Seasonal Forecasts of Biogeochemistry in the CCS: Focusing on the N-CCS

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Nick Bond, & Jan Newton

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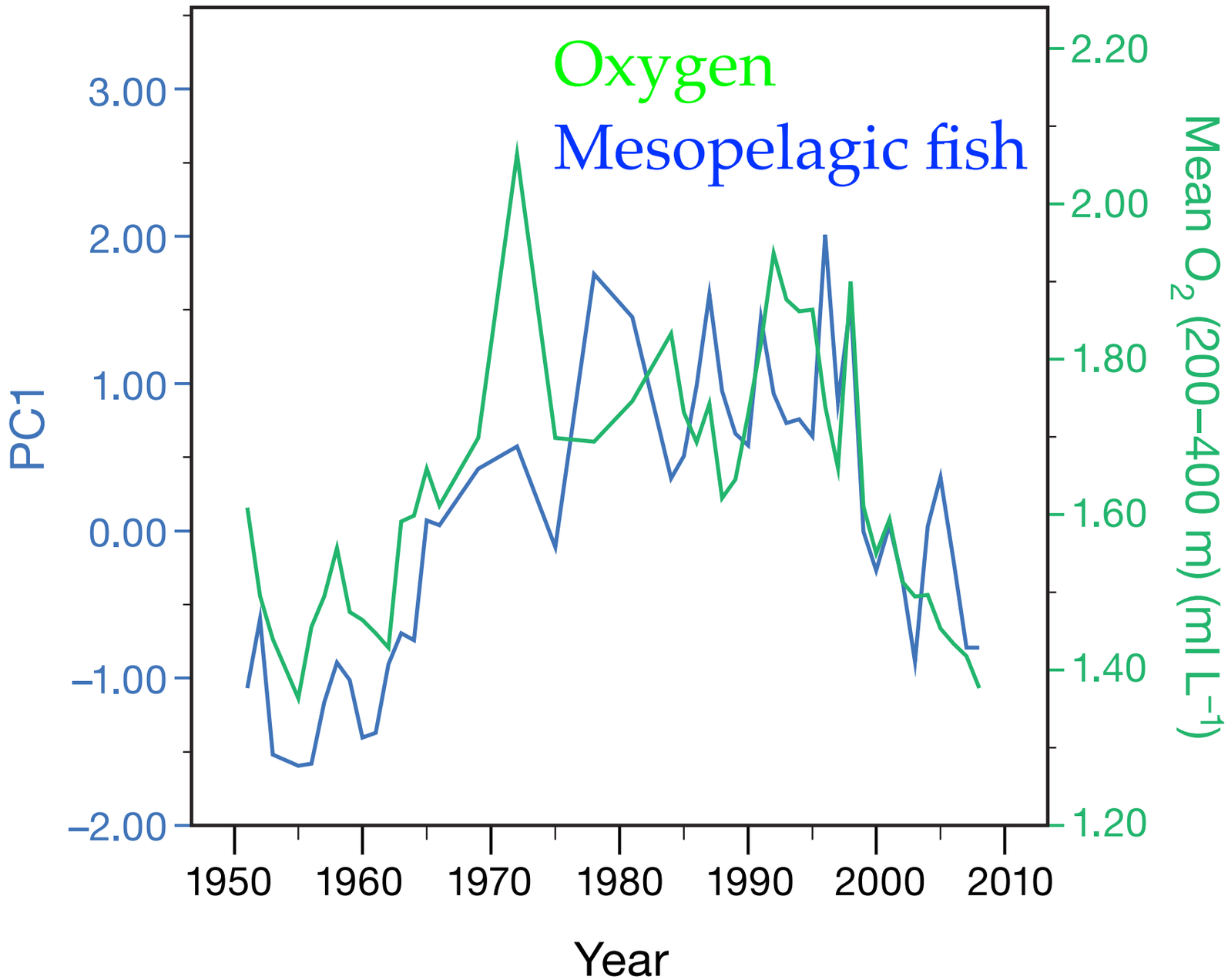
http://www.nanoos.org/products/j-scope/home.php

Fish of commercial interest have changed in abundance over the past several decades - some linked to environmental data



PC1= ichthyoplankton of mesopelagic fish (mainly)

Koslow et al., 2011; 2013

Implications for Marine Food Webs & Ecosystem Services

Many biological processes are sensitive to changes associated with ocean acidification and hypoxia

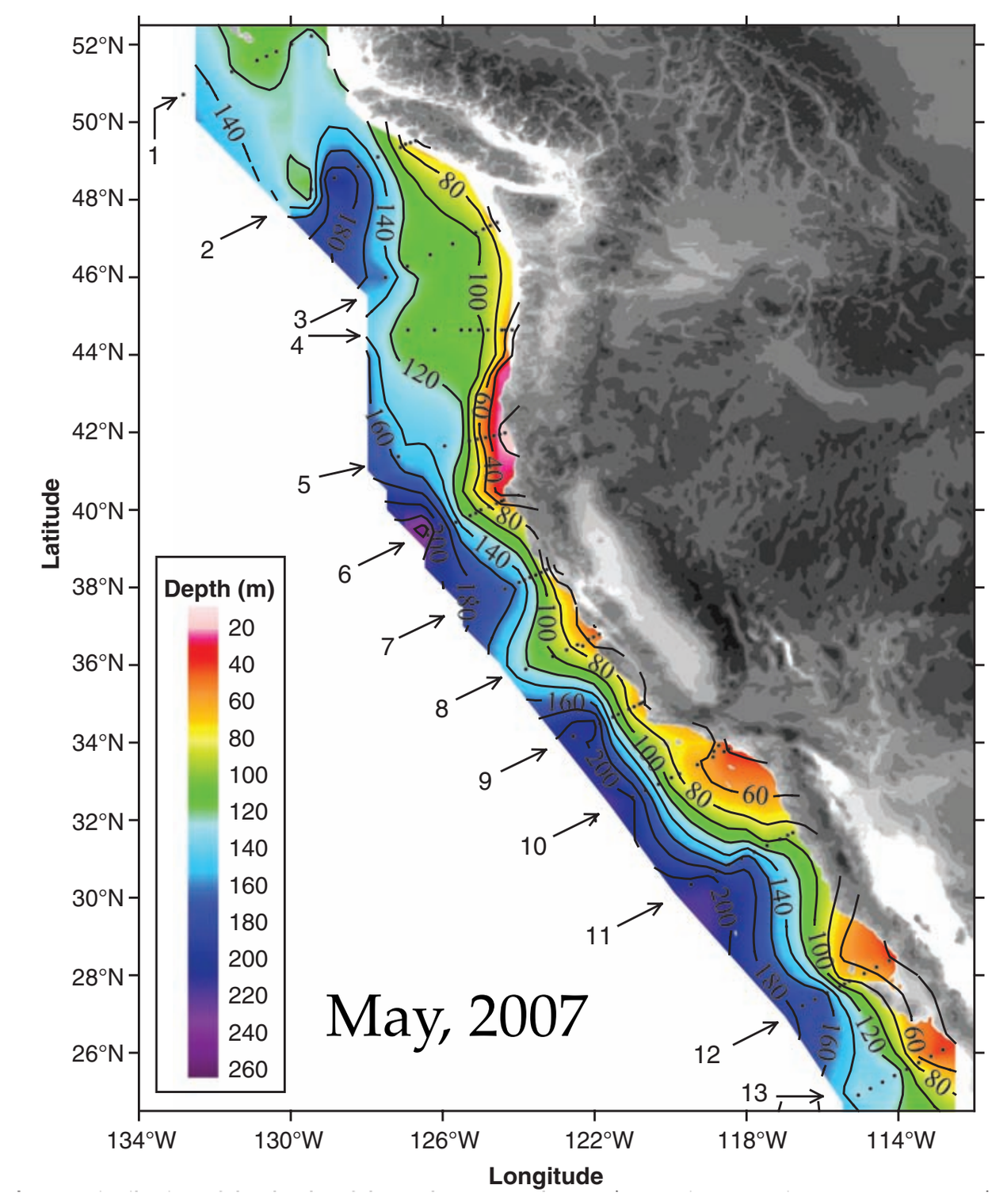
These include:

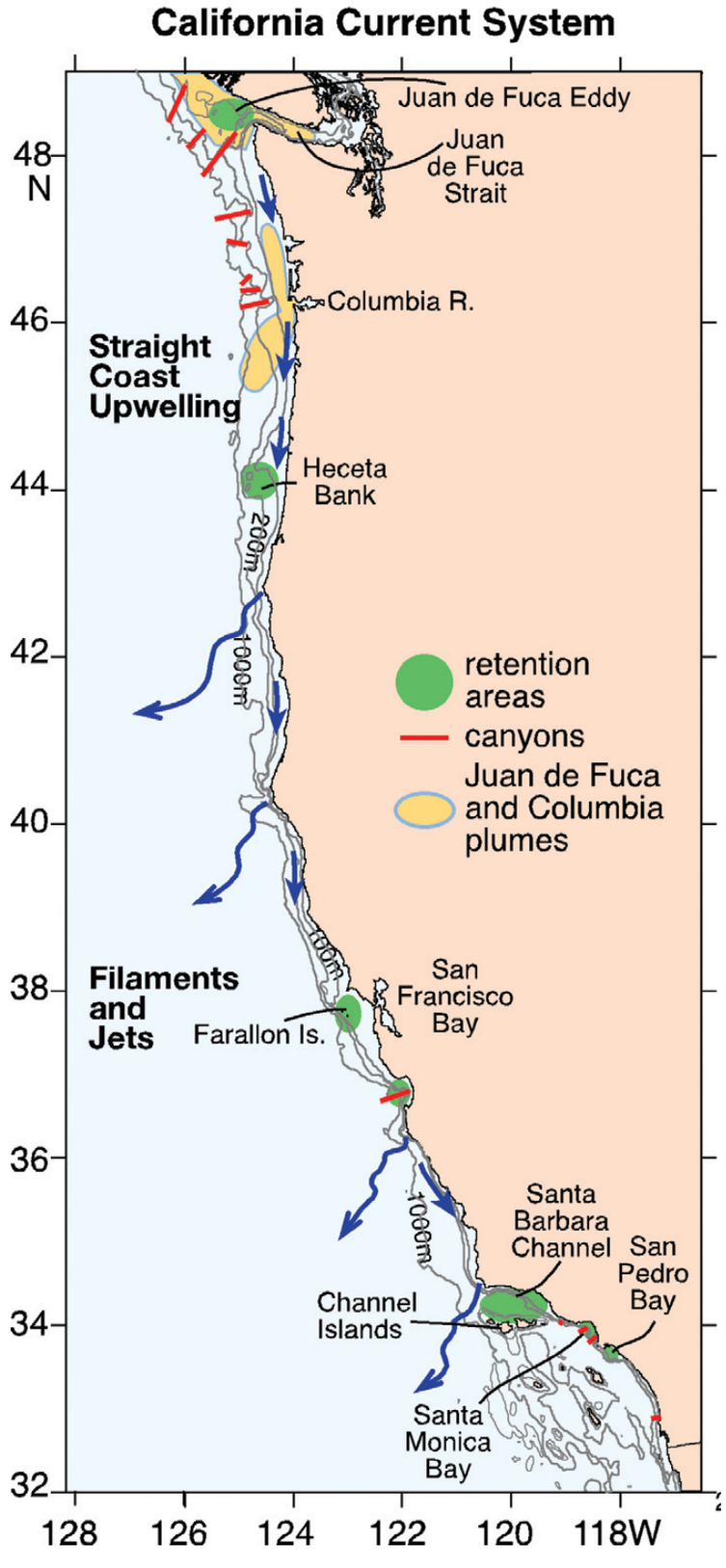
- **Increased mortality** for juvenile shellfish
- Potential **loss of water quality benefits** provided by shellfish
- **Increased risk** for early life stages of Dungeness Crabs
- Potential **increase in toxicity** of harmful algal blooms
- **Impacts on the nervous system** of some fish
- **Increased mortality** among pteropods (a type of plankton) - with potential food web impacts to higher trophic levels like salmon

