Climate Predictions to Support Fisheries Management in a Changing Ocean

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WITH THANKS TO CHARLES STOCK, KATHY PEGION, GABRIEL VECCHI, RICHARD METHOT, MICHAEL ALEXANDER, ALISTAIR HOBDAY, ISAAC KAPLAN, ANDREW PERSHING, SAMANTHA SIEDLECKI, KIRSTIN HOLSMAN, AND MANY OTHERS

Outline

- Climate effects on fisheries
- Environmental considerations in fisheries decisions
- Climate predictions at fishery relevant scales
- Successful application of seasonal forecasts for fisheries
- Challenges and future research needs

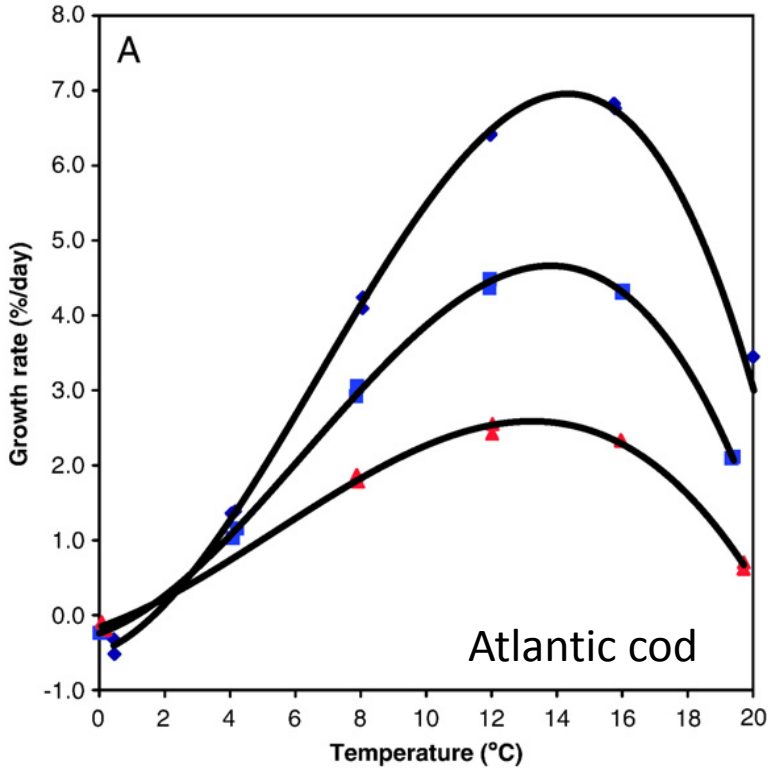
Impacts of climate variability on fisheries

Recruitment

Walleye pollock

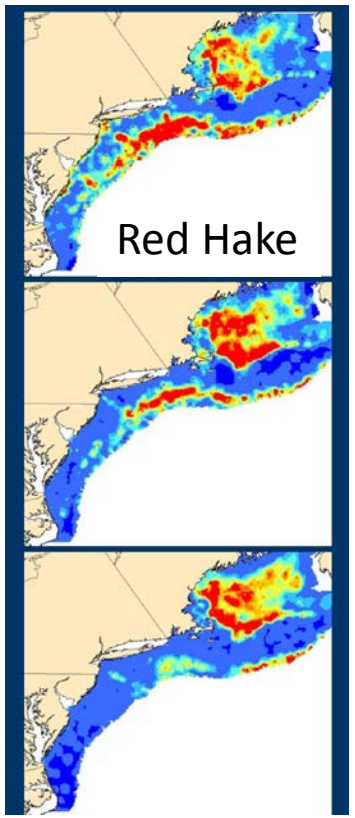
Ianelli et al. 2011

Growth



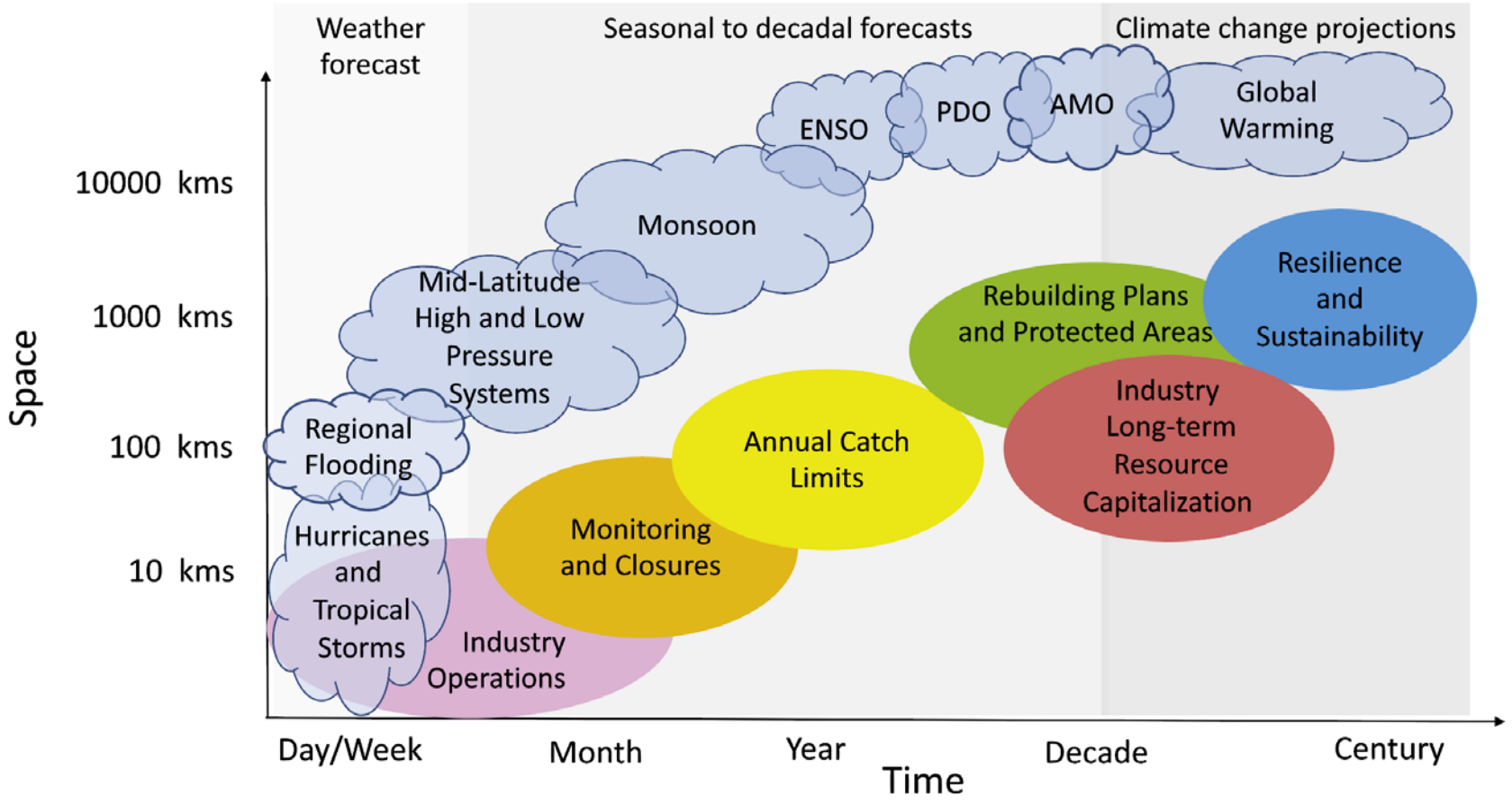
Bjornsson et al. 2007

Distribution



Nye et al. 2009

Fisheries decisions across time scales are impacted by climate effects



Aquaculture
- Extreme weather responses
- Stocking/harvest time

Fishing Industry
- Labor and gear needs
- Where/when/what to fish for

Coastal Management
- Beach closures (e.g. HAB's, jellies)

Fisheries Management
- Fisheries closures to reduce unwanted and incidental capture
- Provision of catch advice

