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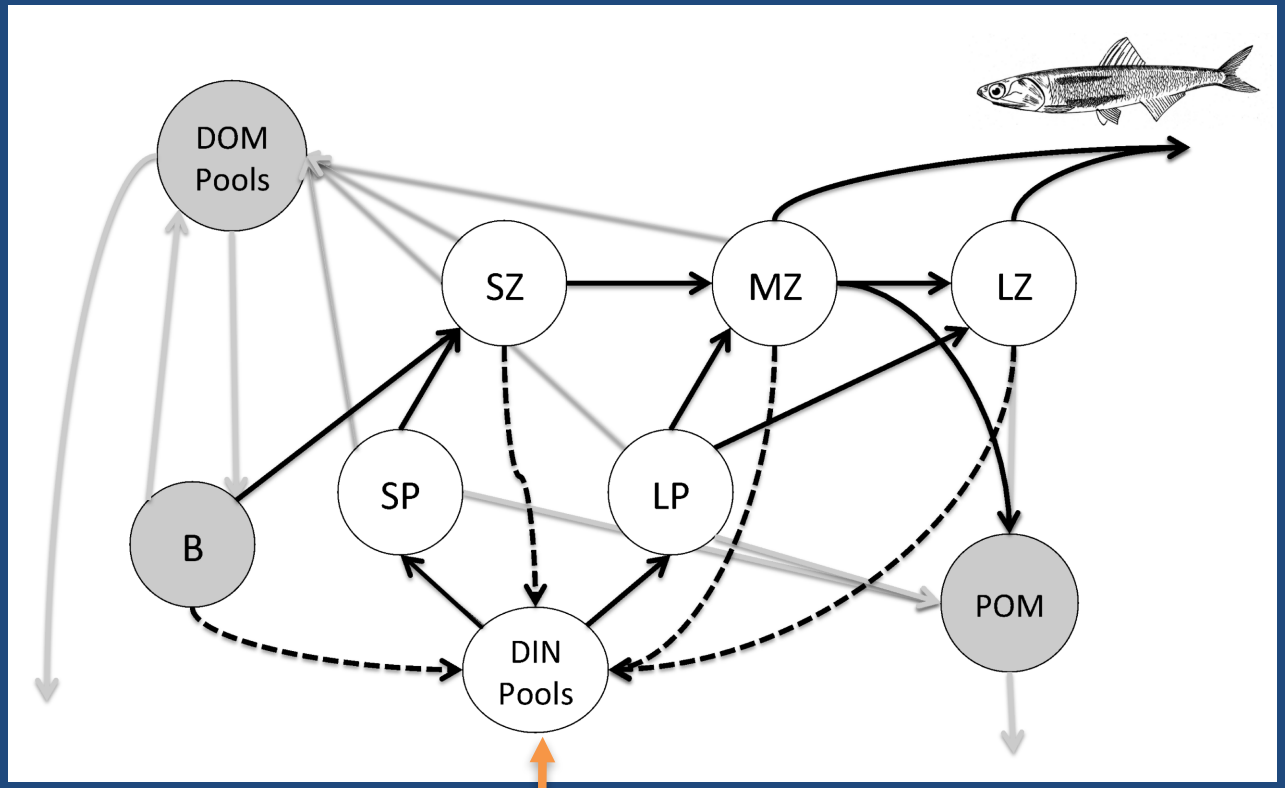
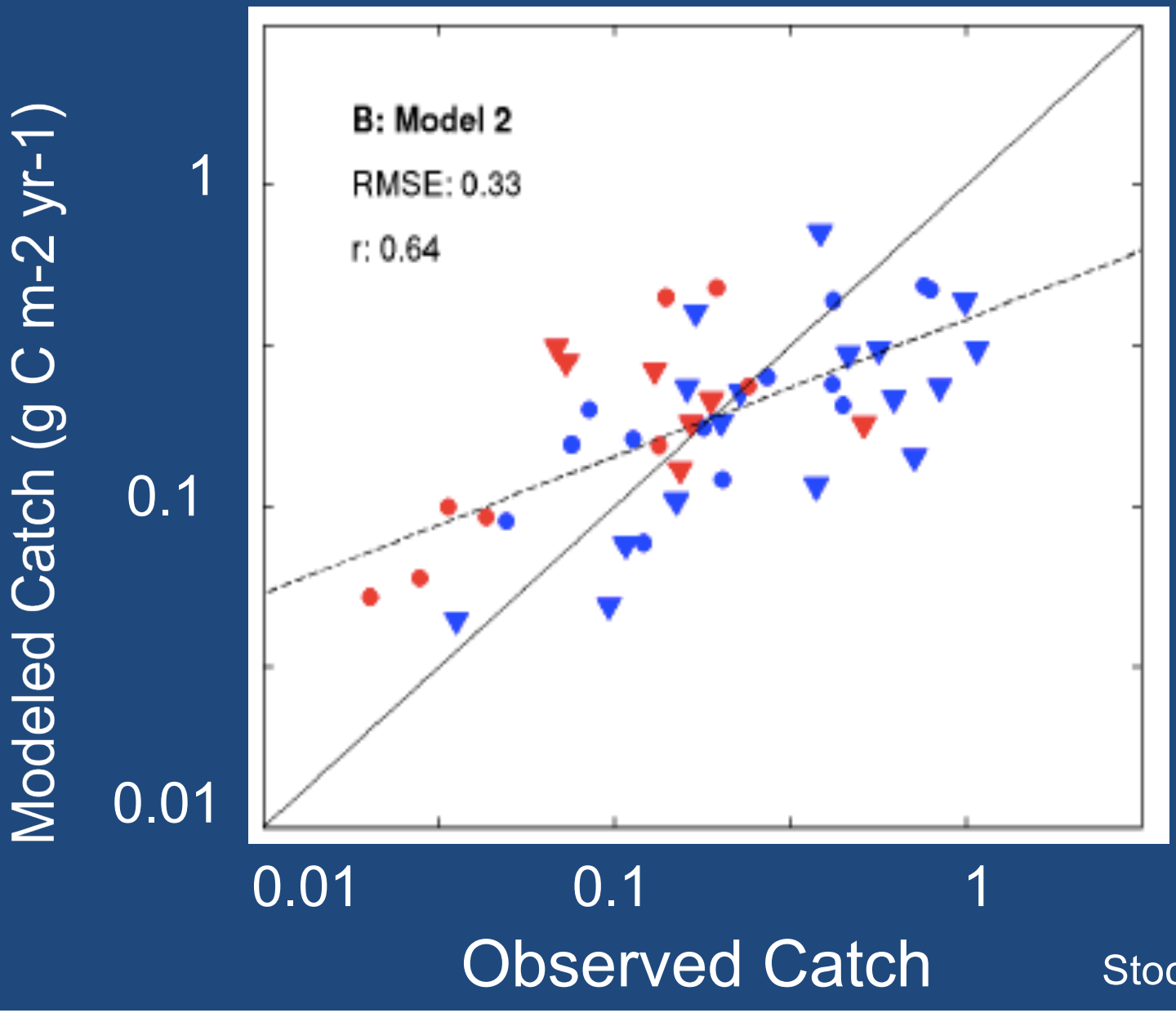