Pteropod

Photo: R. Hopcroft

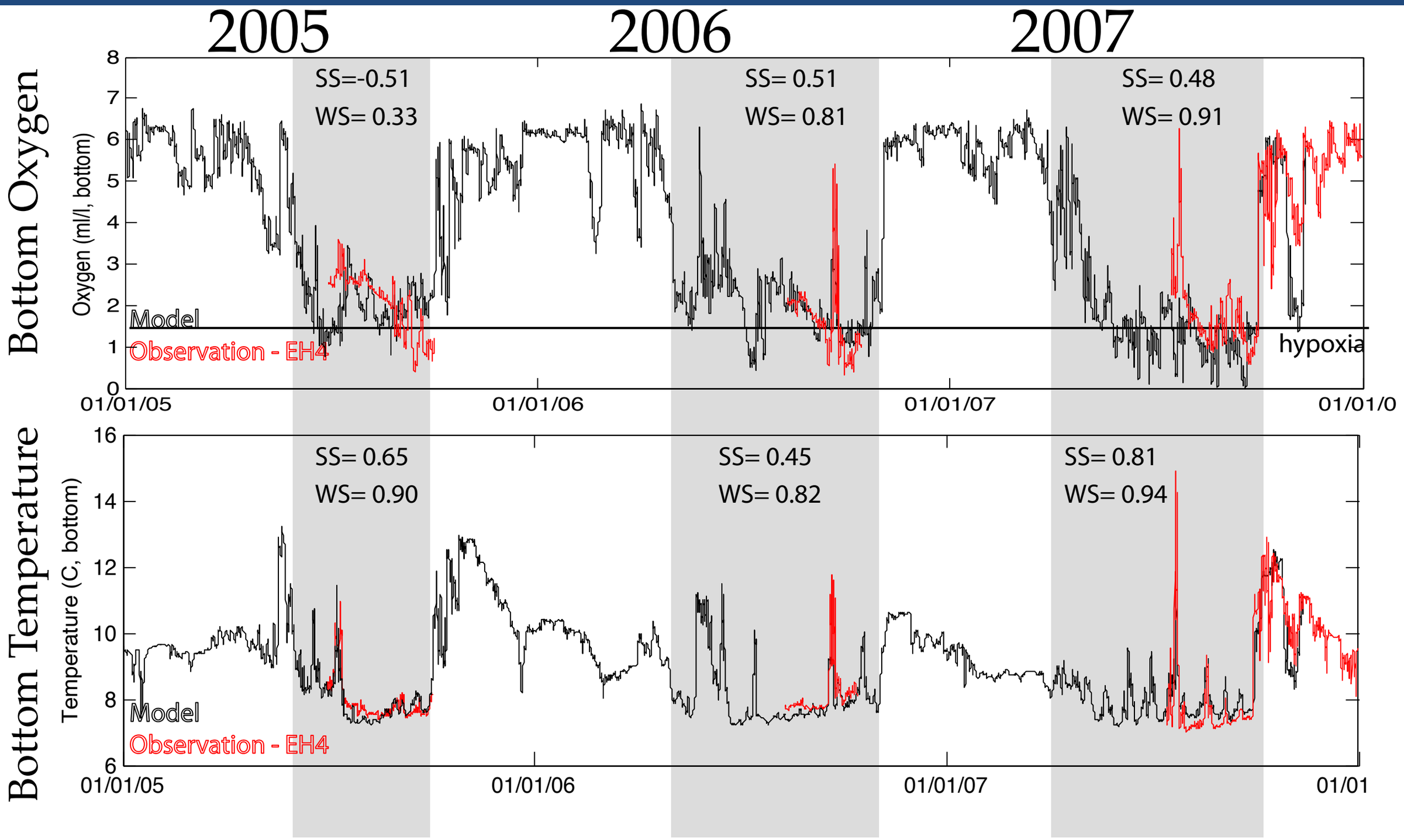
A lot of spatial / temporal variability in corrosive water (Ω) and hypoxia





Feely et al, 2008; Hickey and Banas, 2008

Seasonal decline on the shelf in bot. oxygen



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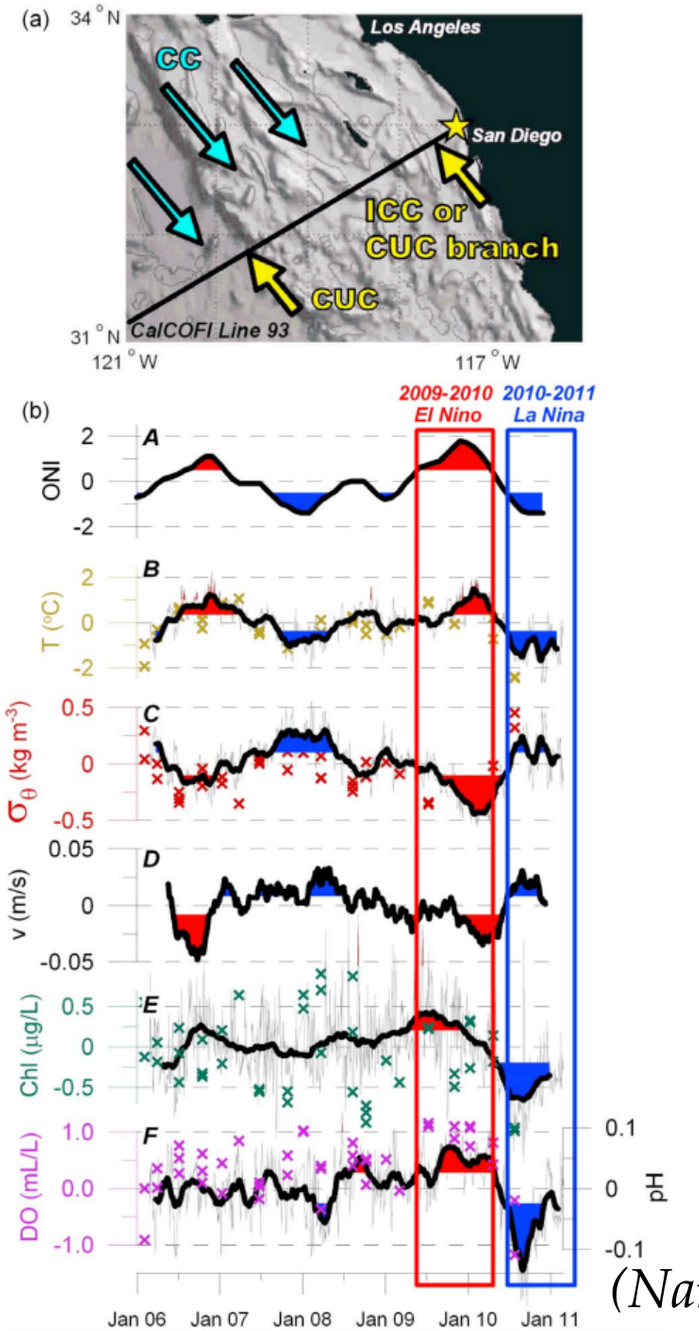
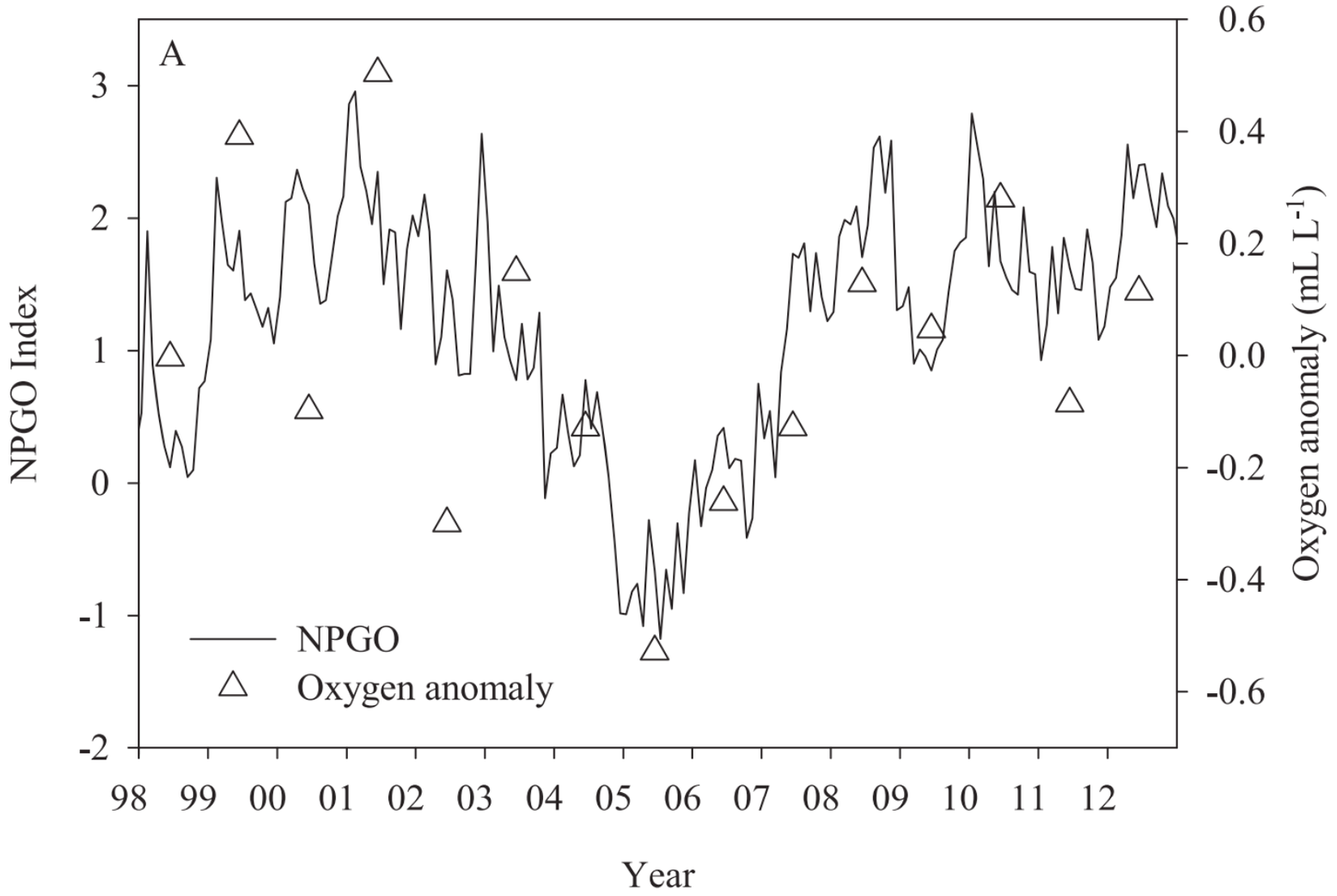
Observations from Connolly et al, 2010; Hickey, unpublished

Siedlecki et al, 2015

ENSO and hypoxia or OA

- **Bottom oxygen in Oregon, inter annual variability correlated with NPGO**
- **In California, El Nino events correlated to higher oxygen and pH, while La Nina events are correlated with lower oxygen and pH.**



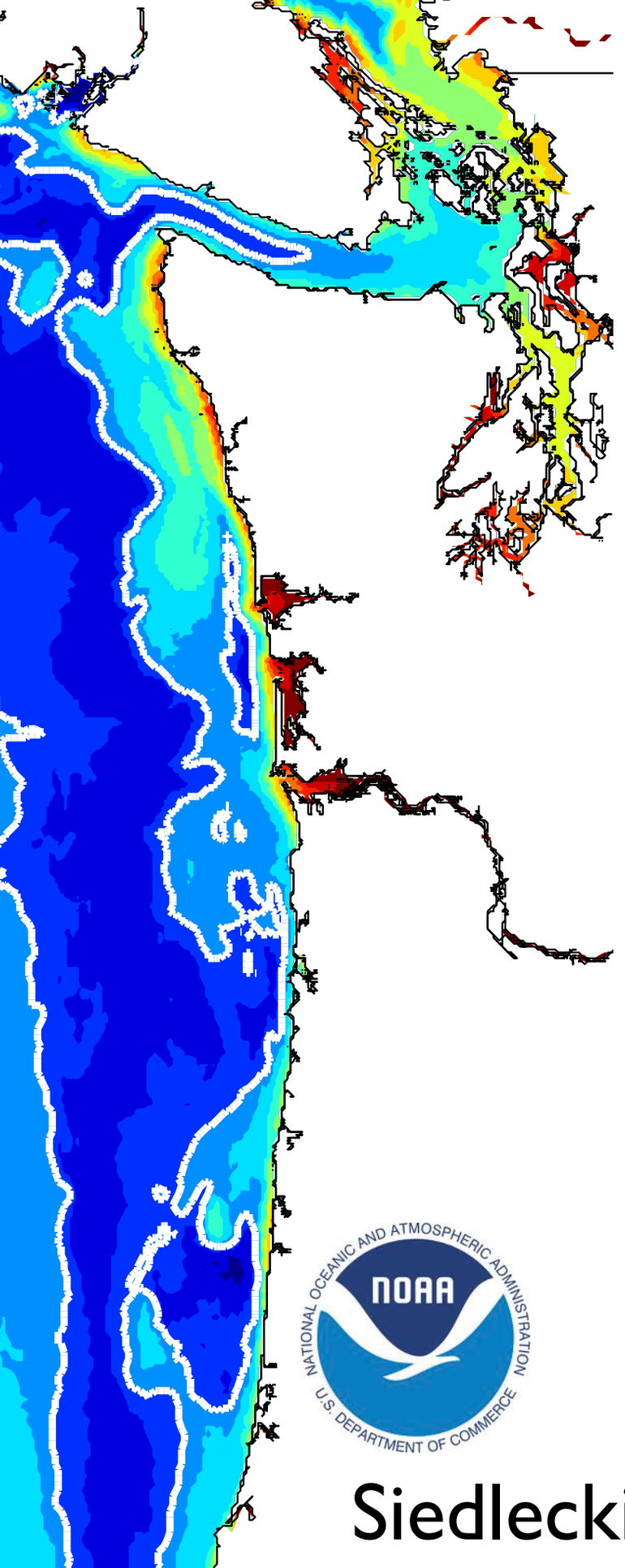


(Nam et al. 2011)

What is needed to build a regional forecast system for ocean conditions?