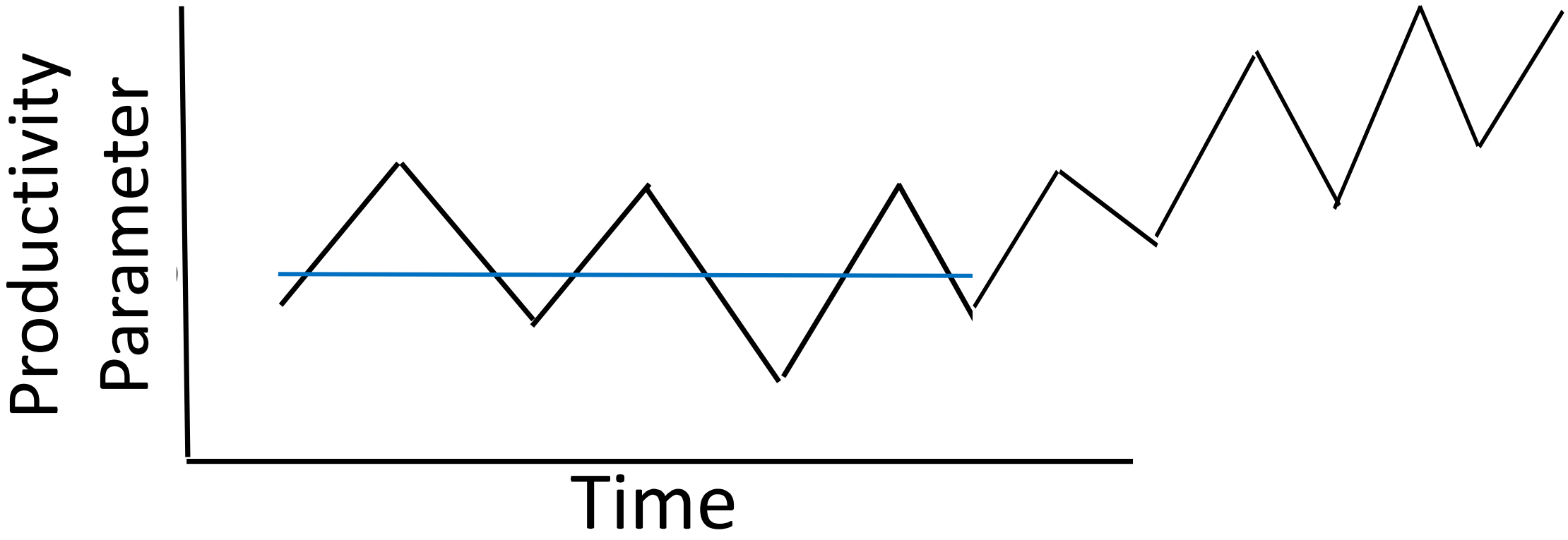
Tommasi et al., 2017; Progress in Oceanography

But fisheries decisions rarely include climate or ecosystem effects

- After a review of 1200 stocks worldwide, only 2% include environmental drivers in tactical management decisions

Skern-Mauritzen et al., 2016; Fish and Fisheries

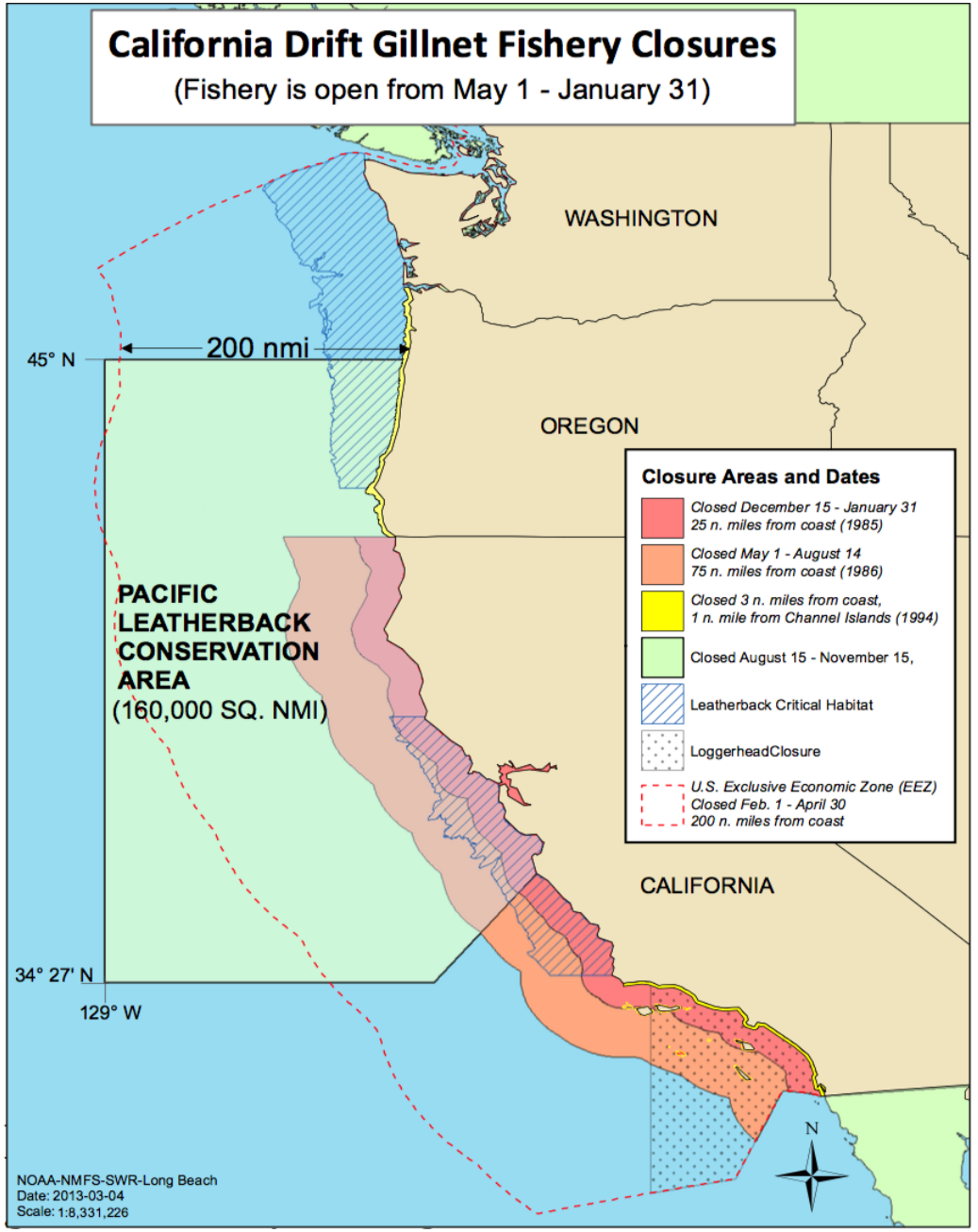
Management frameworks generally assume productivity and distribution will be stationary