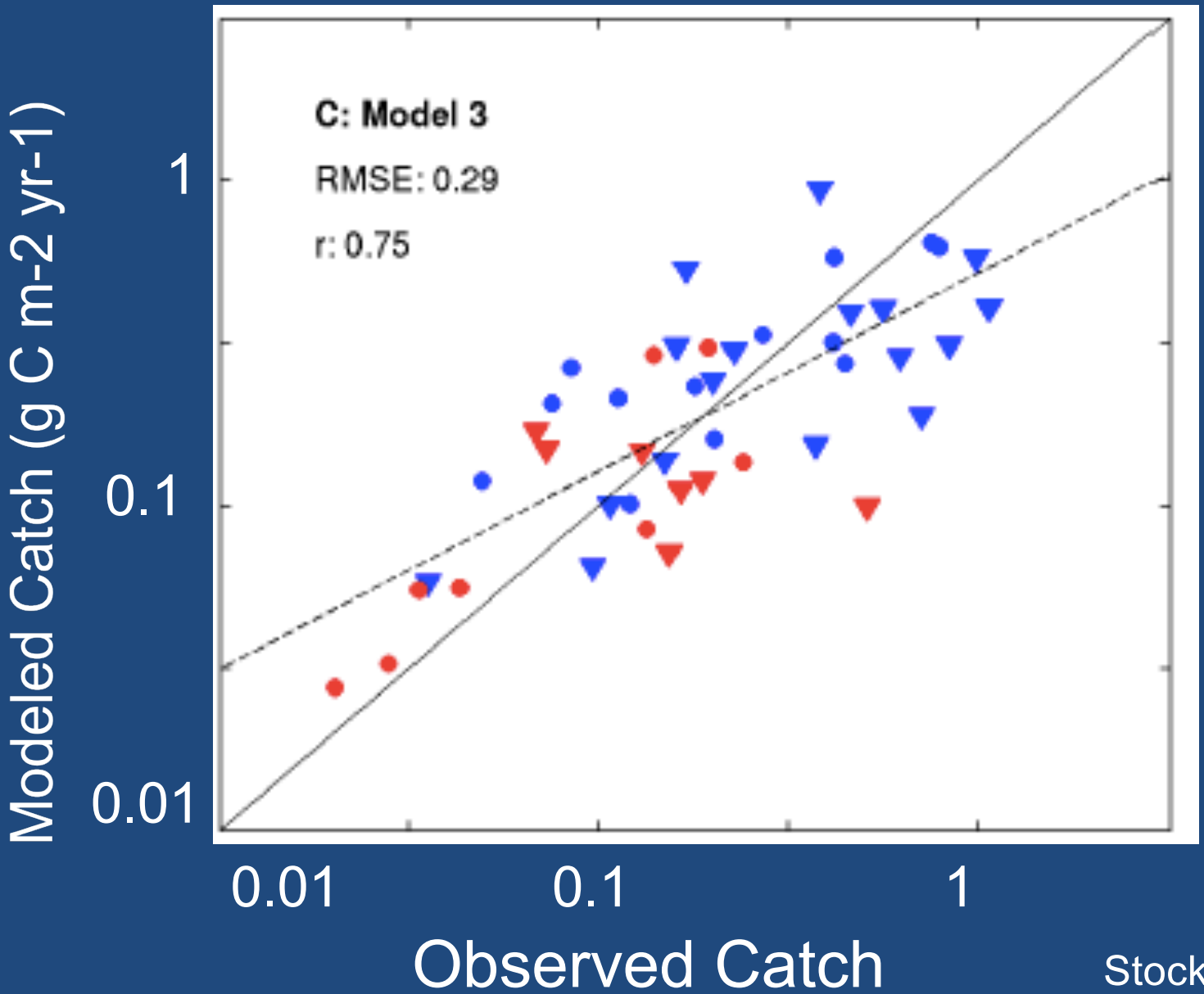
Stock et al., 2014, PinO, 120, 1-28

Model 2: Accounting for benthic and pelagic pathways



Stock et al., PNAS, 2017

Model 3: Benthic-pelagic pathways and reduced tropical trophic efficiency