- **Observational network** with real time data access capabilities.
- Working **hindcast simulations** - regional models that can predict oxygen and/or pH variability over timescale(s) of interest on the shelf, in the past
- **Predictable winds in the region** on the timescale(s) of interest in the **global model** used to drive the regional model
- **Predictable SST in the region** on timescale(s) of interest in the **global model** used to drive the regional model
- **Stakeholder group(s) needs identified**
- Metric of **uncertainty**
- **Continued testing** and comparisons with observations on varying time and space scales…. because these are works in progress!

Siedlecki et al. 2016; Hobday et al. 2016; Tommasi et al. in prep



JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE)

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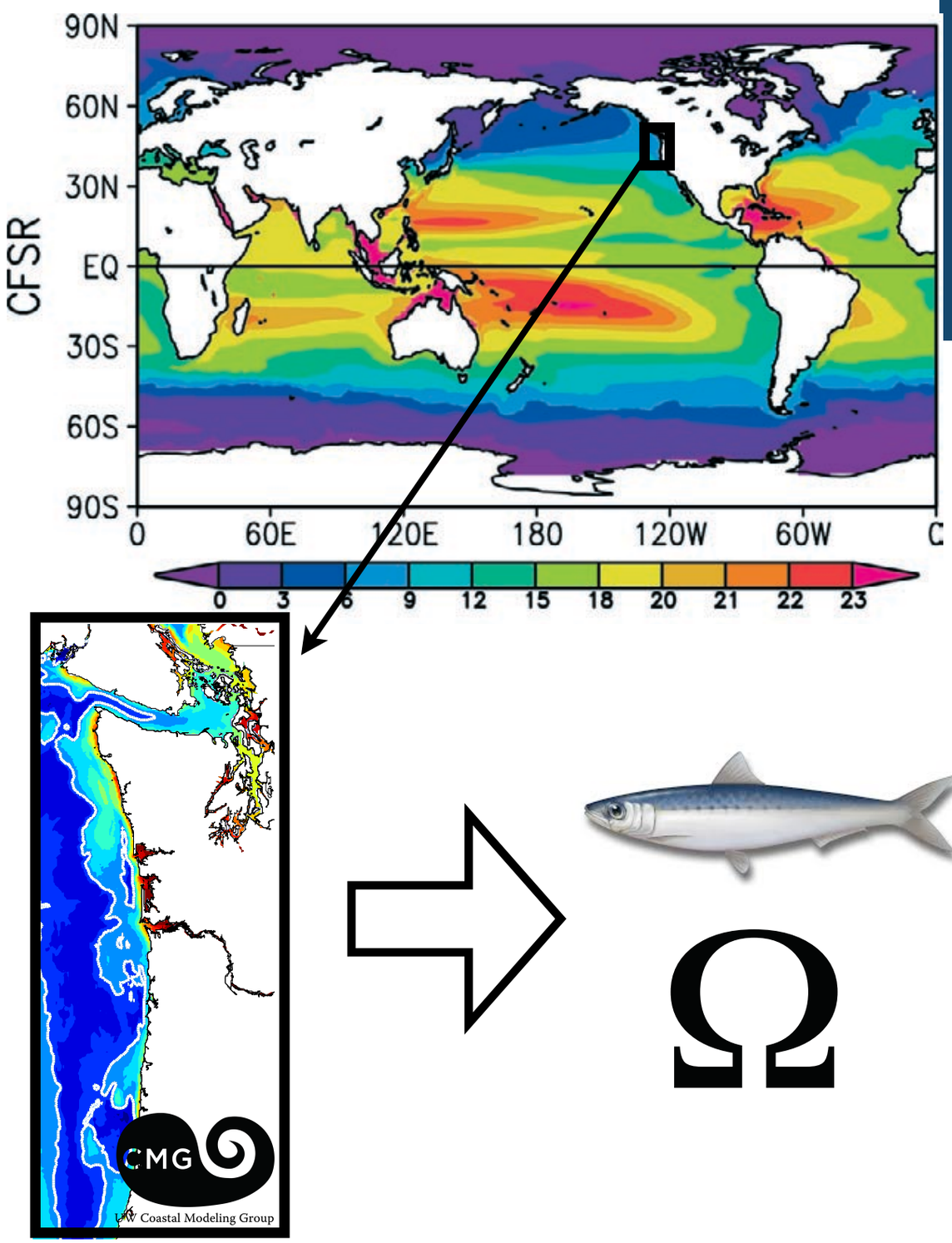
Siedlecki et al, 2016

Building a Forecast System



UW Cascadia Model setup

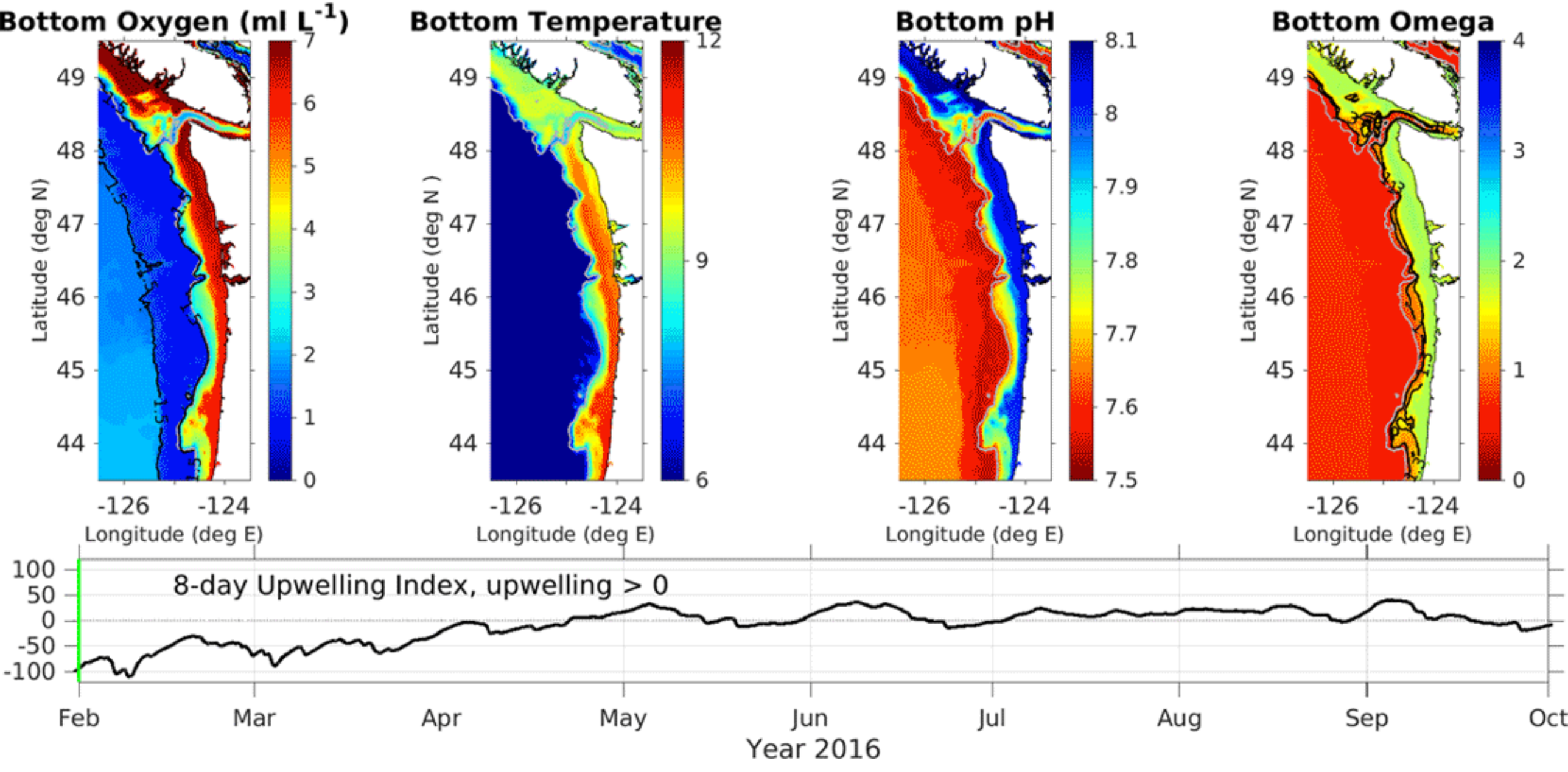
http://faculty.washington.edu/pmacc/cmg/cmg.html
and Giddings et al, 2014

Climate Forecast System (CFS) - ocean boundary conditions and atmospheric forcing (Ocean: ~50km, Atm: ~200km resolution)

CFS + UW CMG regional ROMS-based model with biogeochemistry (~1.5 km resolution)

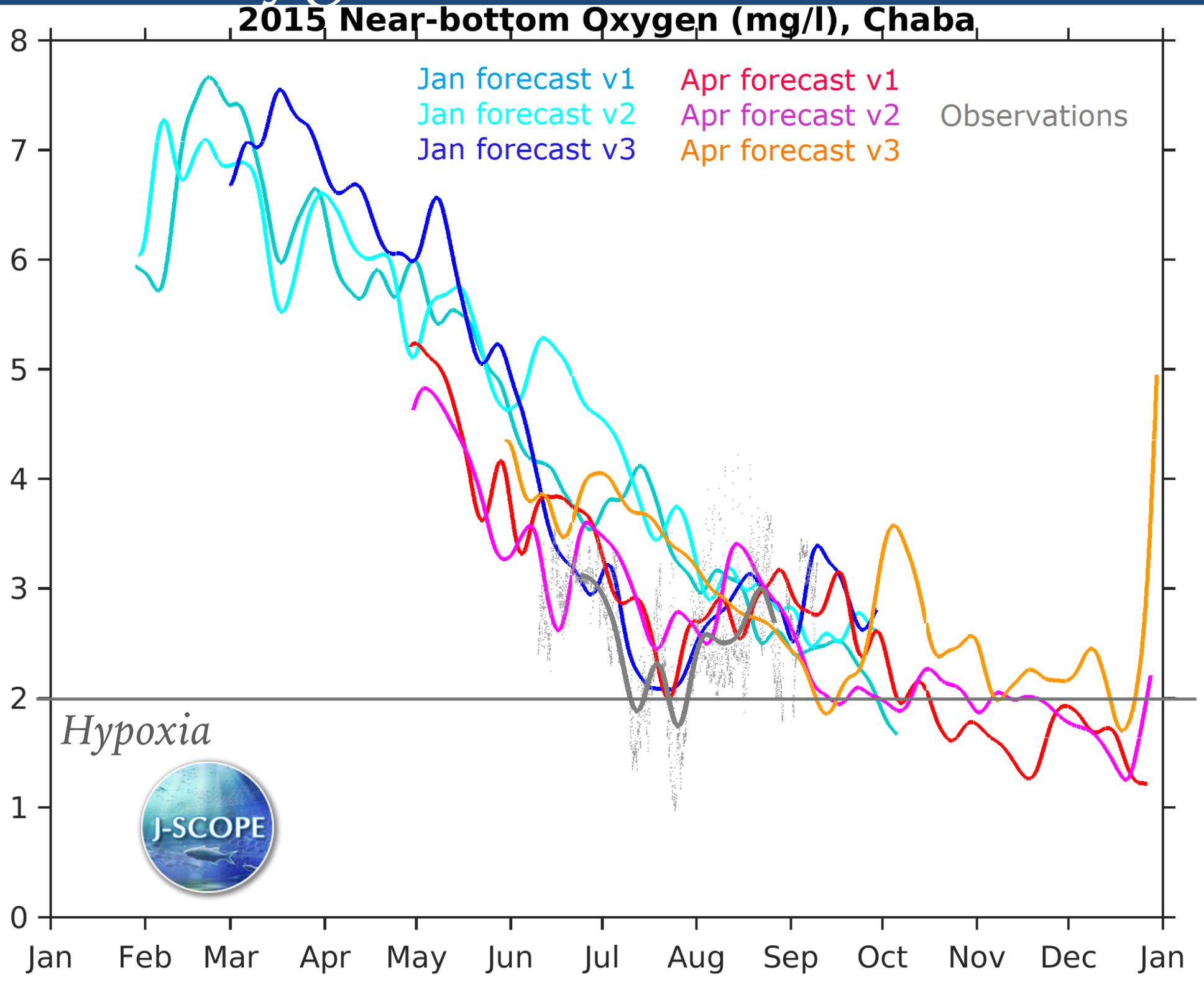
Biogeochemical model including Oxygen (Siedlecki et al., 2015) and *new* -DIC and TA