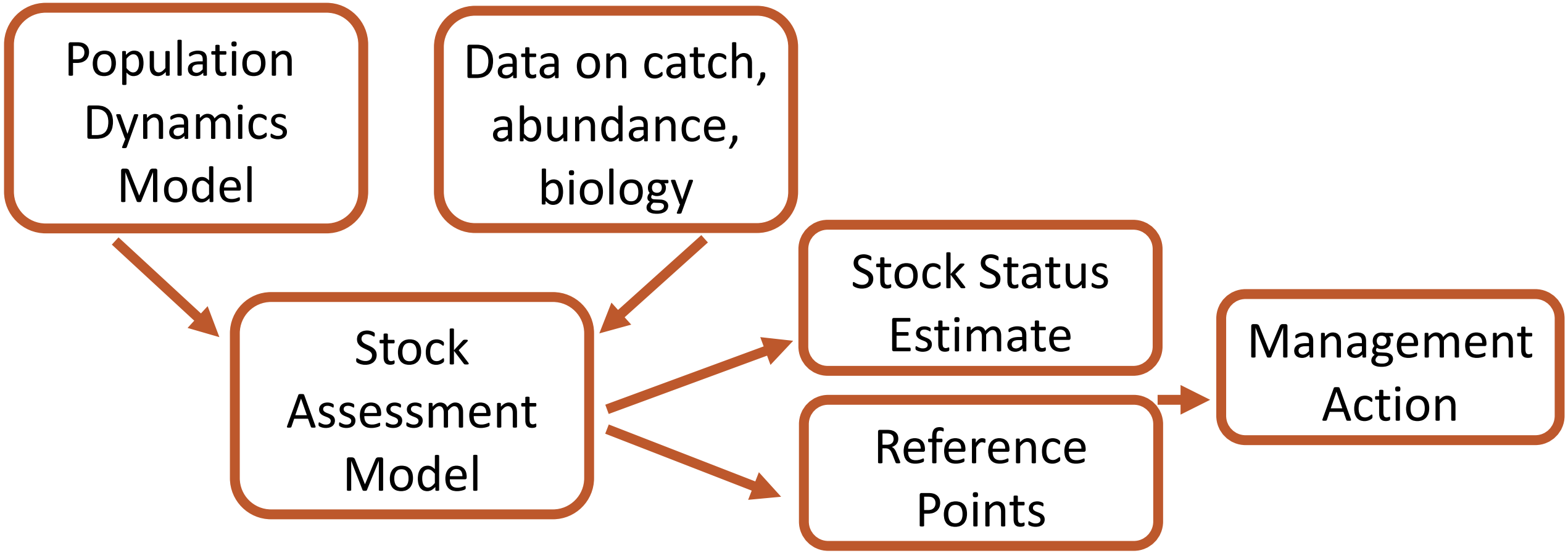
Tommasi et al., 2017; Progress in Oceanography

Implications for Management

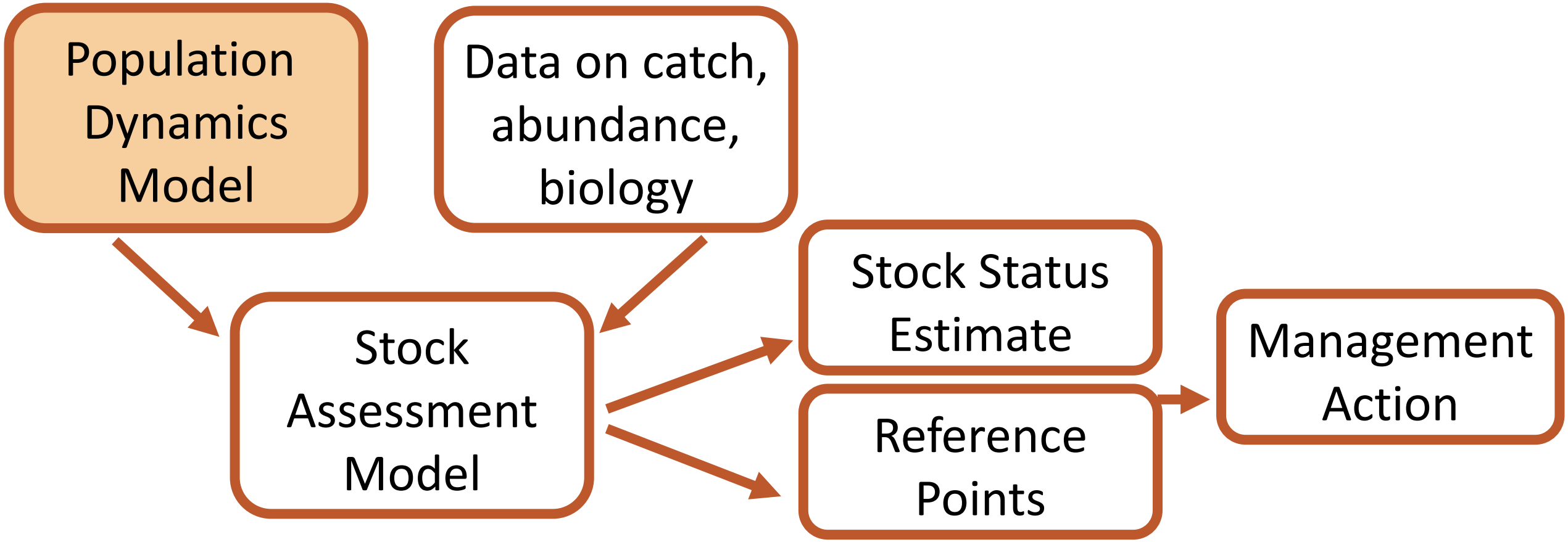
- Static spatial and temporal closures
- Ineffective if fish phenology or distribution change with varying ocean dynamics