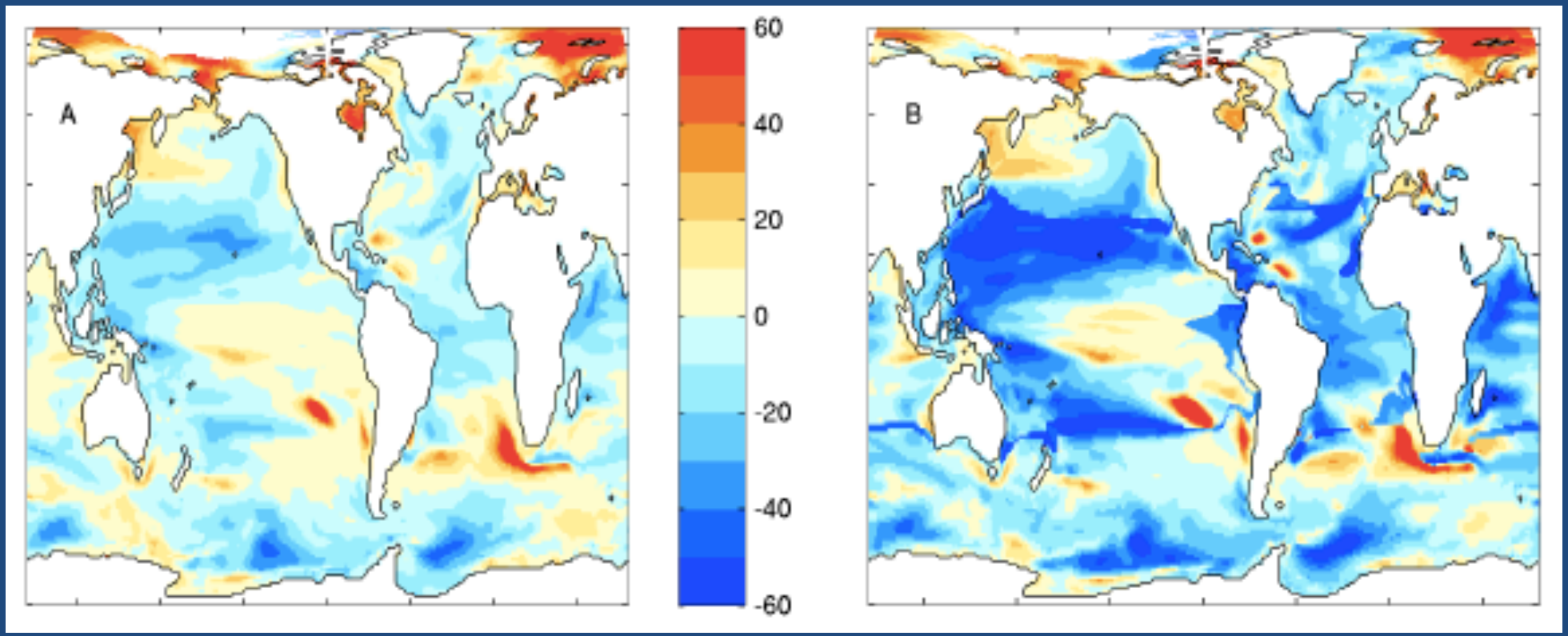


Stock et al., PNAS, 2017

Potential for regional changes in fish catch exceeding 50% under RCP8.5

% NPP change

% Catch change



100 * ((2051-2100) – (1951-2000)) / (1951-2000); RCP8.5