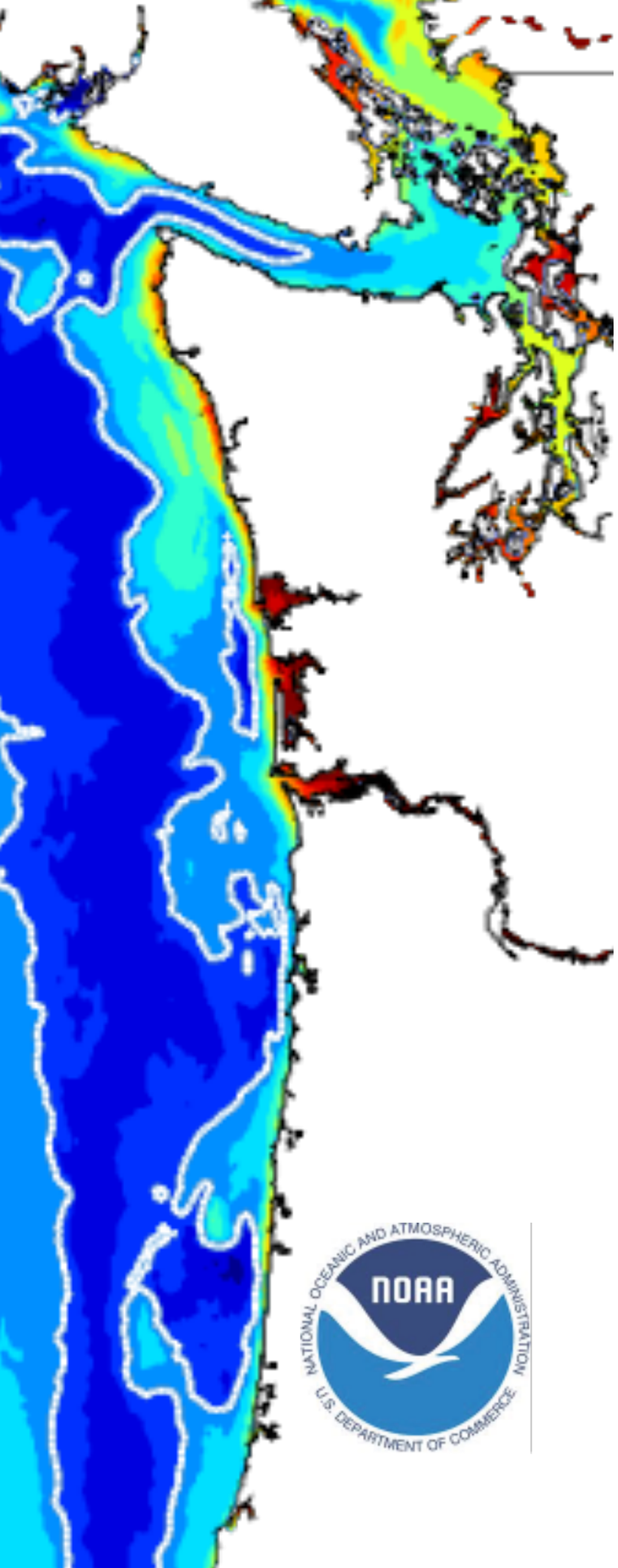
January 2016 Forecast



J-SCOPE

Mini-Ensemble Forecasts 2015-Onset of Oxygen decline at Cha'ba





J-SCOPE Climatology: Extending our records in time and space

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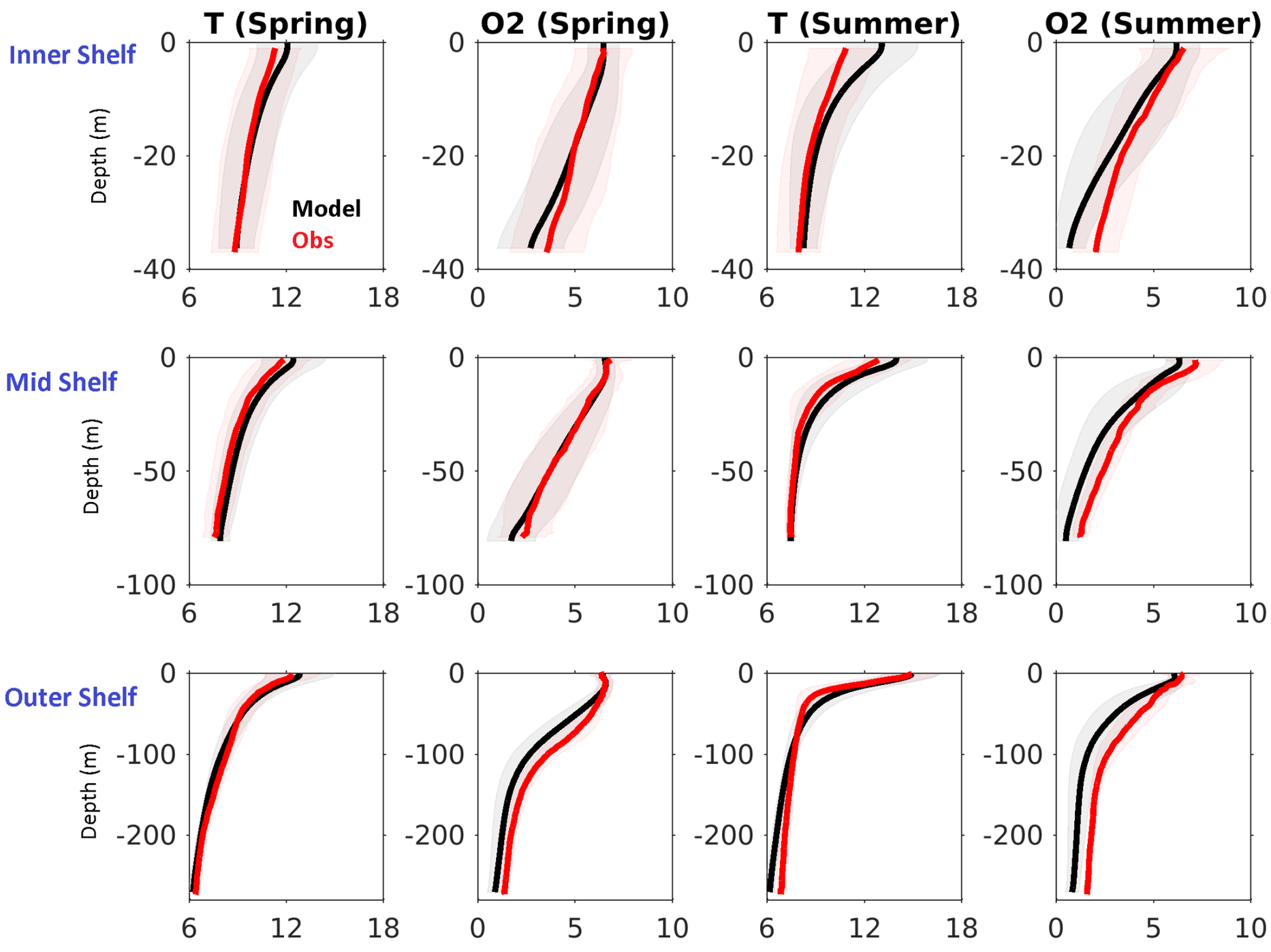
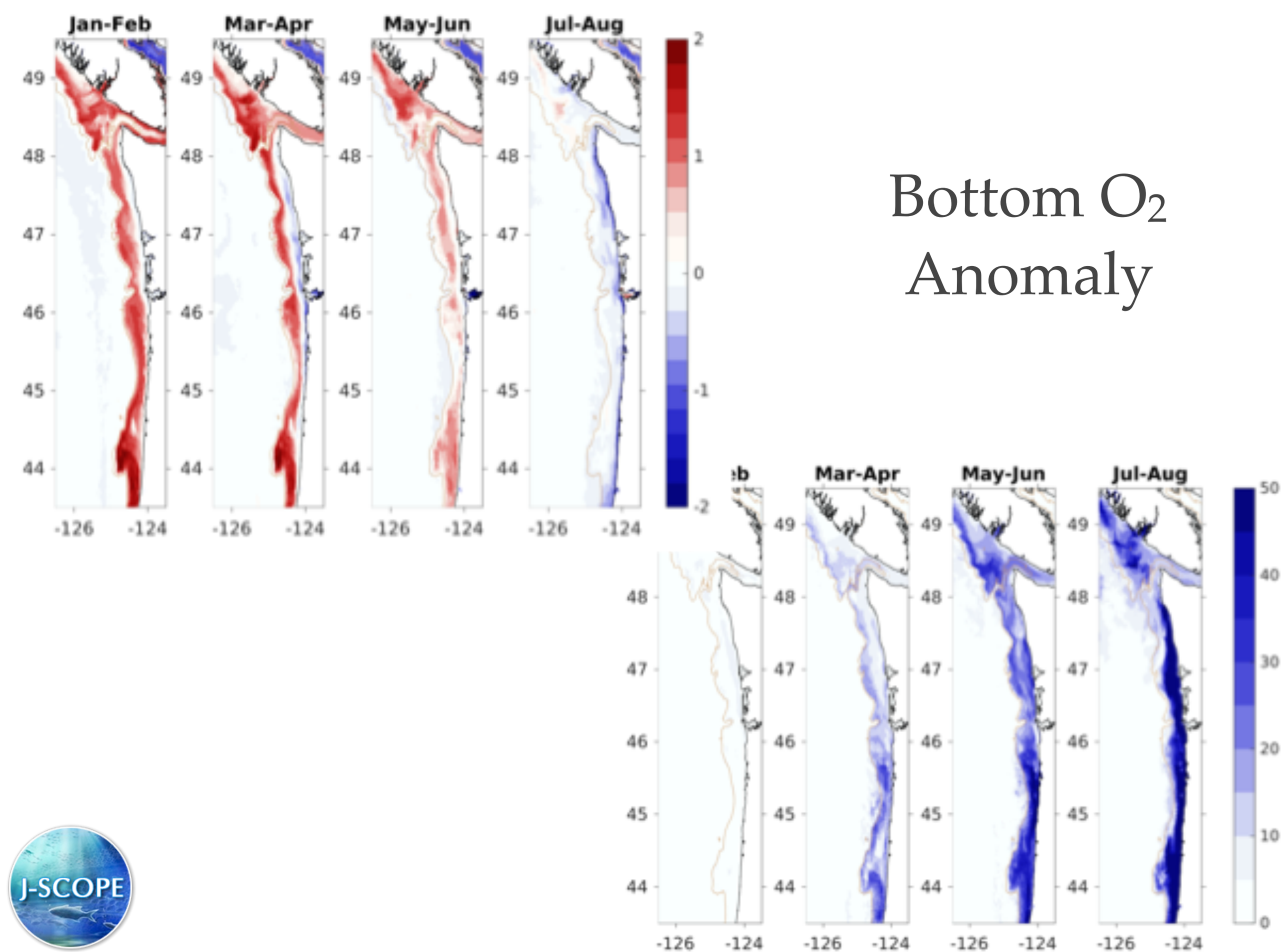
Mini Model Climatology—2009-2014