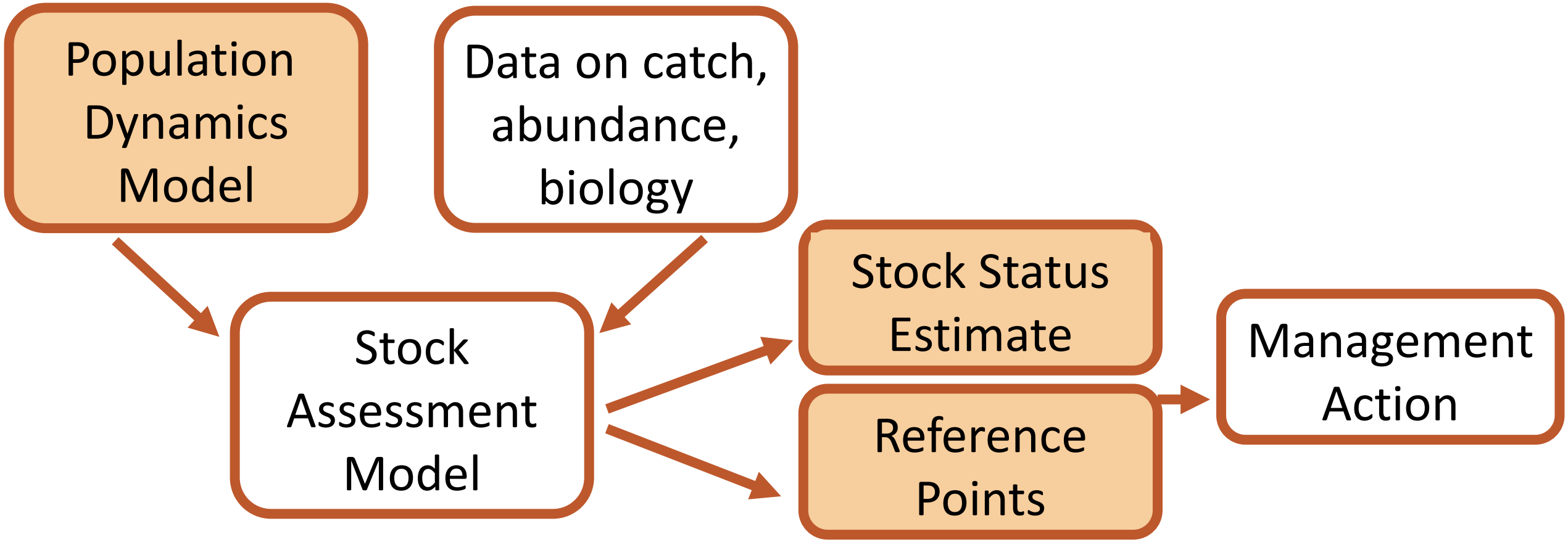
Implications for Management



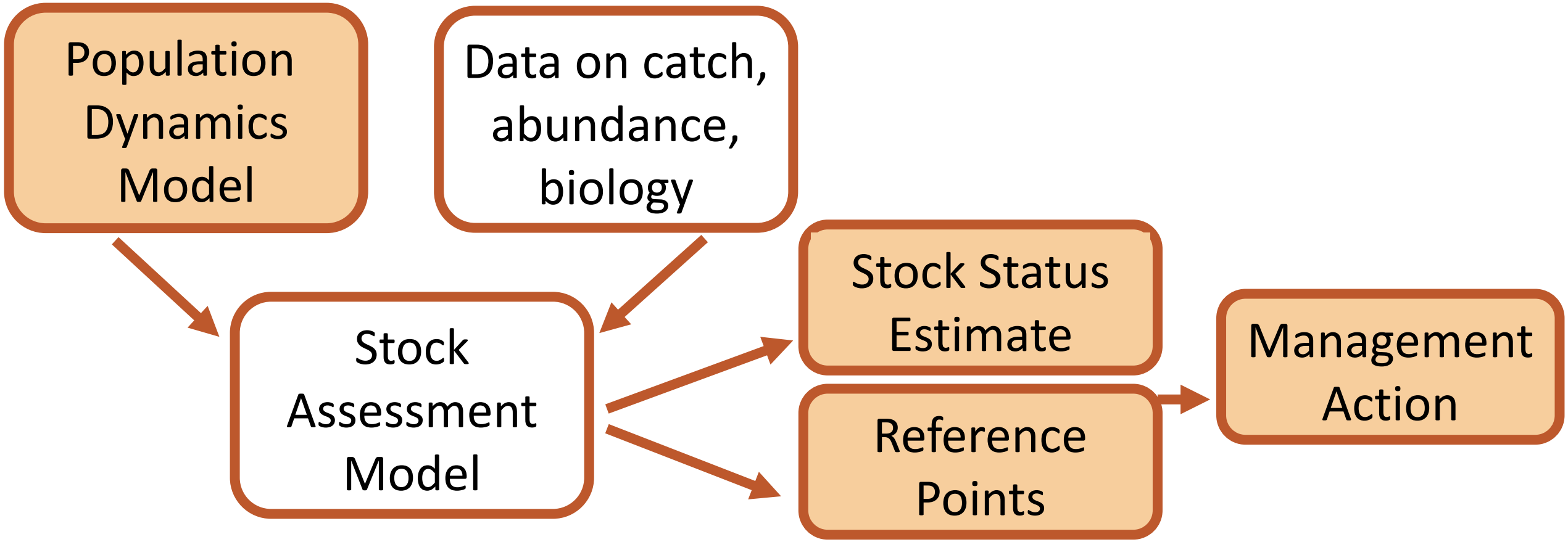
Implications for Management



Implications for Management



Implications for Management



Challenges to integration of environmental effects into fisheries management

- No skillful forecasts of environmental conditions at the scale at which the fish operate and are managed
- Emergent effects of climate on marine ecosystems are complex
- Limited availability of time series for model development and validation

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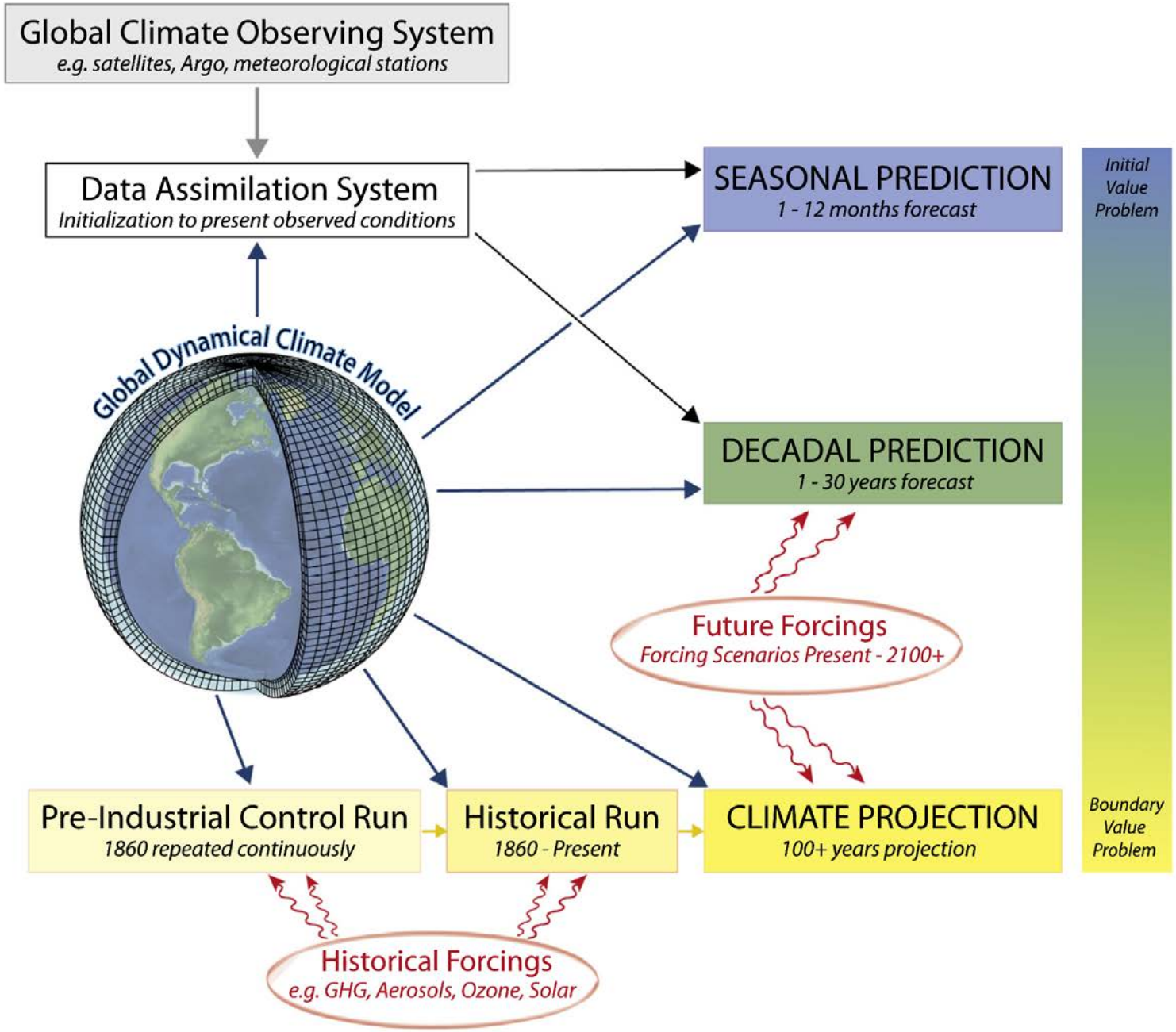
But things are changing…

Climate predictions differ from climate projections

- Prediction models are initialized with observations
- Initial value problem
- Predict statistics of climate over monthly to 30 year time scales (seasonal to decadal forecast)
or evolution of single weather feature at hourly to weekly timescales (weather forecast)



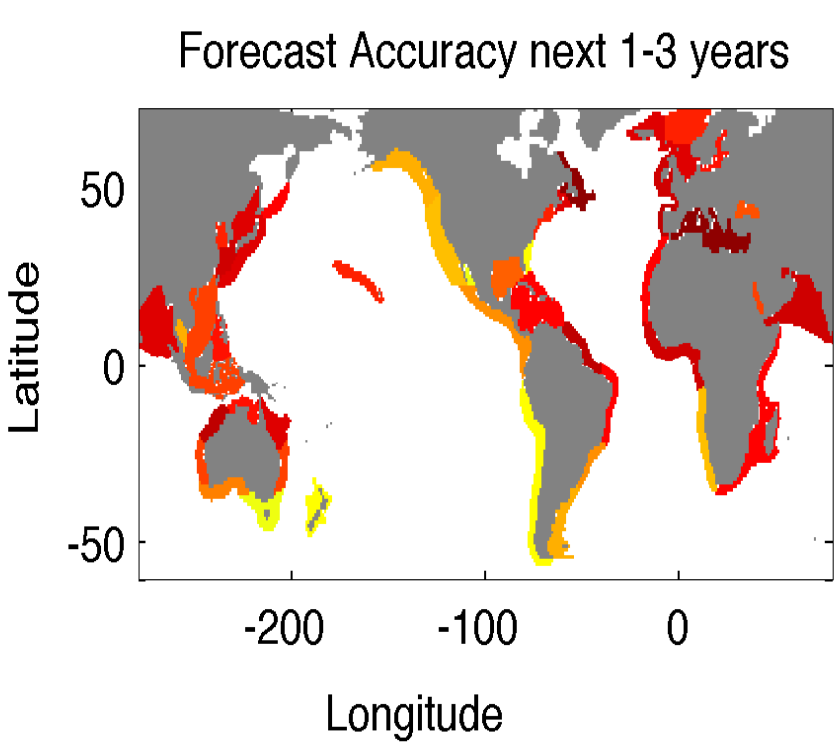
Tommasi et al., 2017; Progress in Oceanography