Stock et al., PNAS, 2017

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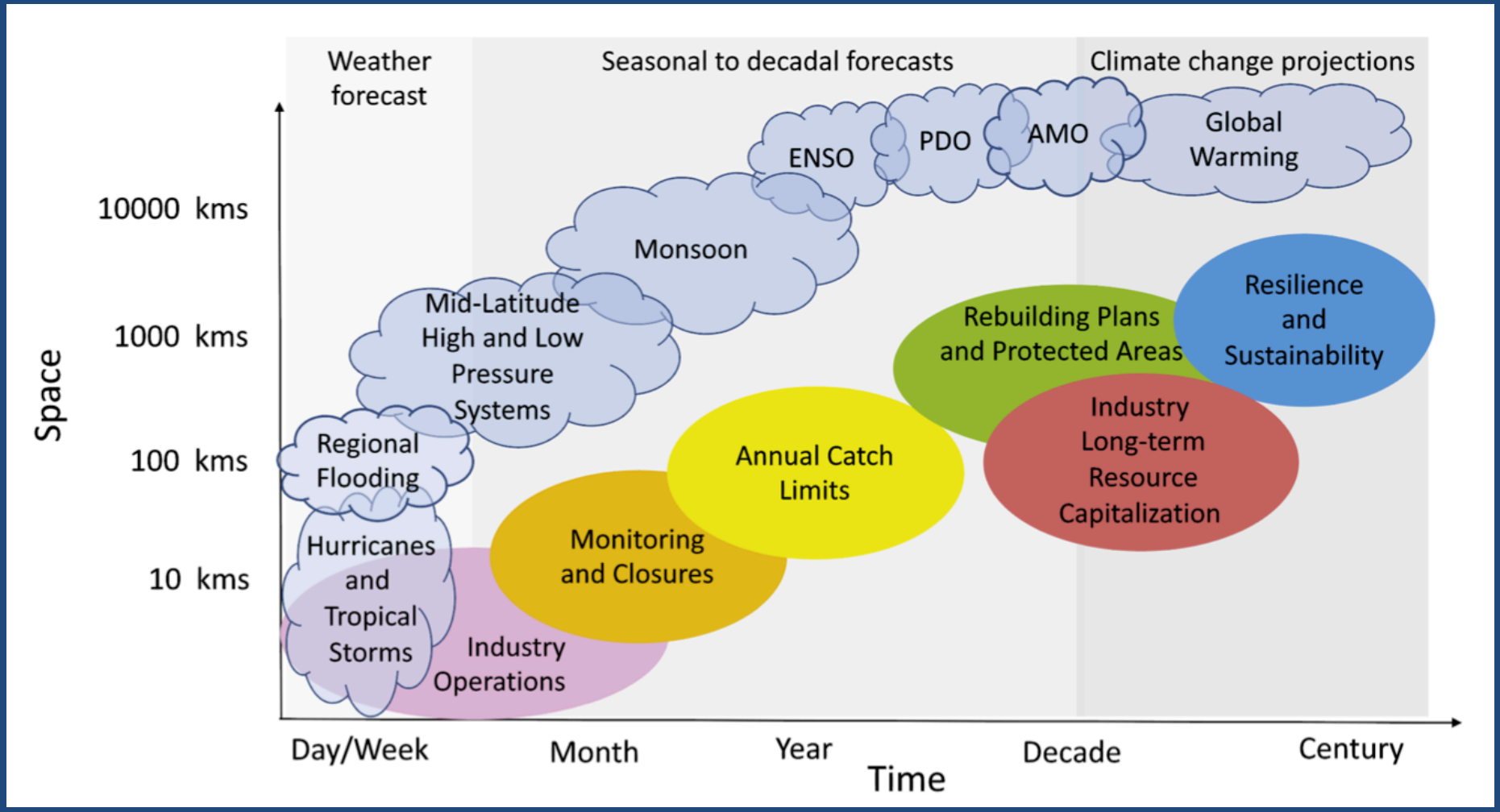
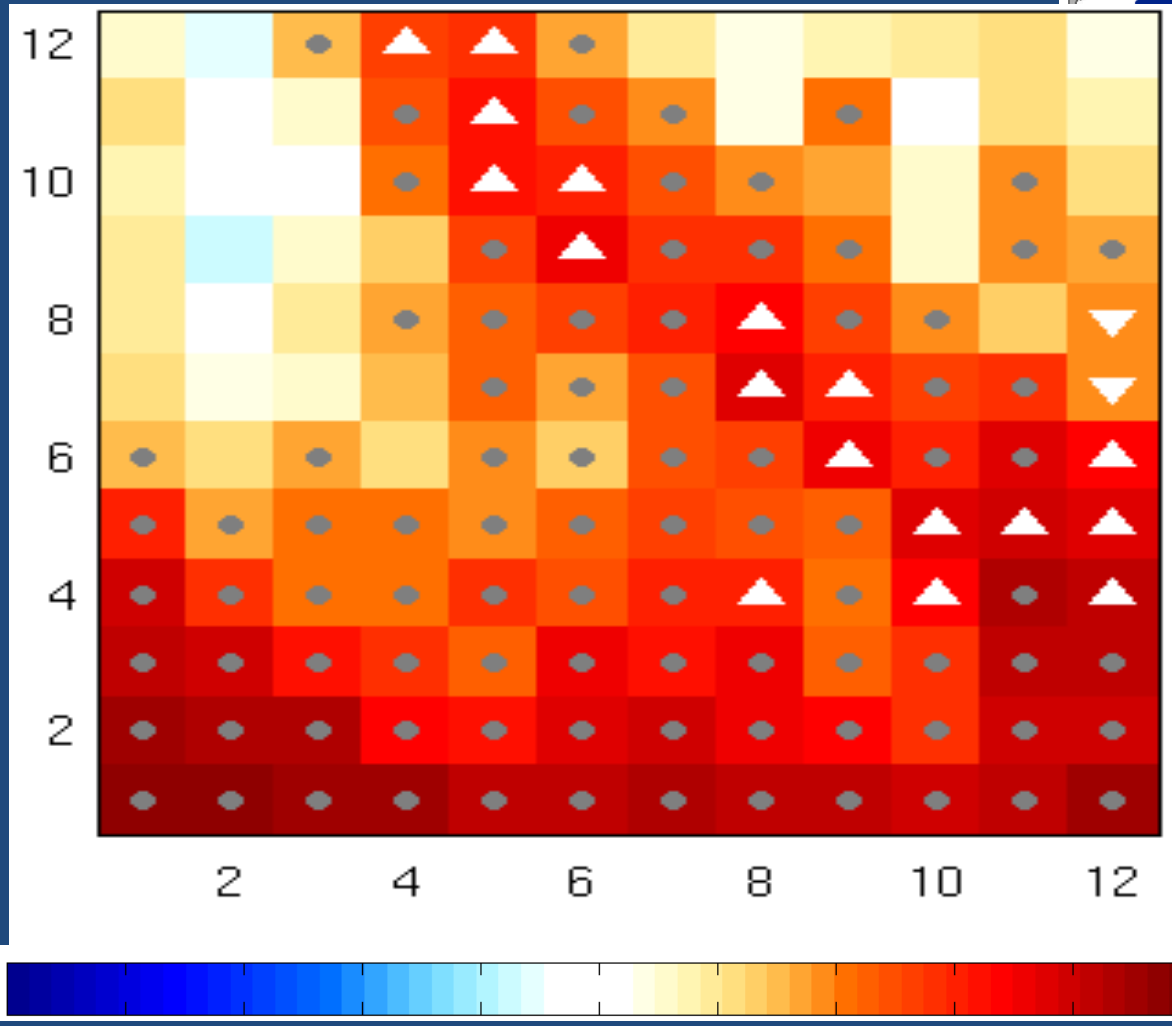
Climate-informed short-term decisions for long-term resilience?