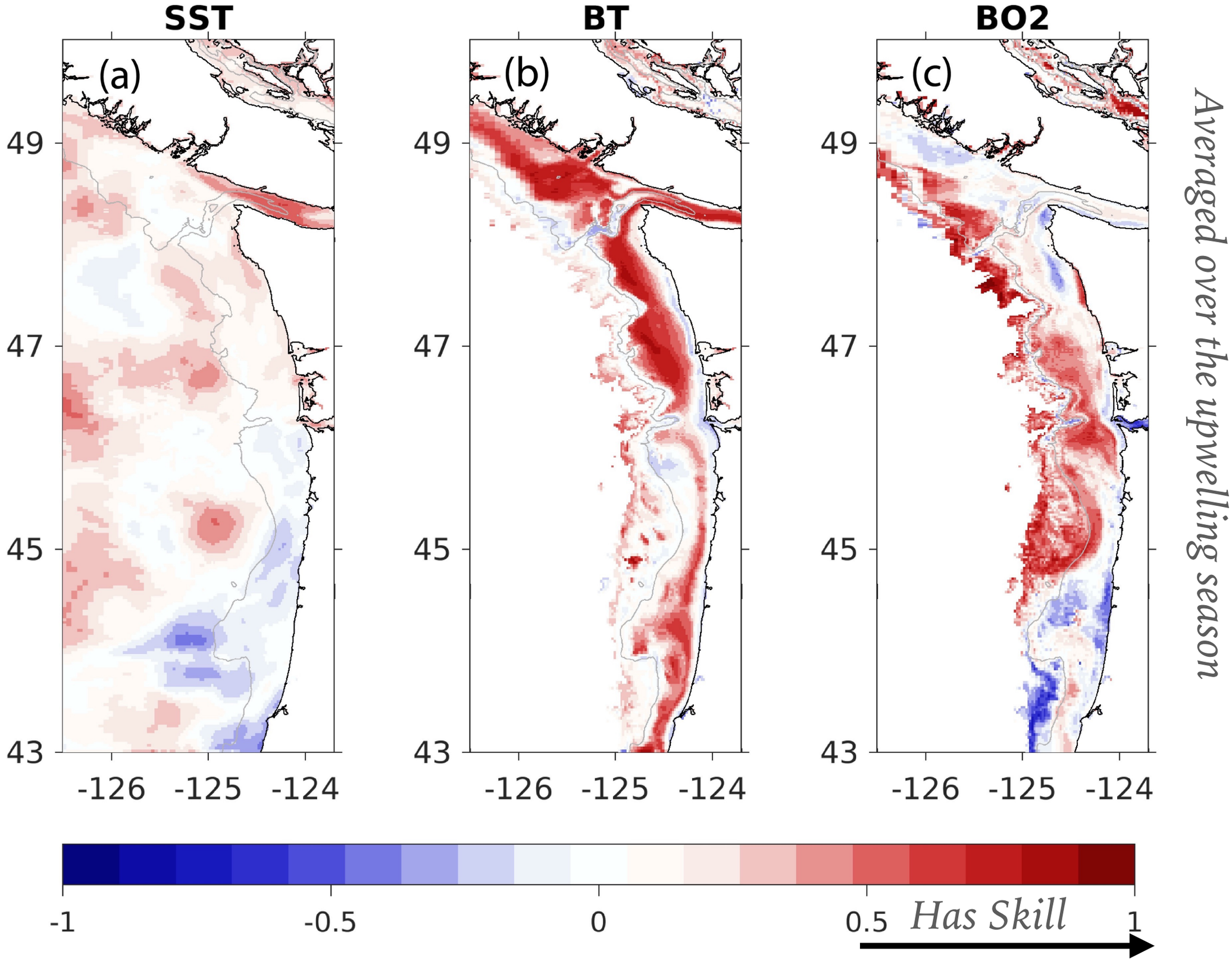
Siedlecki et al, 2016



Bottom O_2 Anomaly

J-SCOPE

predictable on Seasonal Timescales



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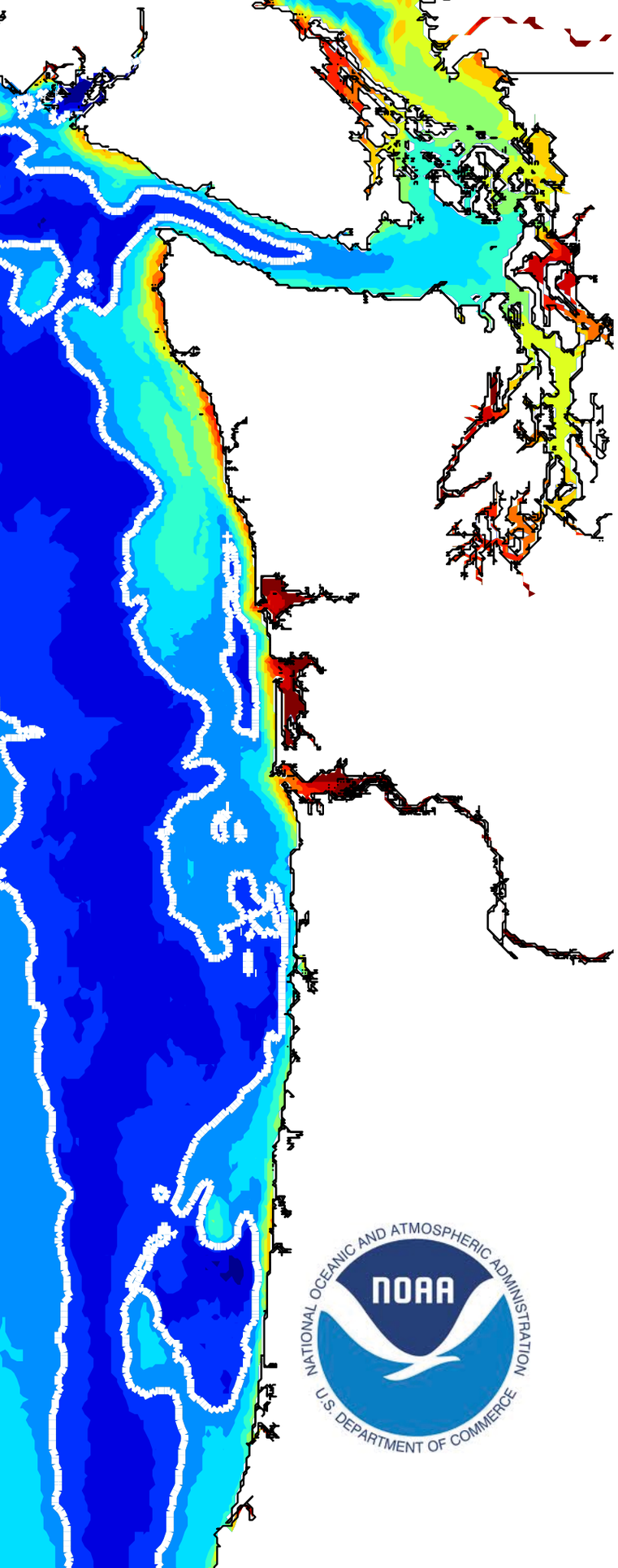
Siedlecki et al., 2016



J-SCOPE January 2016 OA Forecasts

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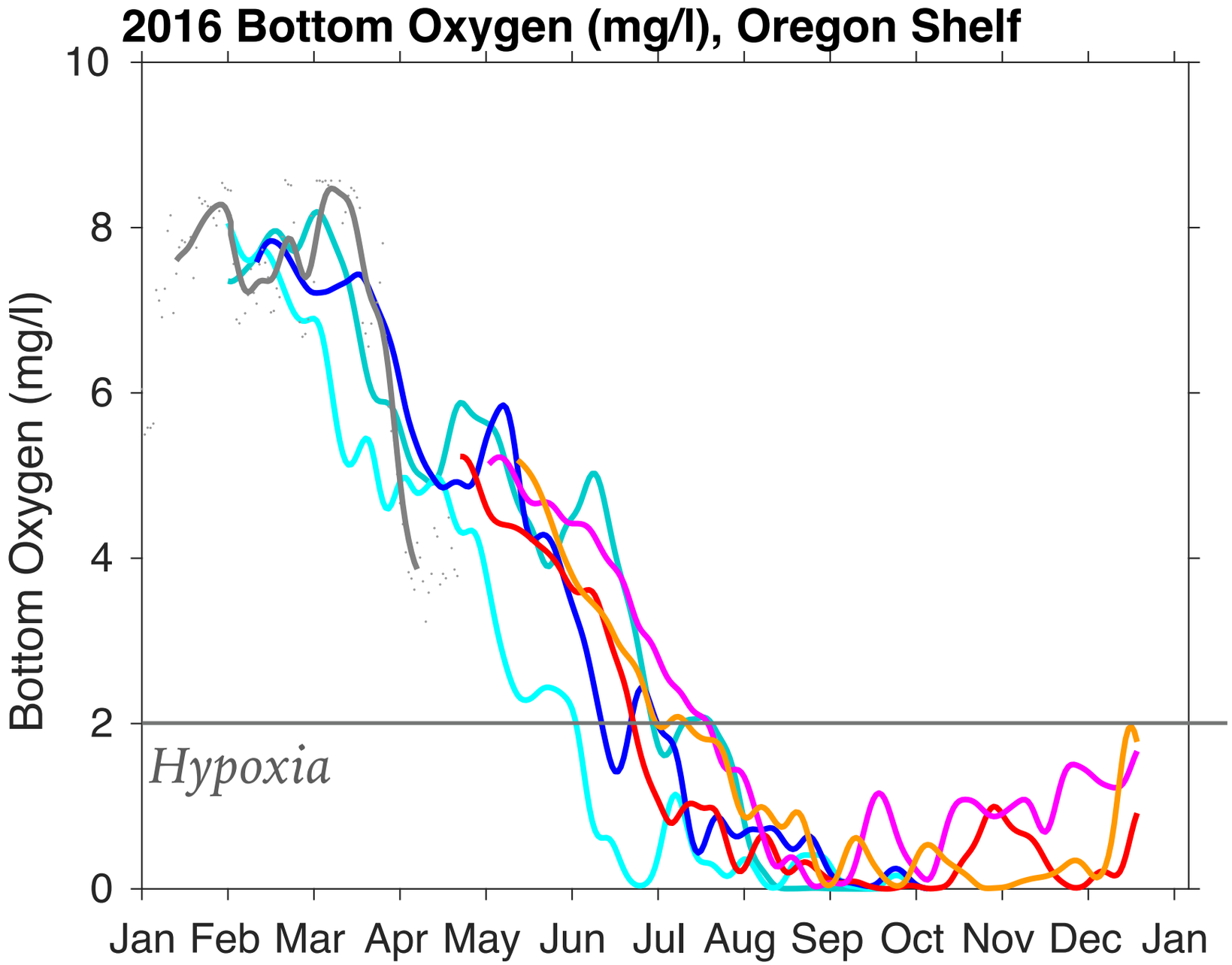
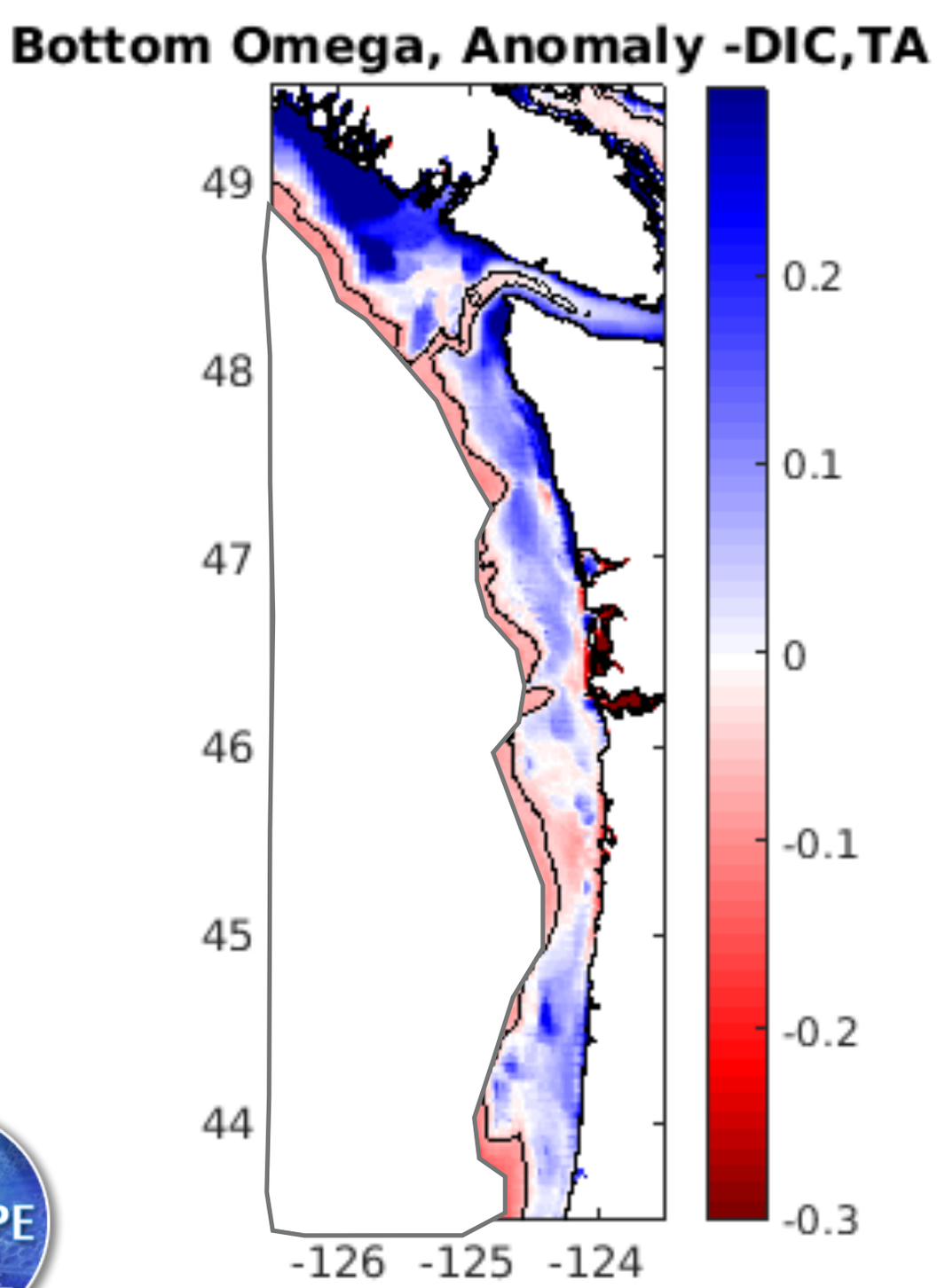
Bottom Ω Anomaly- 2016 forecast