Skillful predictions at fishery relevant scales

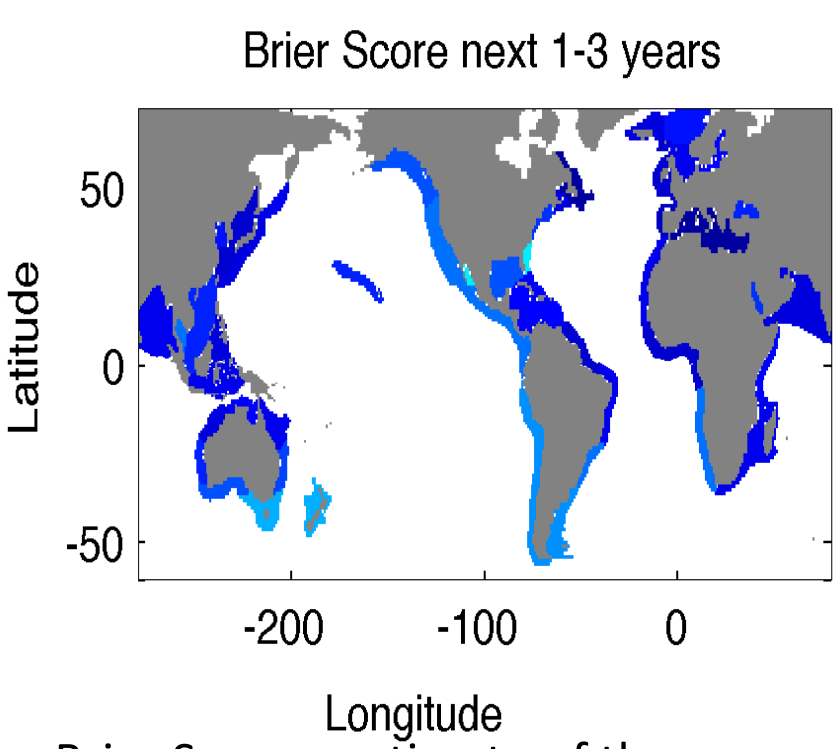
Based on the Anomaly correlation coefficient (ACC) for SST anomalies from reforecasts during 1982- 2009

Stock et al., 2015; Progress in Oceanography; Hervieux et al., 2017; Climate Dynamics; Jacox et al., 2017; Climate Dynamics

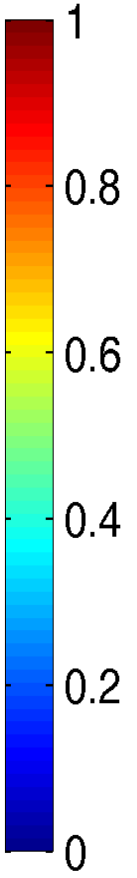
Skillful predictions at fishery relevant scales



Forecast Accuracy = proportion correct of a yes/no forecast of an event



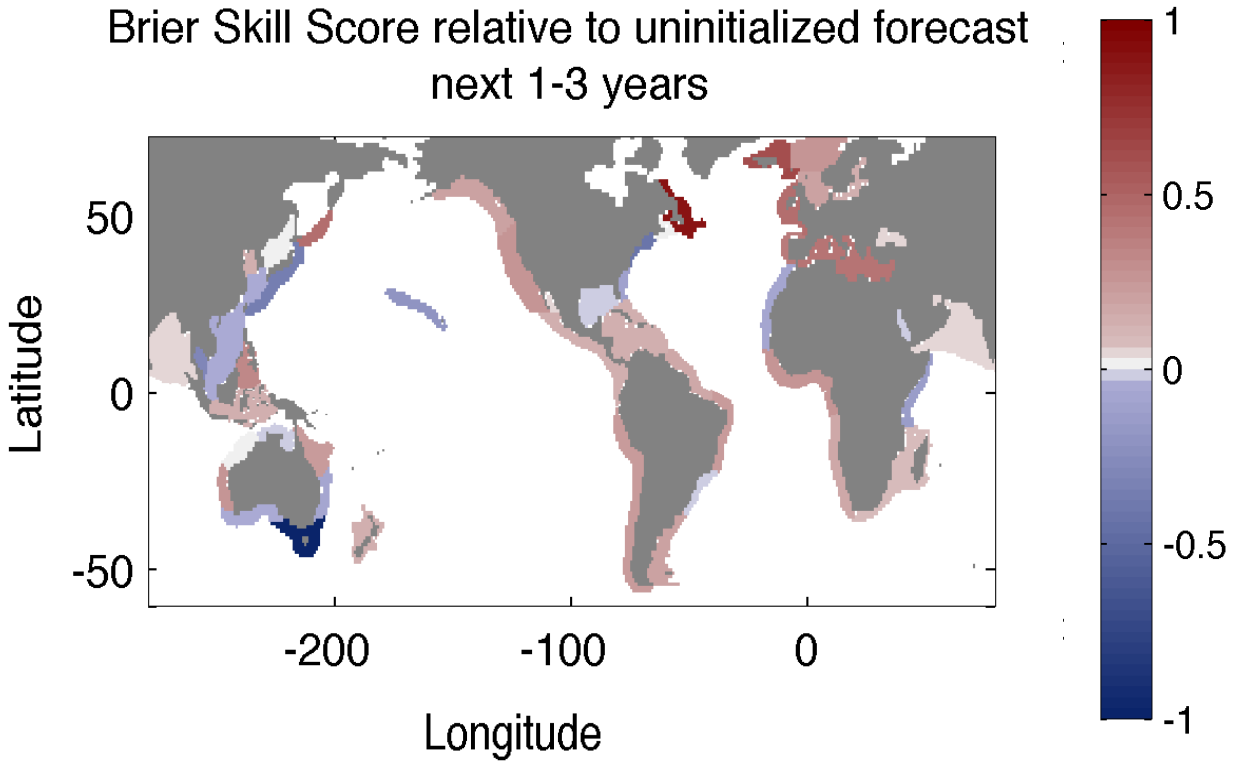
Brier Score = estimate of the mean square error of the probabilistic forecast



Skill for the probabilistic forecast of SST over the next 1-3 years being in the upper (warm) tercile based on reforecasts from 1965-2011