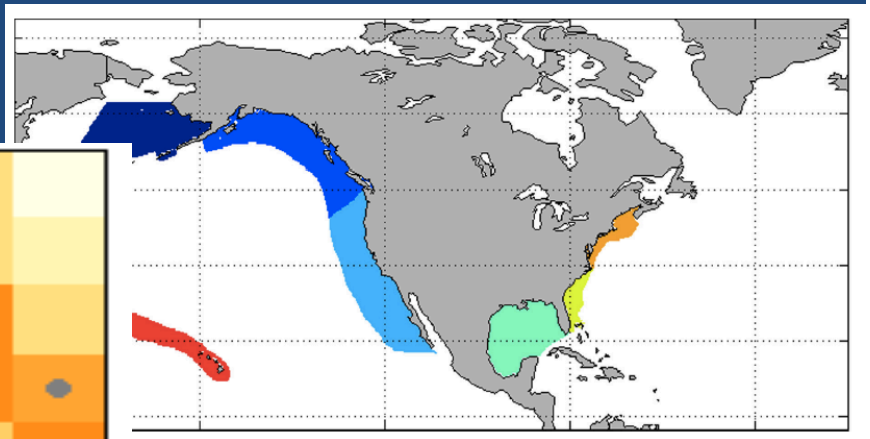


Tommasi et al., Progress in Oceanography, 2017

Skillful seasonal SST predictions for many LMEs, some with leads of 6 months or more