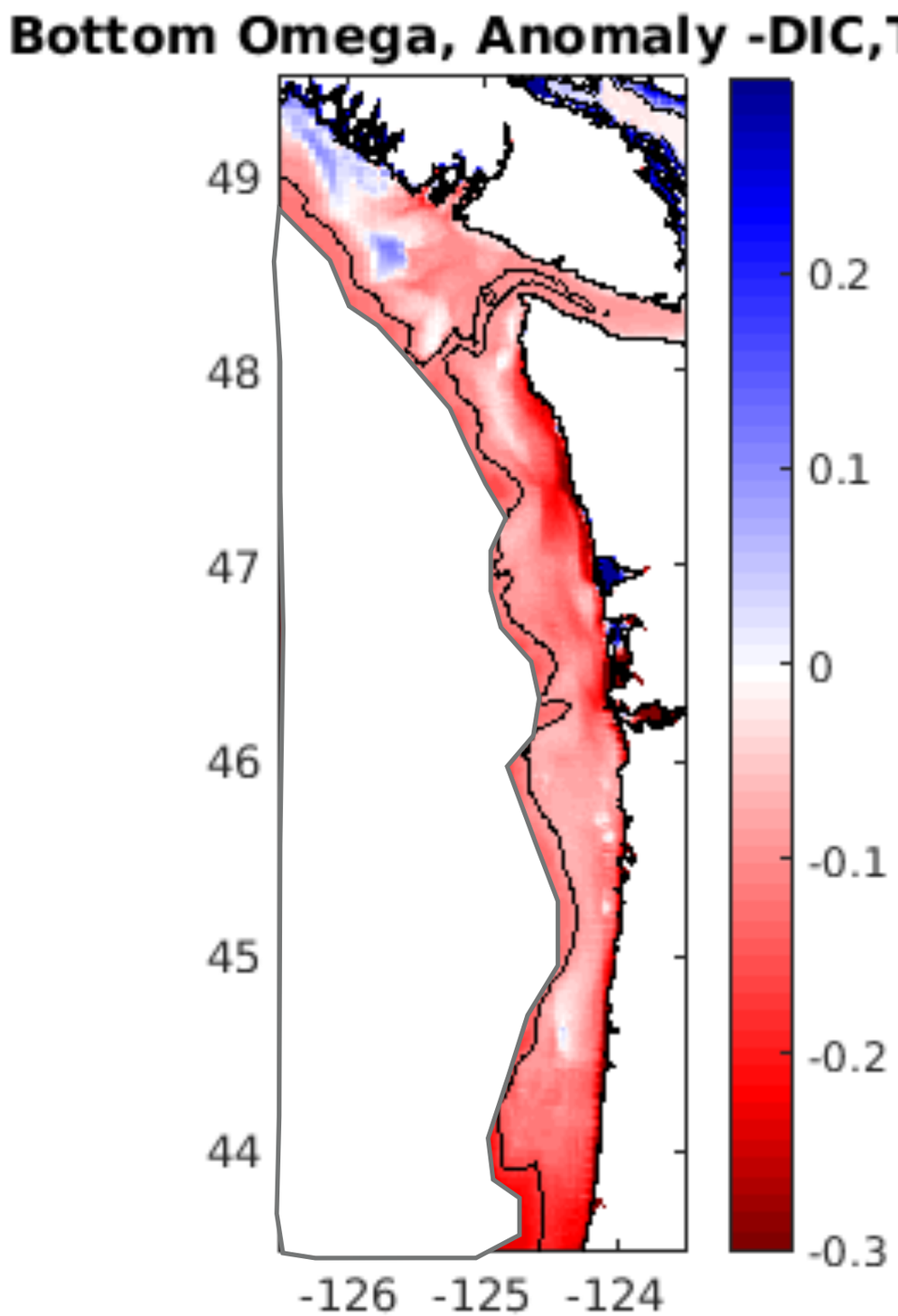


Bottom Ω Anomaly- 2016 forecast

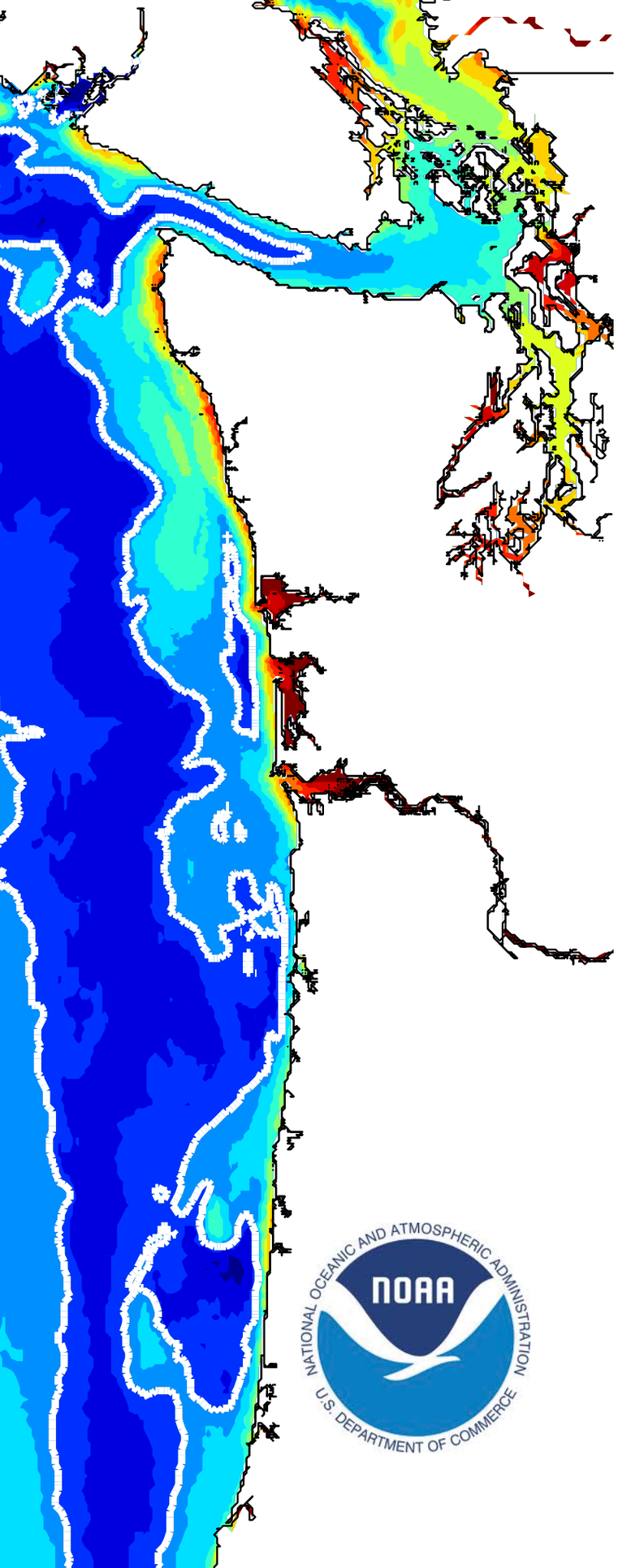
May/June



Jul/Aug



Anomaly from mini-climatology (2009-2014)



J-SCOPE Habitat/ Ecosystem Indices

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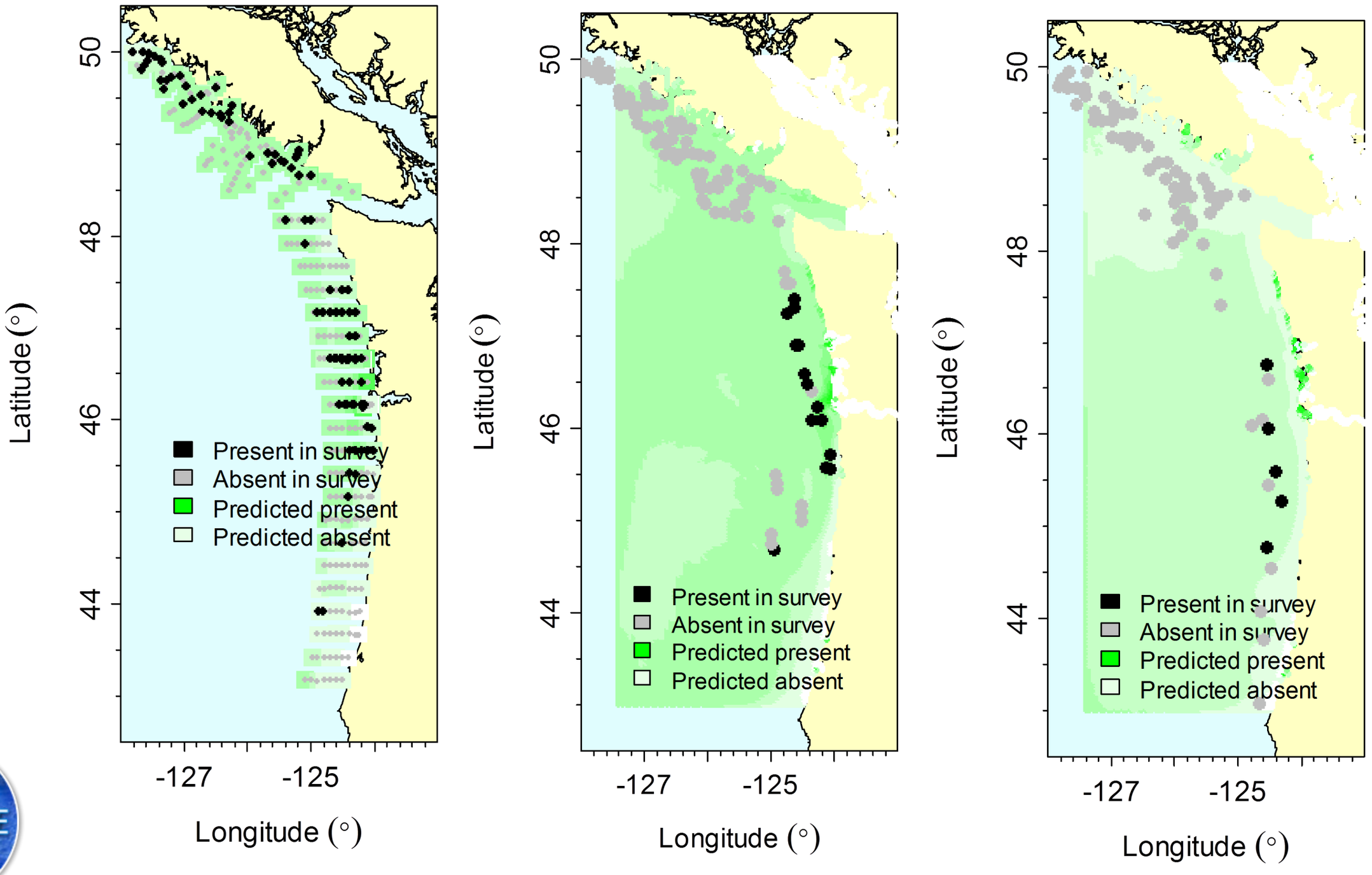
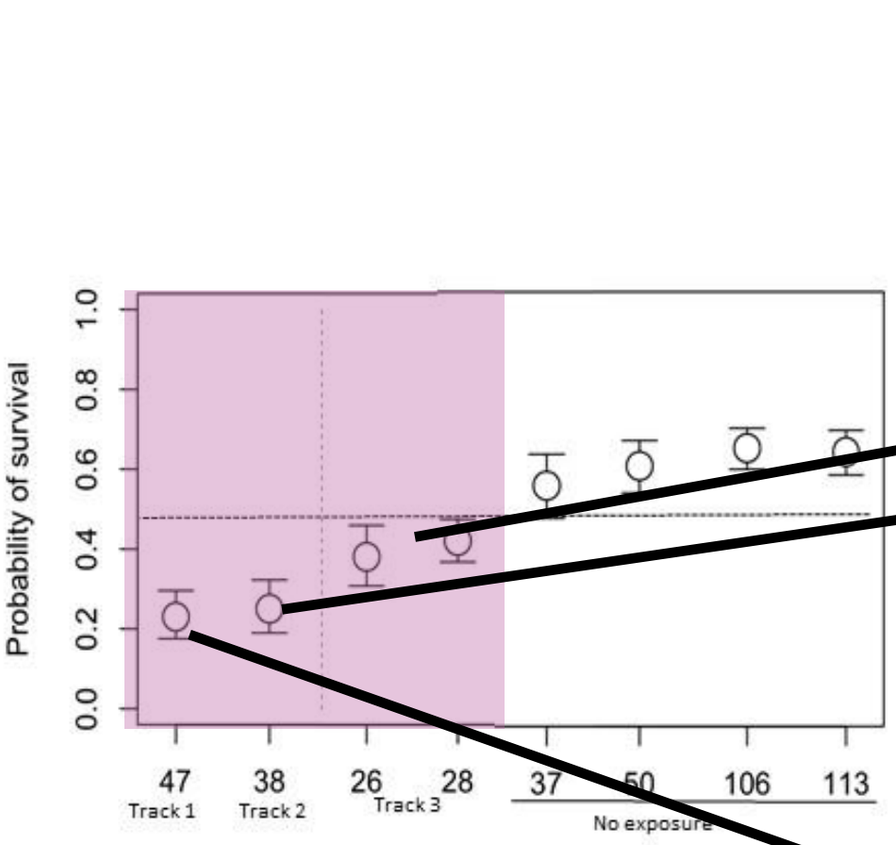
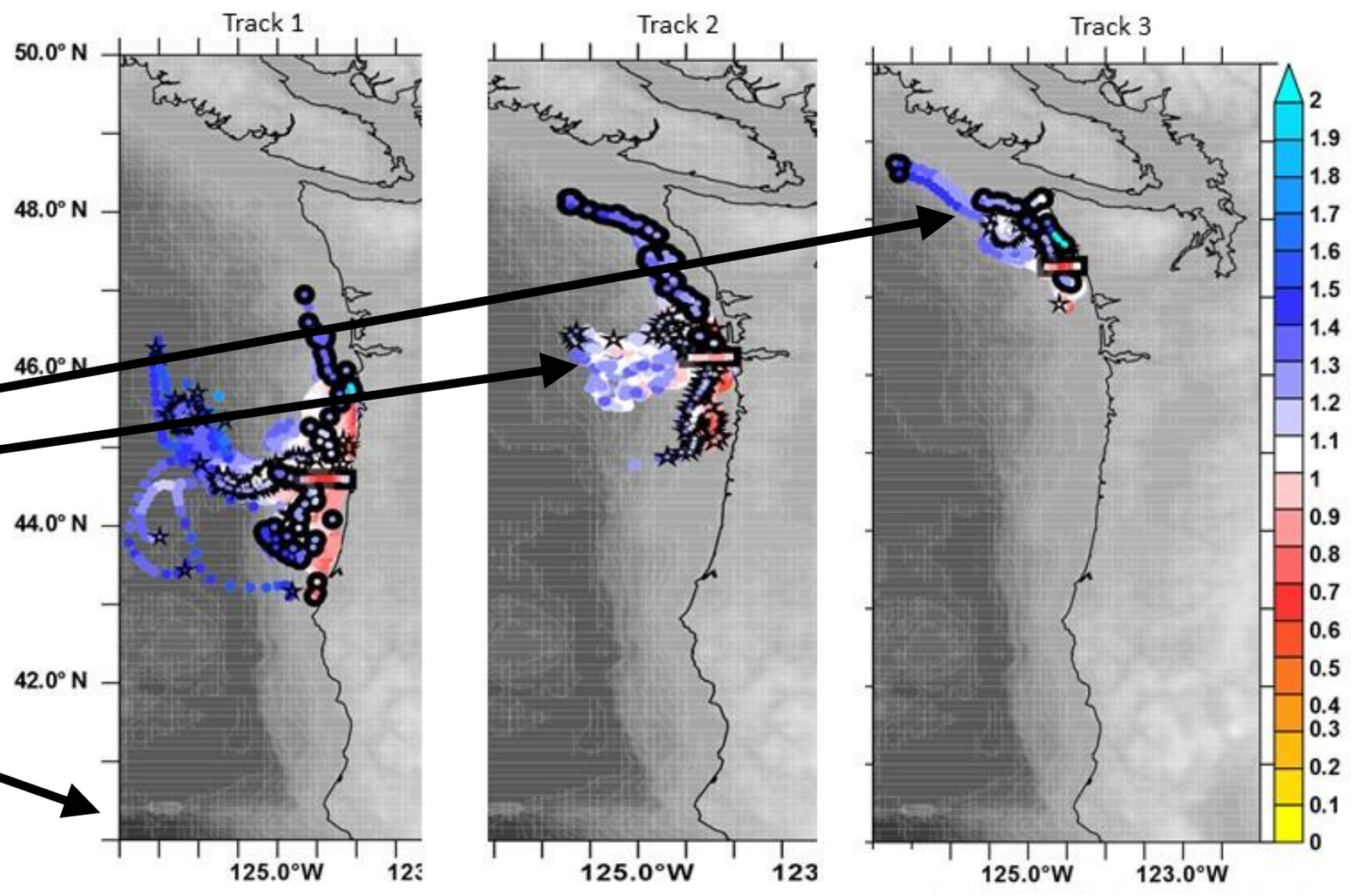
Sardine Forecast