Tommasi et al., 2017; Frontiers in Marine Science

Skillful predictions at multi-annual scales

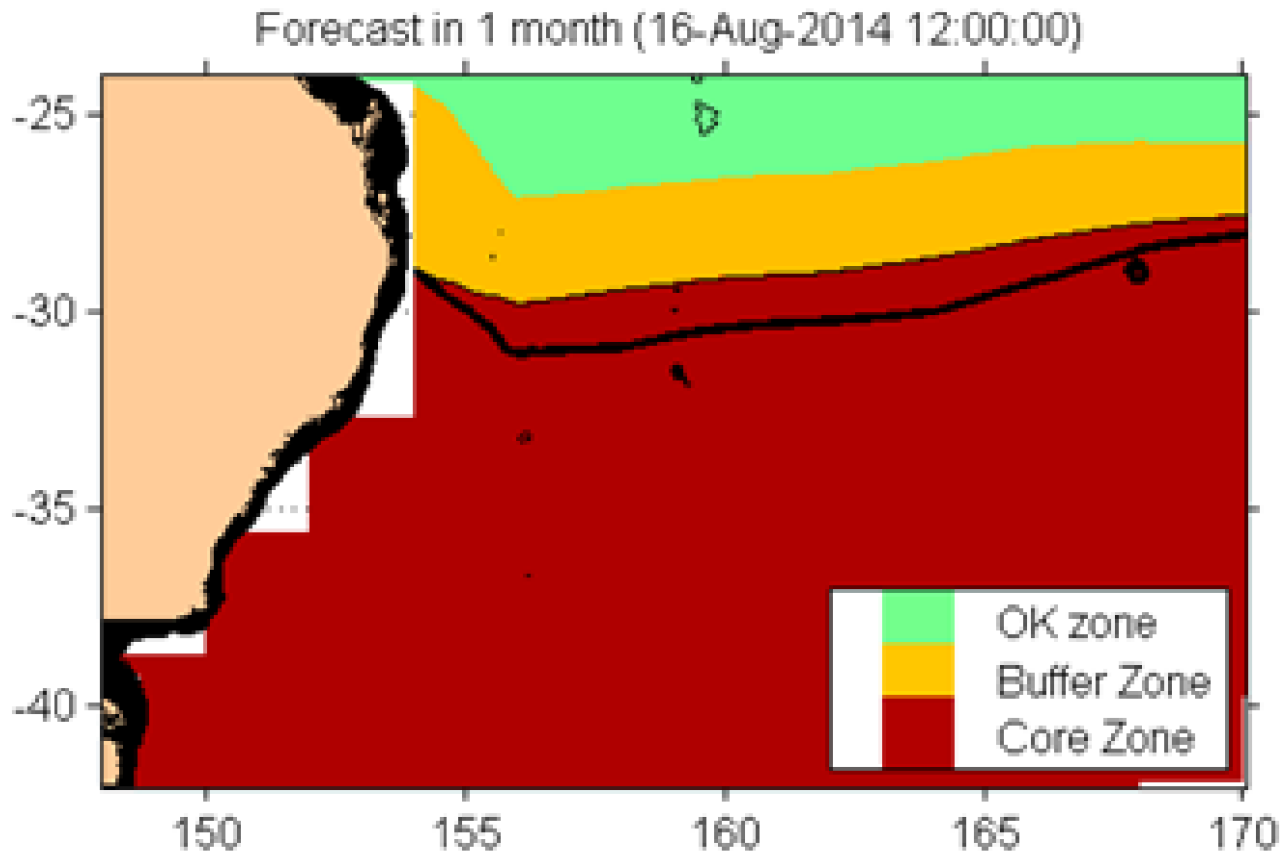


Except for North Atlantic LMEs, skill was due to the predictable signature of radiative forcing changes over the 50 year time period rather than prediction of evolving modes of climate variability

Brier Skill Score = Negative scores indicate no additional skill as compared to an uninitialized forecast

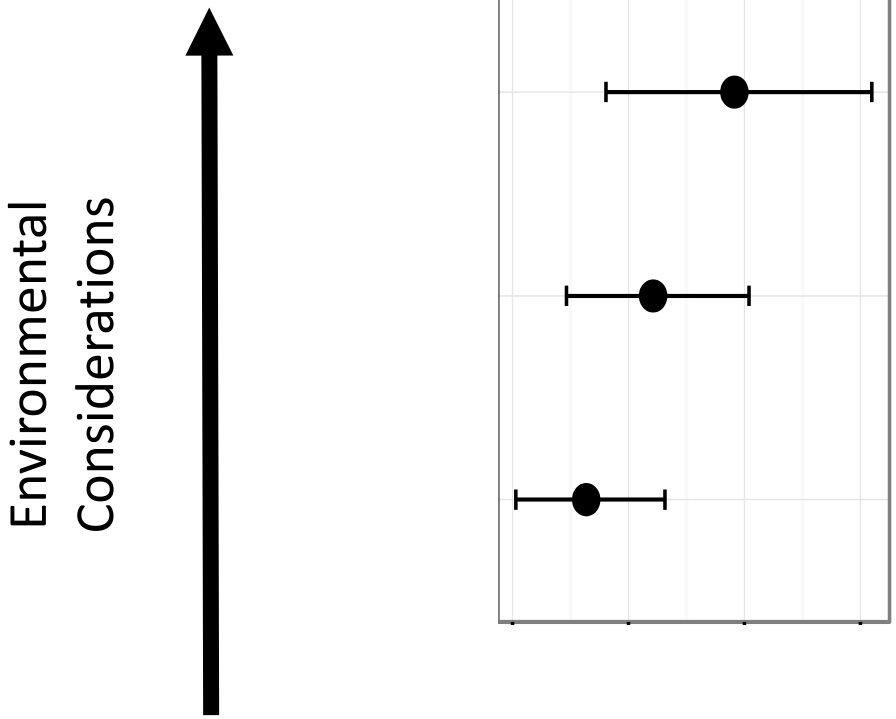
Tommasi et al., 2017; Frontiers in Marine Science

Successful application of climate forecasts in fisheries management



Seasonal forecasts to reduce bycatch in the Australian east coast eastern tuna and billfish fishery

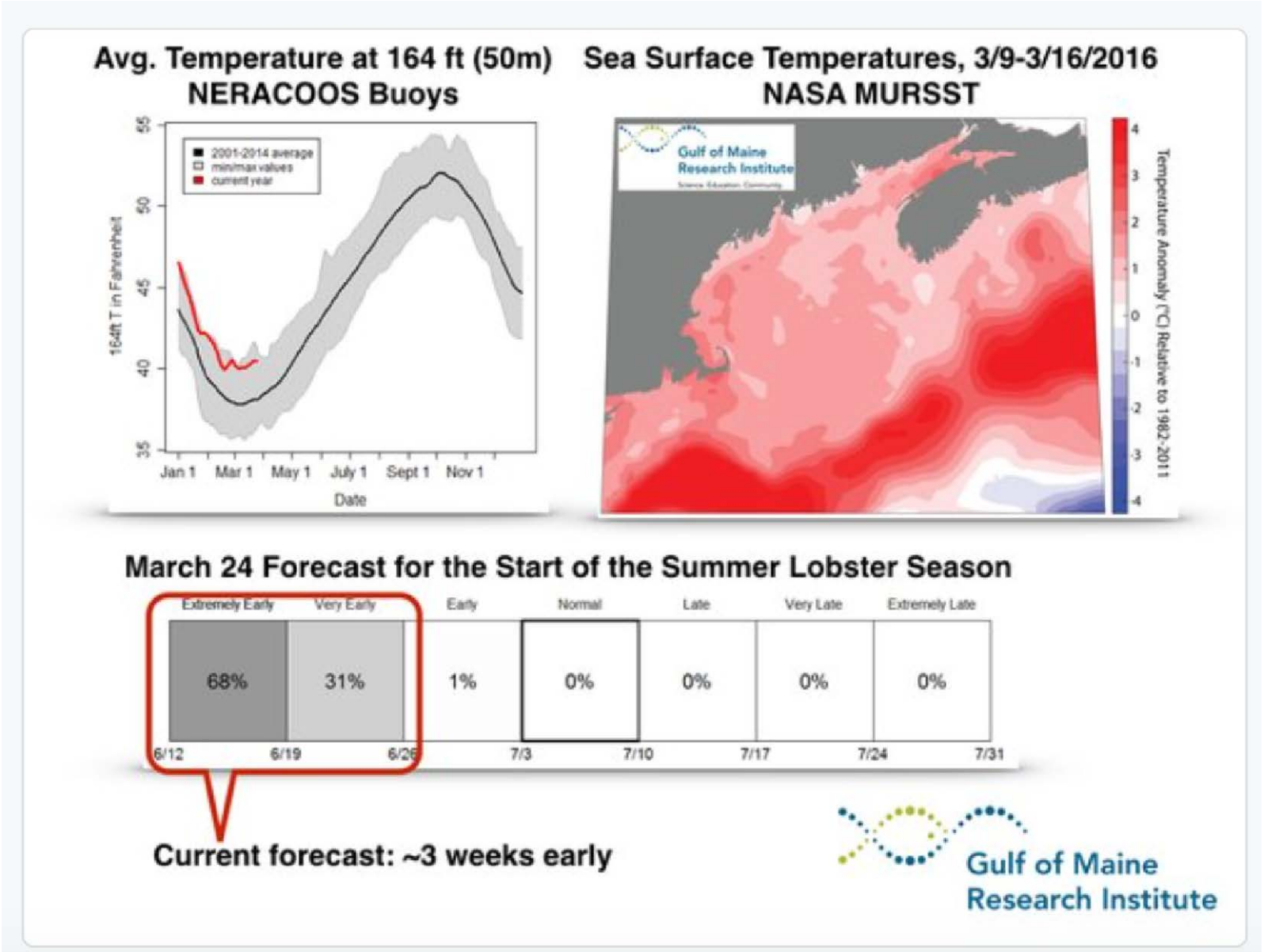
Hobday et al. 2011, Canadian Journal of Fisheries and Aquatic Sciences