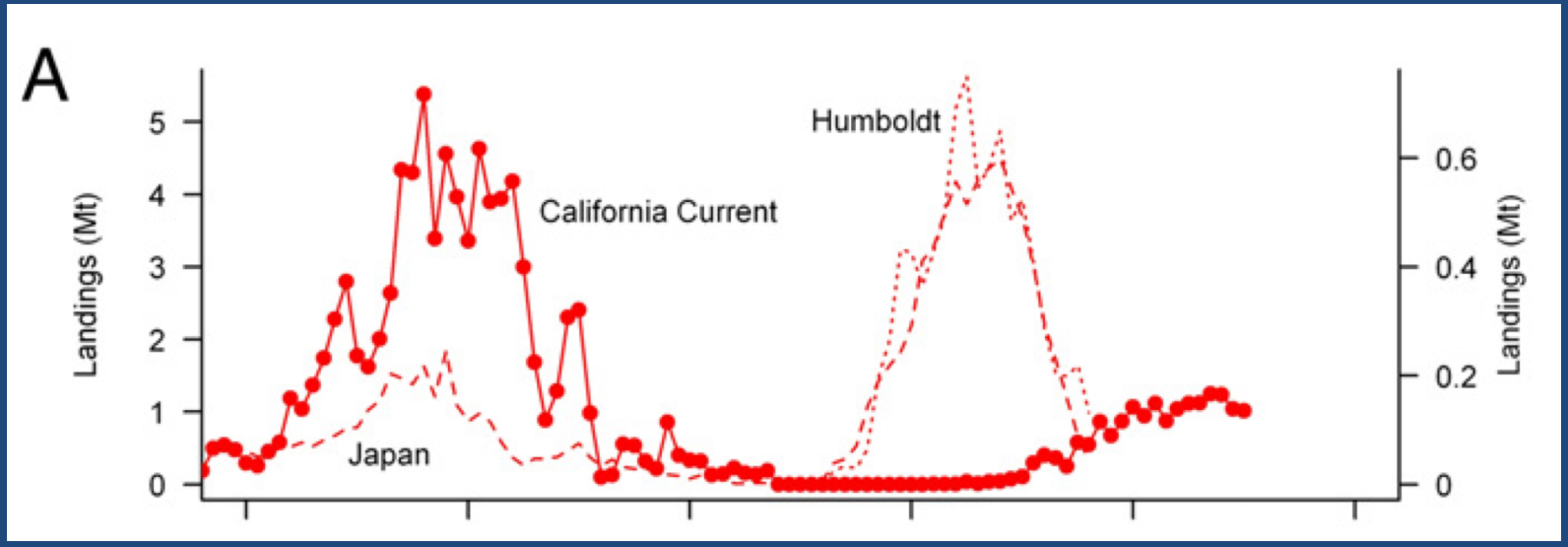
Gulf of Alaska SST prediction

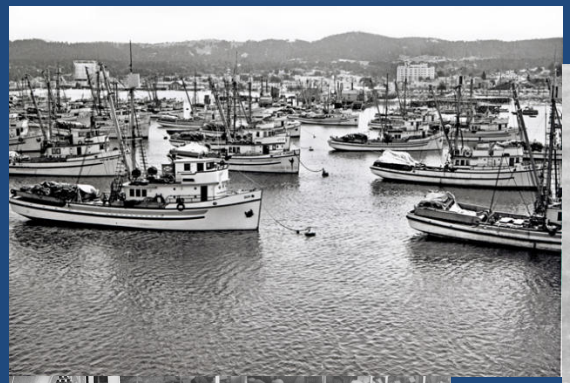




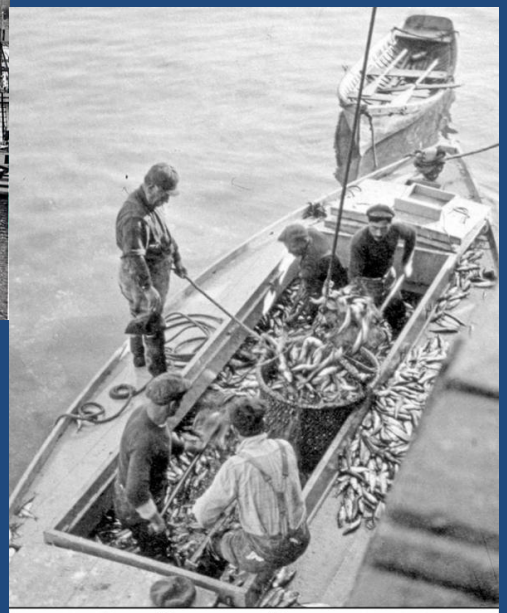
Stock et al., Progress in Oceanography, 2015; see also Tommasi et al., 2017; Frontiers in Marine Science for multi-annual prediction

Many of the most acute impacts of climate arise from climate variations over years to decades