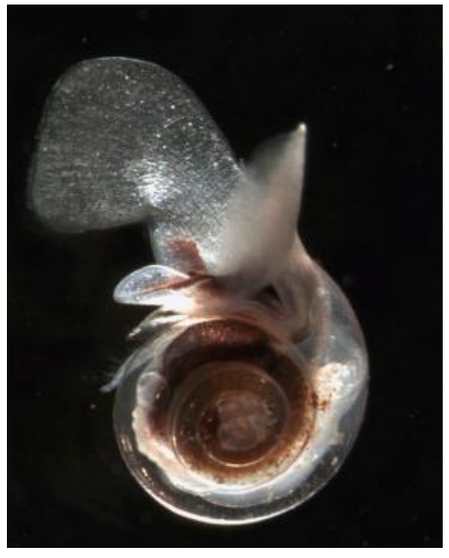


Kaplan, I. C., Williams, G. D., Bond, N. A., Hermann, A. J. and Siedlecki, S. A. (2016), **Cloudy with a chance of sardines**: forecasting sardine distributions using regional climate models. Fisheries Oceanography, 25: 15–27. doi: 10.1111/fog.12131

Implications for Marine Food Webs - Pteropods







Pteropod

Photo: R. Hopcroft

Particles released along tracks where samples obtained

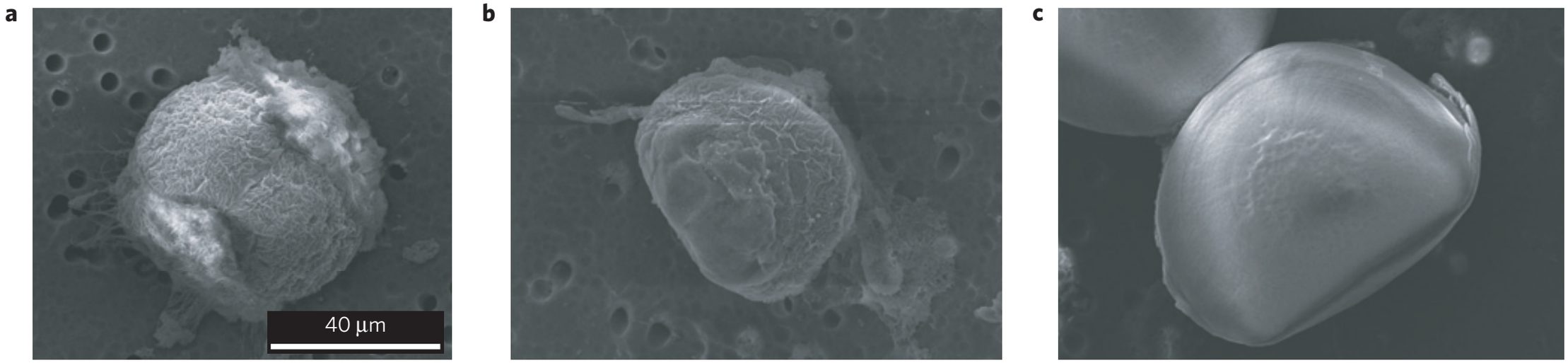
Particles vertically migrate

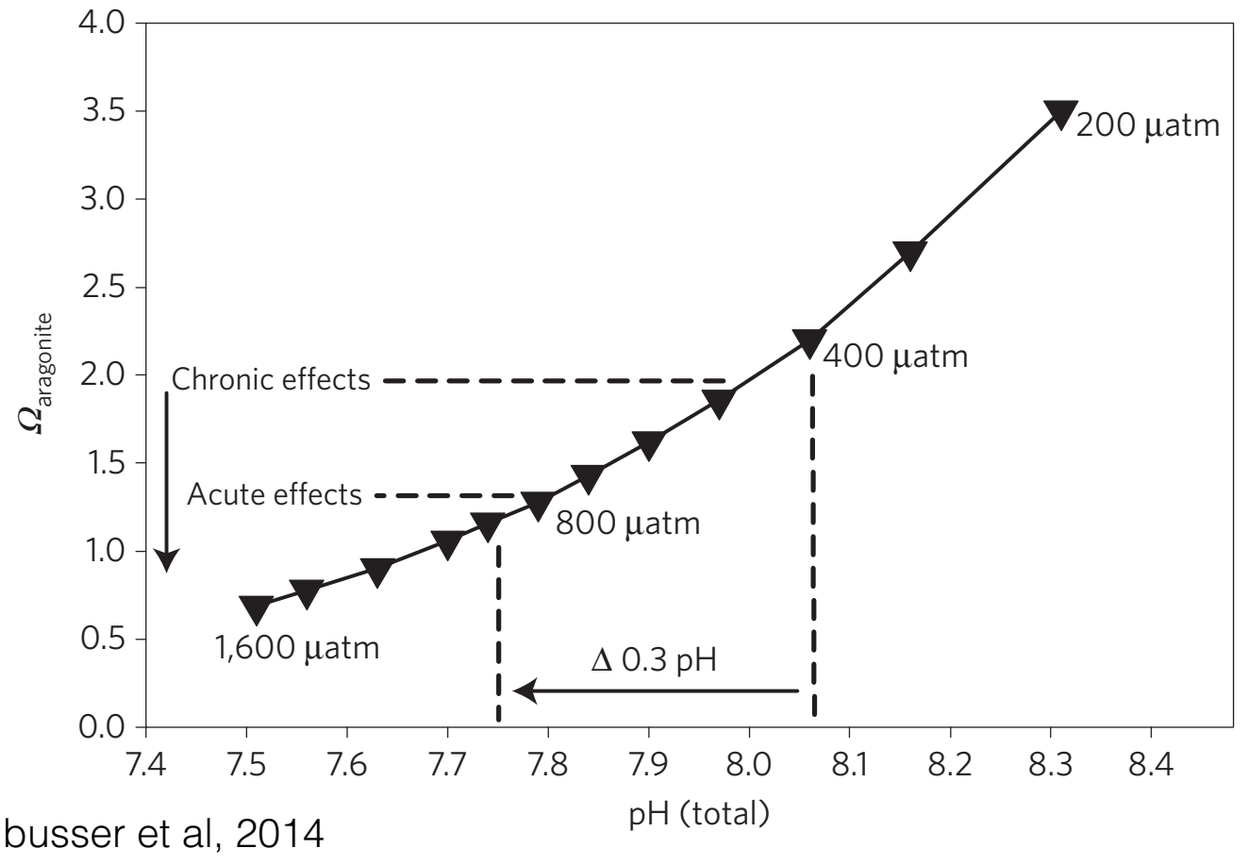
Particle tracks run forward and backward in time for 30 days to calculated undersaturation days experienced

Bednarsek et al., in review

Undersaturation Days - a Severity Index

NATURE CLIMATE CHANGE DOI: 10.1038/NCLIMATE2479 ARTICLES





Waldbusser et al, 2014

Saturation-state sensitivity of marine bivalve larvae to ocean acidification

George G. Waldbusser[1]*, Burke Hales[1], Chris J. Langdon[2], Brian A. Haley[1], Paul Schrader[2], Elizabeth L. Brunner[1], Matthew W. Gray[2], Cale A. Miller[3] and Iria Gimenez[1]