Biomass
(1000mt) +/–95th to 5th
percentiles

Seasonal forecasts to improve catch advice for California sardine

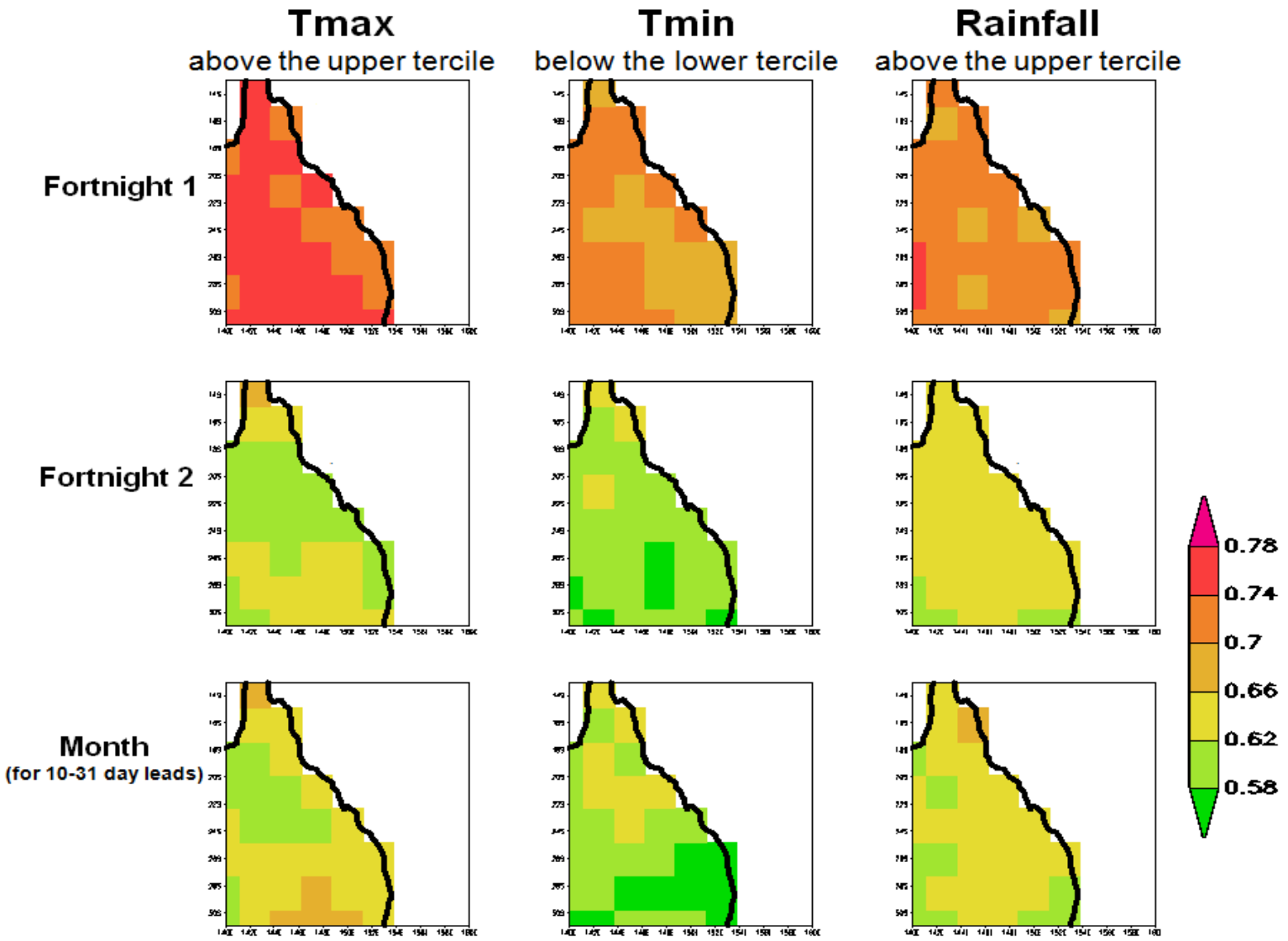
Tommasi et al. 2017, Ecological Applications



Forecast of the start of the lobster fishing season in the Gulf of Maine

Mills et al., in prep; Tommasi et al. 2017, Progress in Oceanography

Accuracy of probabilistic forecast for maximum air temperature, minimum air temperature, and rainfall in Queensland, Australia

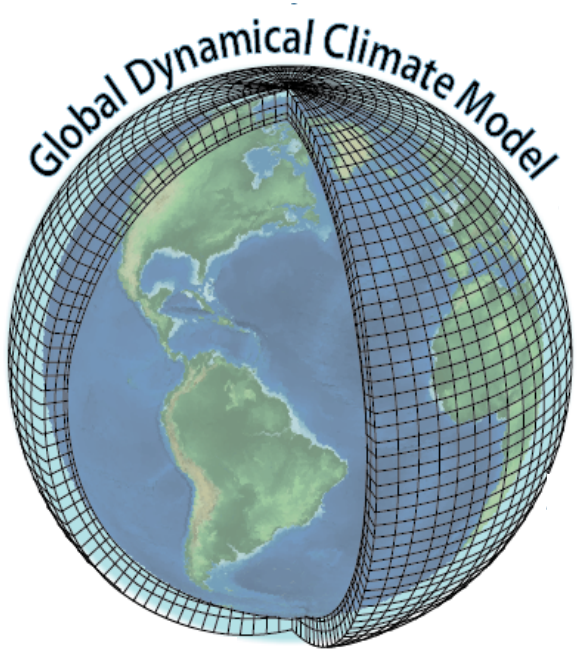


Seasonal forecasts to improve prawn aquaculture farm management

Spillman et al. 2017, Aquaculture

Challenges and Future Research Needs

- Reduction in climate model bias through improvements in model formulation and initialization



Challenges and Future Research Needs

- Verify predictability of ecosystem relevant variables at decision relevant scales beyond SST

In hot water: Columbia's sockeye salmon face mass die-off

Warm water temperatures have made life 'grim' for sockeye salmon in the Pacific Northwest

Challenges and Future Research Needs

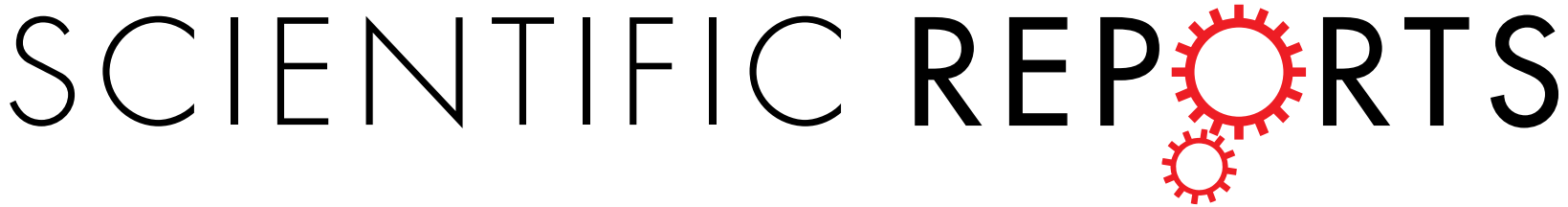
- Develop biogeochemical prediction capabilities

SEACHANGE Oyster dying as coast is hit hard

A Washington family opens a hatchery in Hawaii to escape lethal waters.