Women cannery workers on the line - 1949

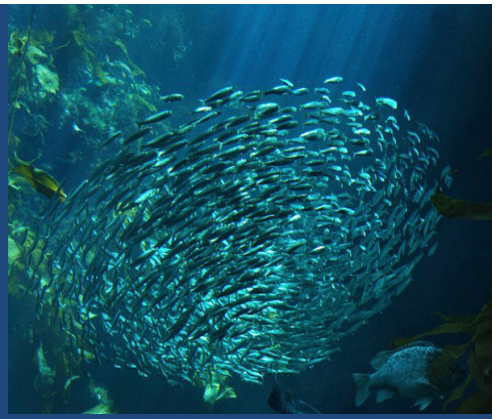


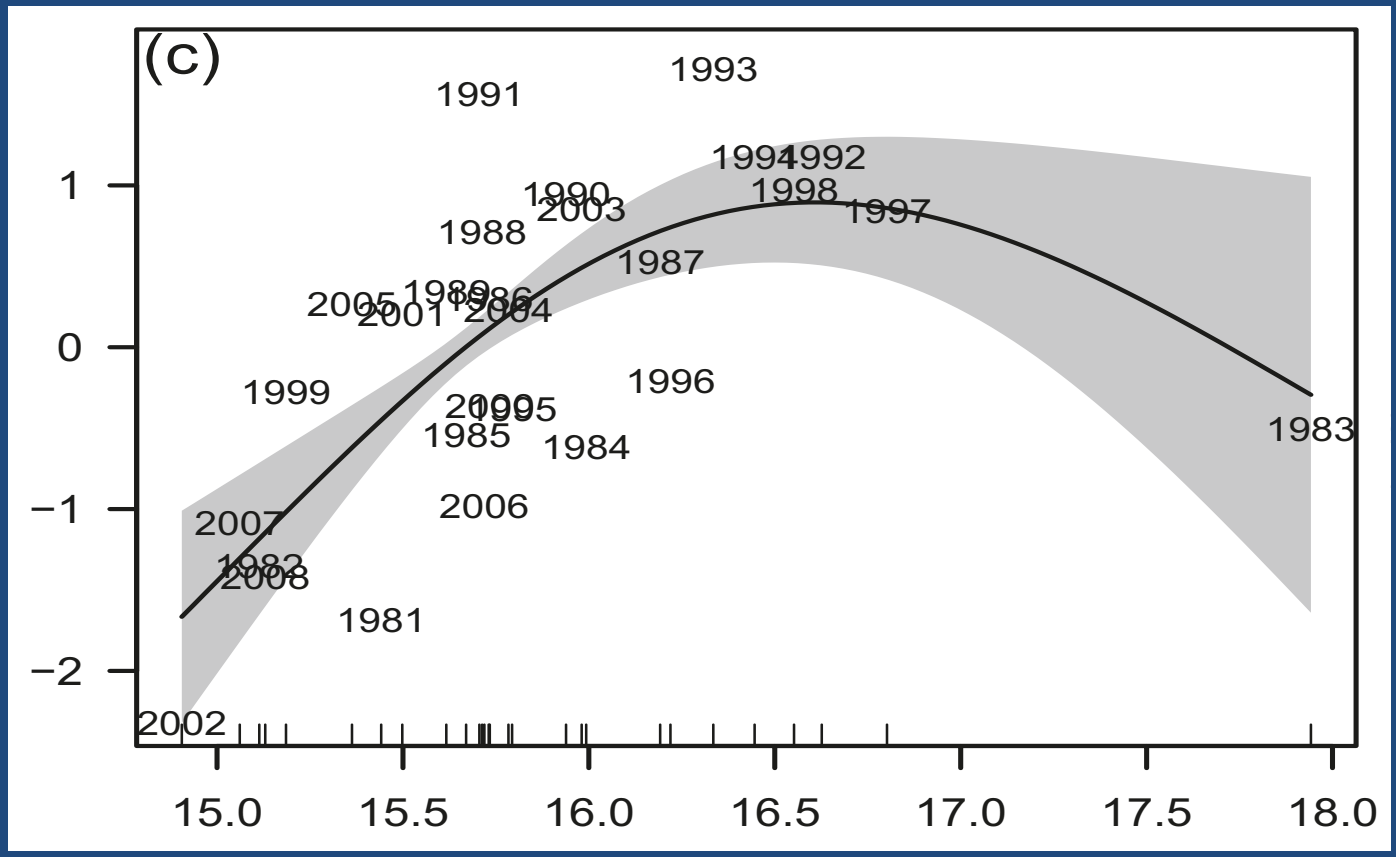
Unloading sardines - 1920s

End of an Era - Cannery Row.1950

Photos courtesy of the city of Monterey

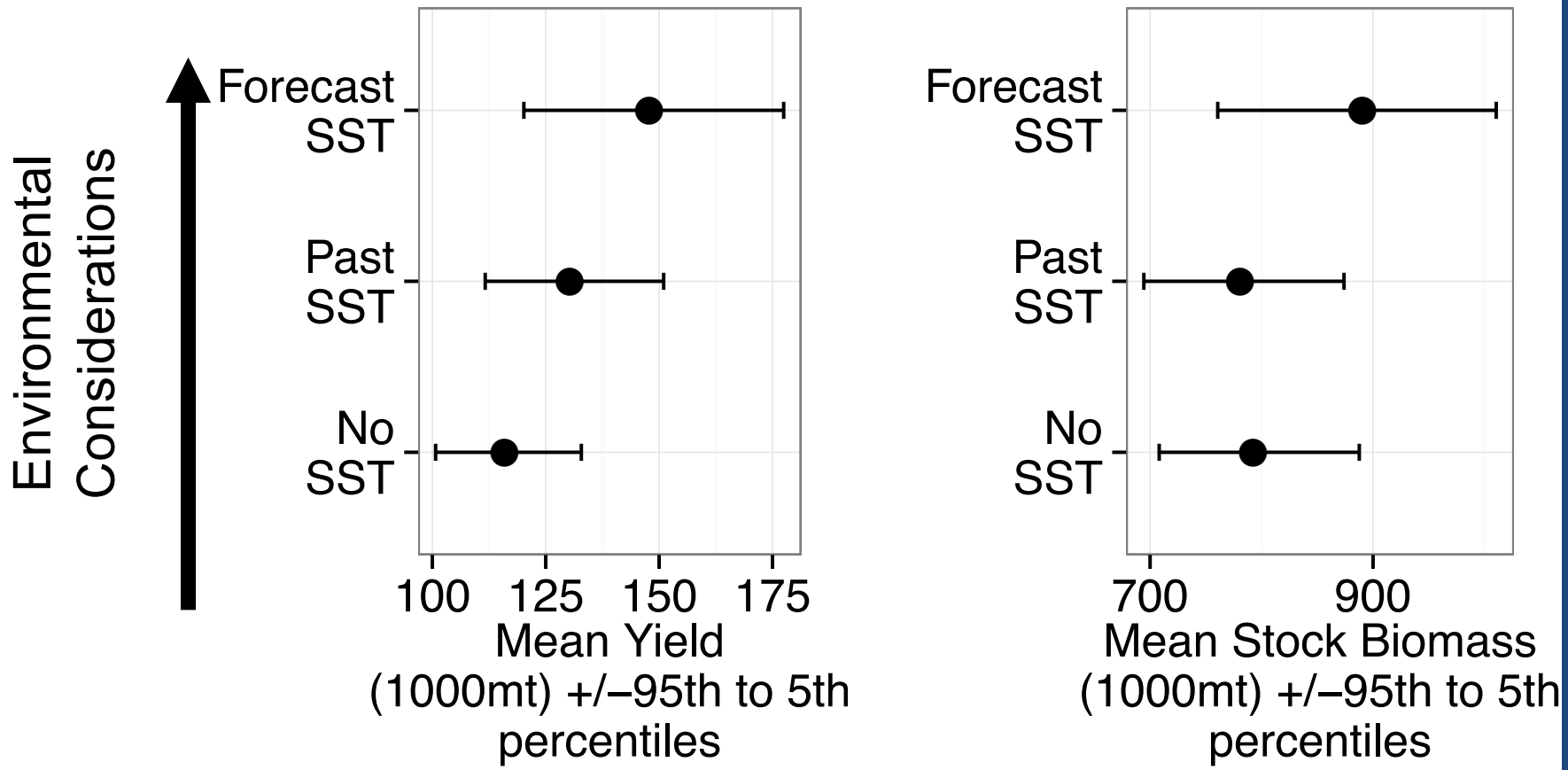
California sardine recruitment depends on SST anomalies