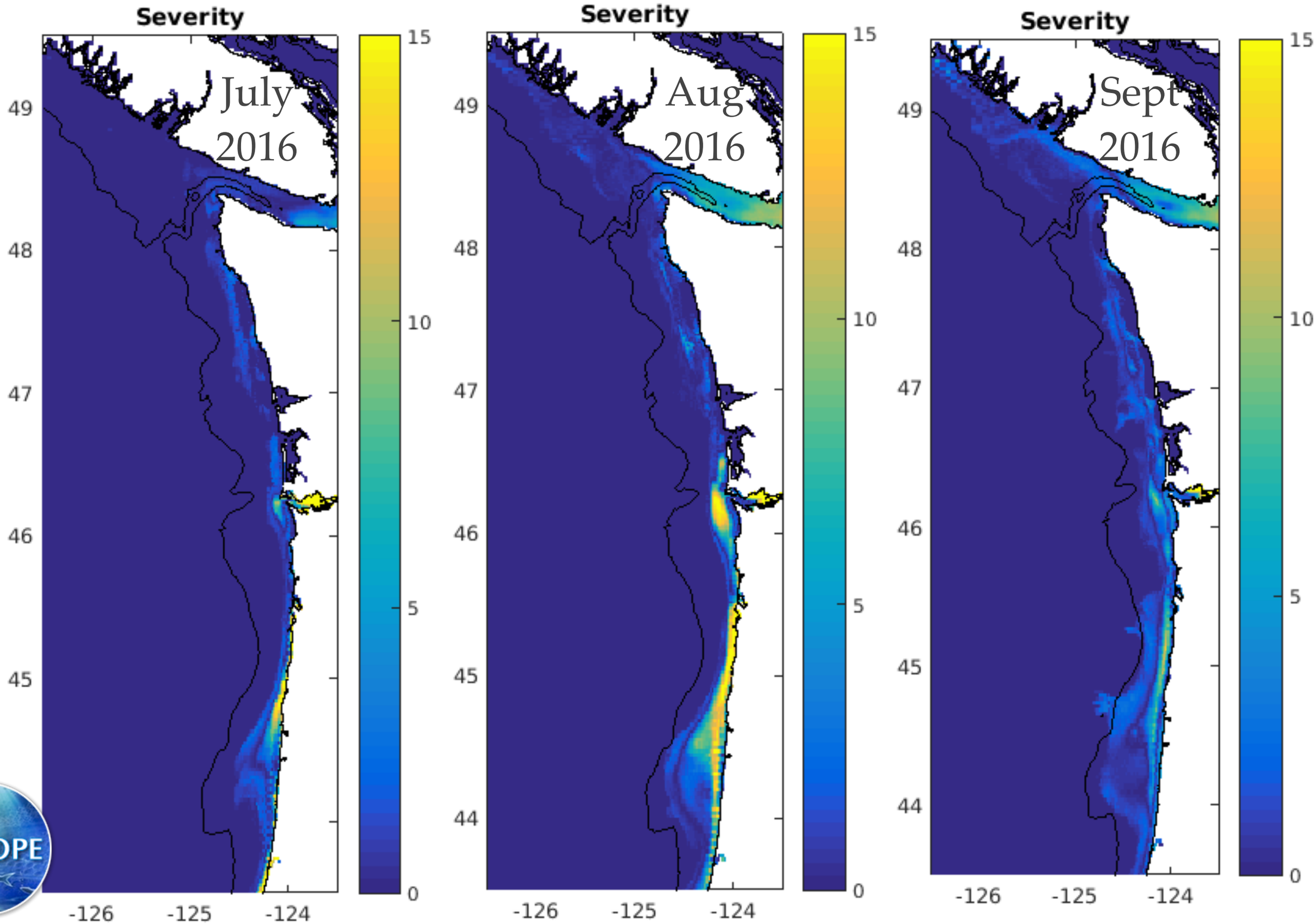
$$I = T - \Omega_{mean},$$

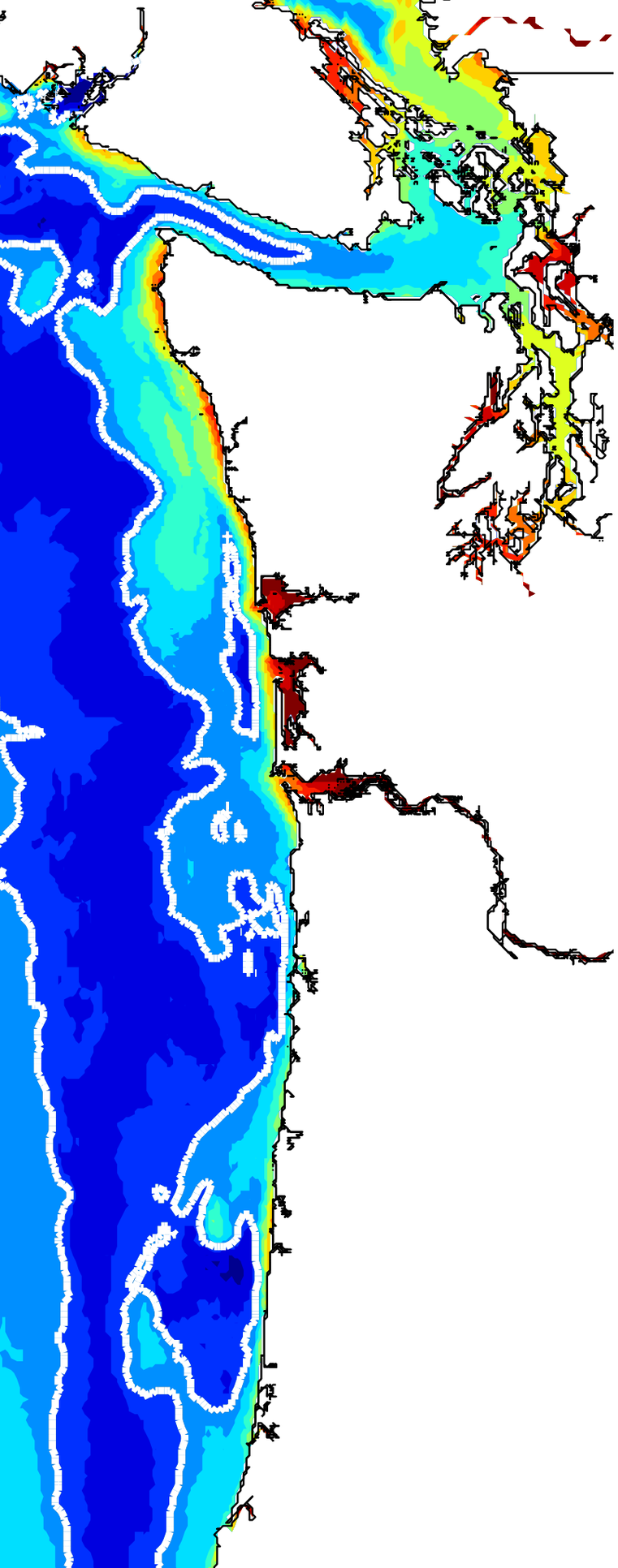
$$S = I \times D,$$

D = days, T = threshold

Hauri et al, 2013

30 day Severity Index, T=1.3, surf 50 m





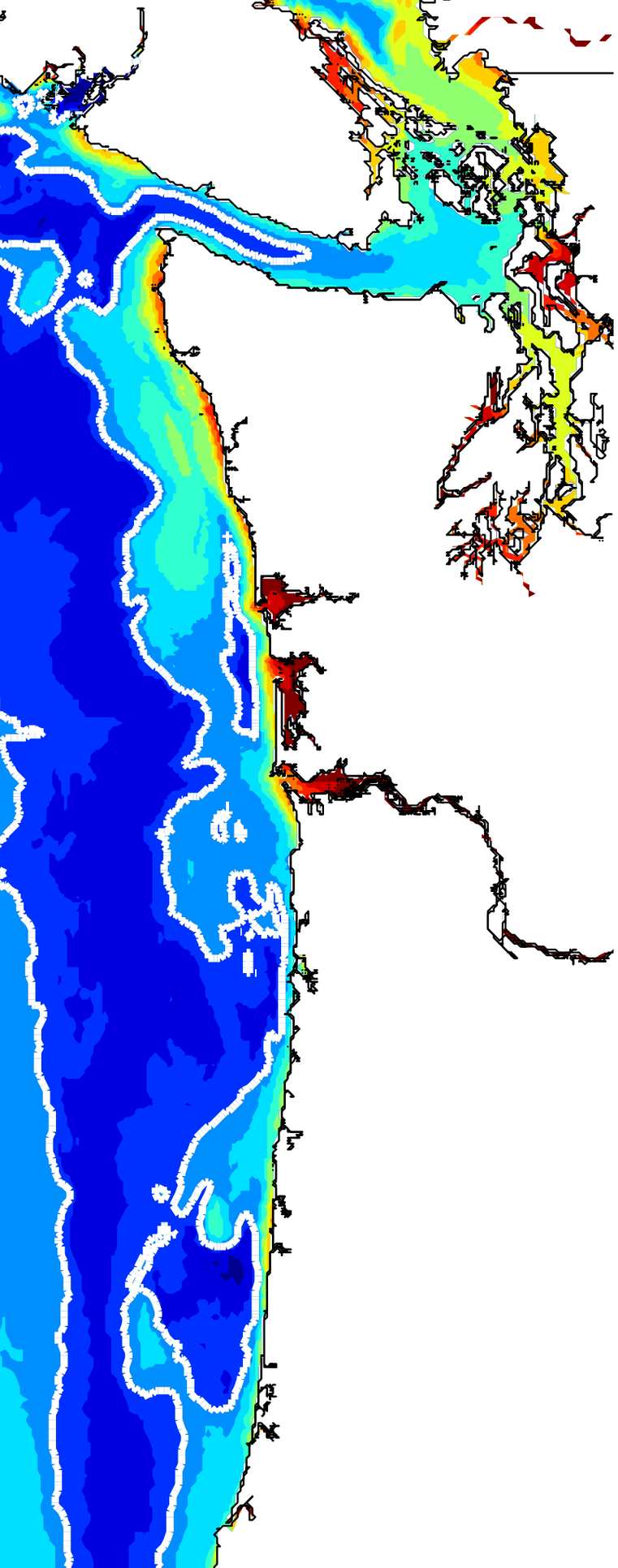
Conclusions

J-SCOPE forecasts (2009, 2013-2014) of subsurface ocean conditions have measurable skill on seasonal timescales, for variables relevant to management decisions for fisheries, protected species and ecosystem health.

Forecasting efforts are aided by a relationship with local stakeholders and a real-time observational network

Physical and biogeochemical conditions are not enough we need to move toward indices designed with management in mind - requires these measurements and development is done together

Long term monitoring is essential to establish these relationships between environmental variables and biological indices, but in the absence of data, a well validated model can be used as well.



Next Steps

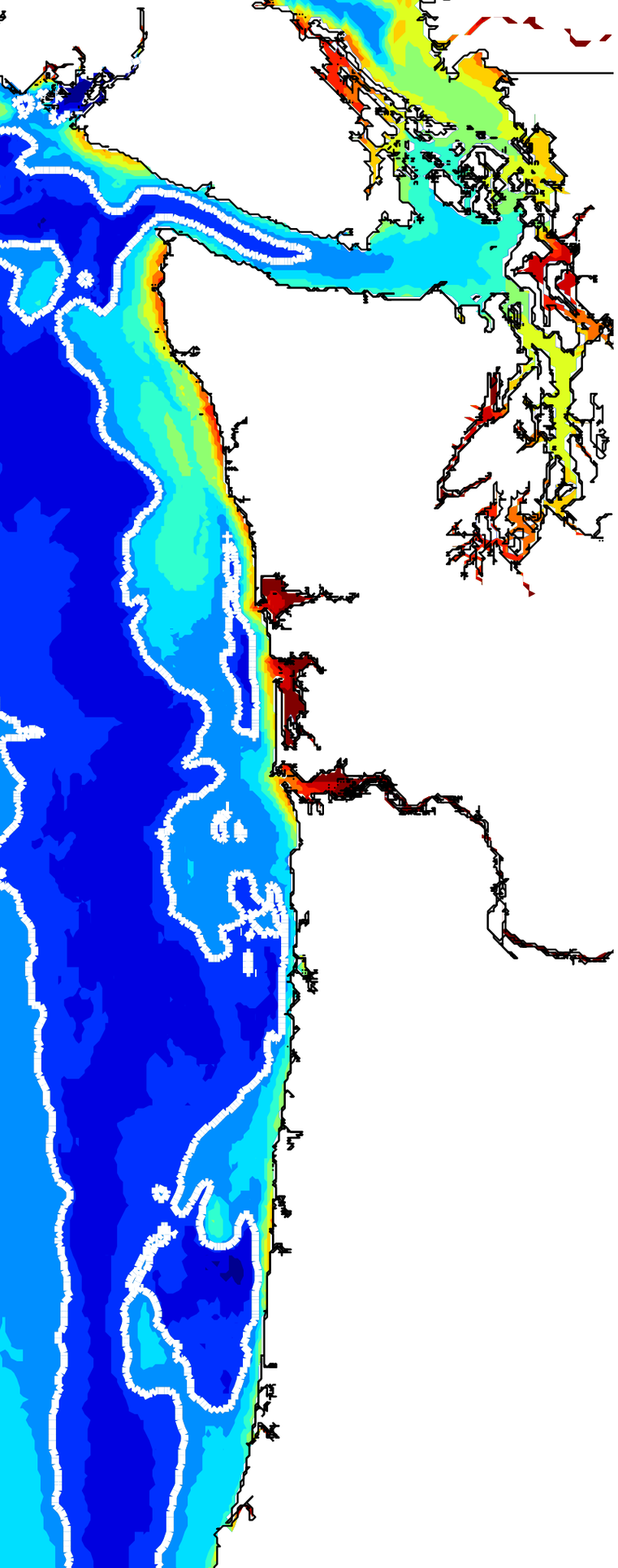
Expand forecasts to Multi-Model Ensemble?

Providing output for Pacific Fishery Management Council via Integrated Ecosystem Assessment (IEA)

Applications to additional stakeholders:

- hake
- crab

Validate hake, crab, shellfish indices with data - may require commercial collaborations



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Acknowledgements

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