Challenges and Future Research Needs

- Develop biogeochemical prediction capabilities



OPEN

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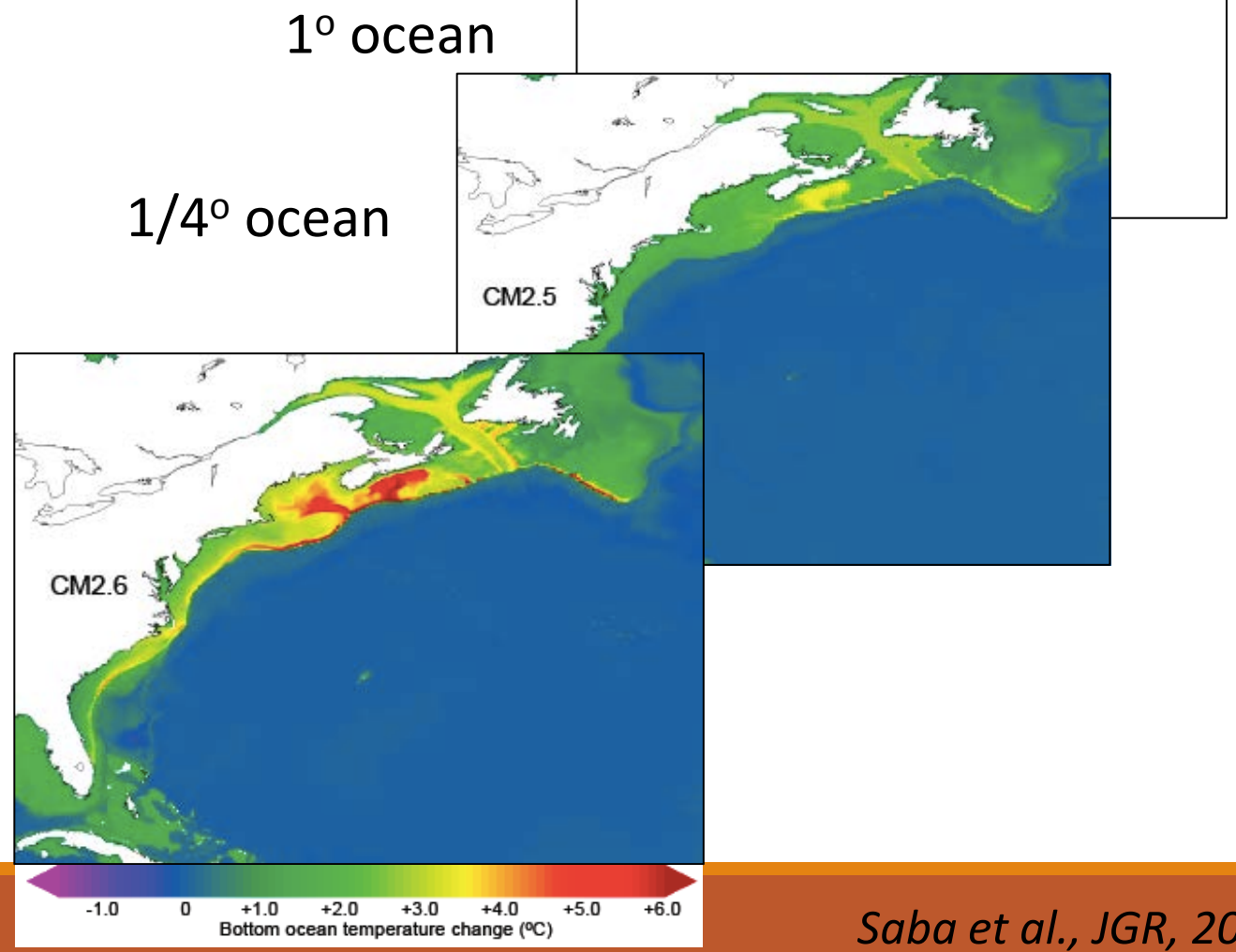
Challenges and Future Research Needs

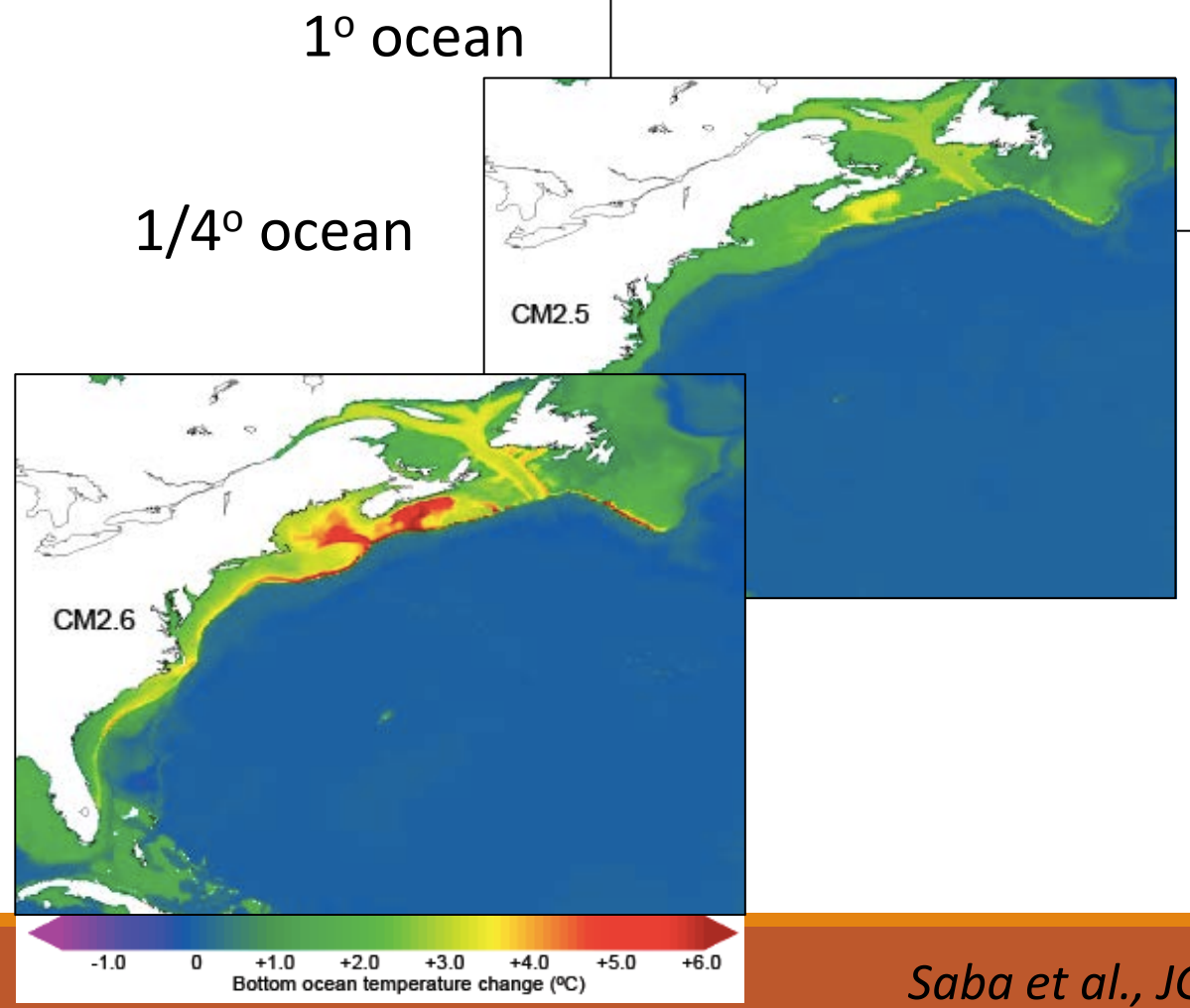
- Unresolved local processes can limit predictability of ecosystem relevant variables



Saba et al., JGR, 2016

Challenges and Future Research Needs

- Improve climate predictability at LMR-relevant regional scales through higher resolution global prediction systems or the development of downscaling frameworks



Saba et al., JGR, 2016

Challenges and Future Research Needs

- Emergent effects of climate on marine ecosystems are complex
- Limited availability of time series for model development and validation

Changing Nature of Ecosystem

West coast fisheries hit hard by poor ocean conditions

Oregon Public Broadcasting News , October 2016

http://www.opb.org/news/article/west-coast-fisheries-hit-hard-by-poor-ocean-conditions/

Recent Methodological Advances in Fisheries Models

- Spatial distribution models for dynamic ocean management (Hazen, W3)
- Salmon freshwater mortality forecast for in season catch advice (DFO, WG-40)
- Spatio-temporal fisheries models (Thorson, S1, S3)
- Ecological threshold indicators to inform fisheries management (Samhouri et al. 2017, Hunsicker S3)
- Climate enhanced stock assessment models (Holsman et al. 2016, Hollowed S6)

Thank you!

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