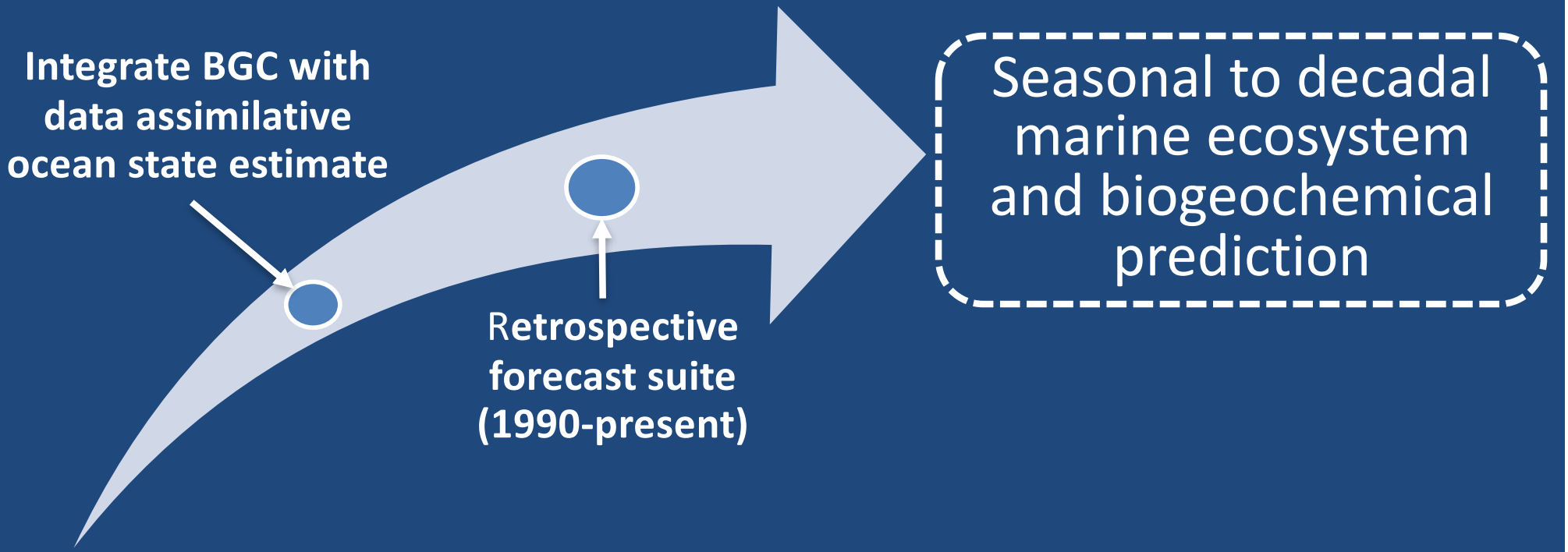
Lindegren and Checkley, 2013

Increased expected yield and stock biomass through anticipatory management



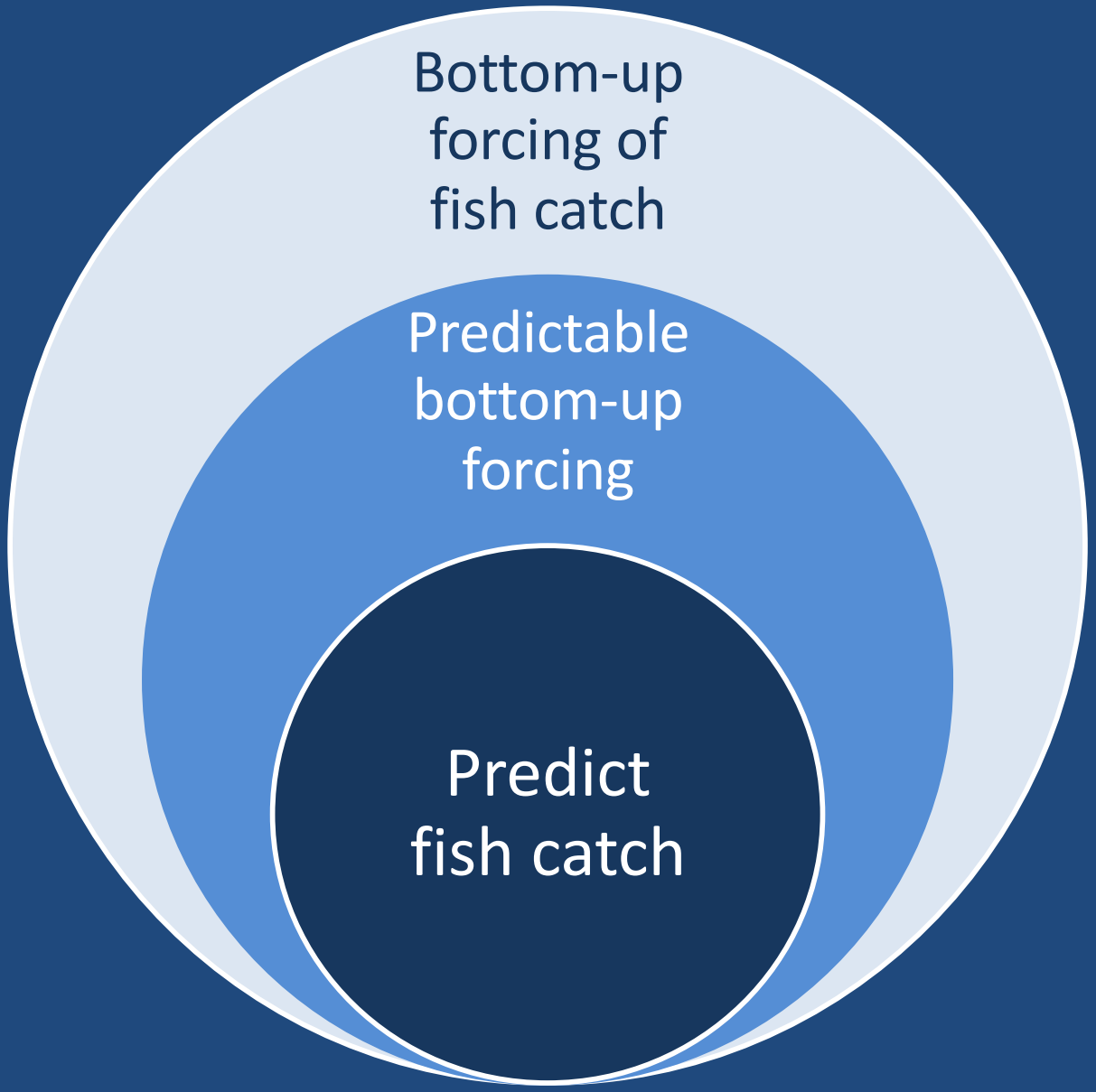
Tommasi et al., 2016; Ecological Applications

Toward seasonal to decadal ocean ecosystem prediction



NOAA marine ecosystem tipping points initiative: Park et al., JAMES, 10, 891-906; Park et al., in press

Can we predict inter-annual fish catch variations?



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