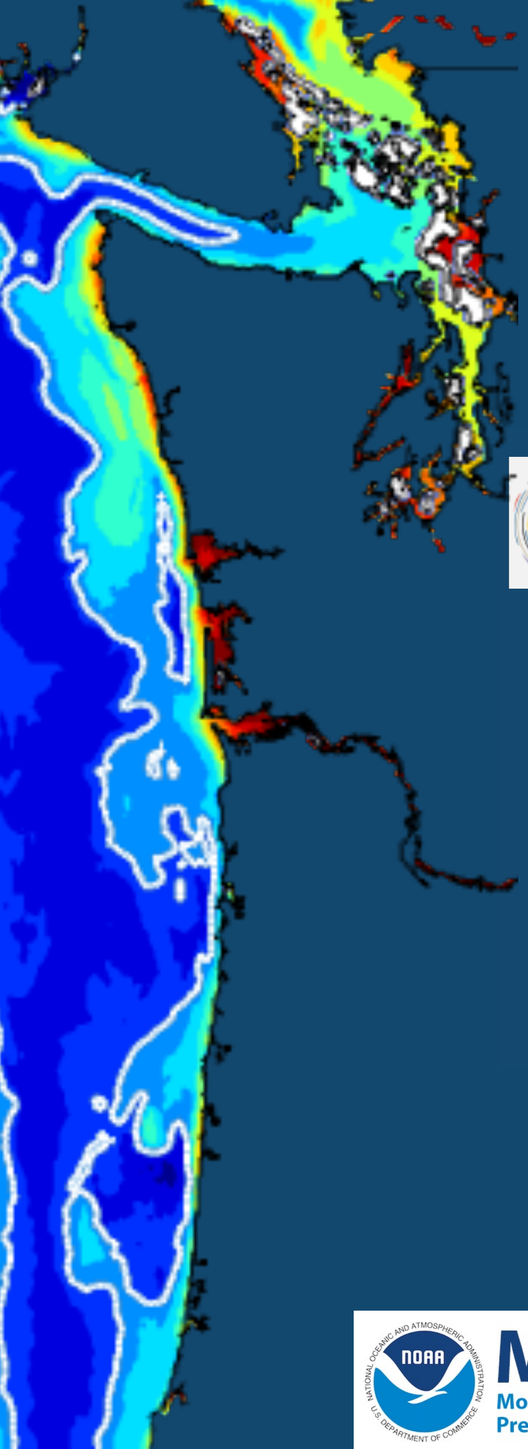
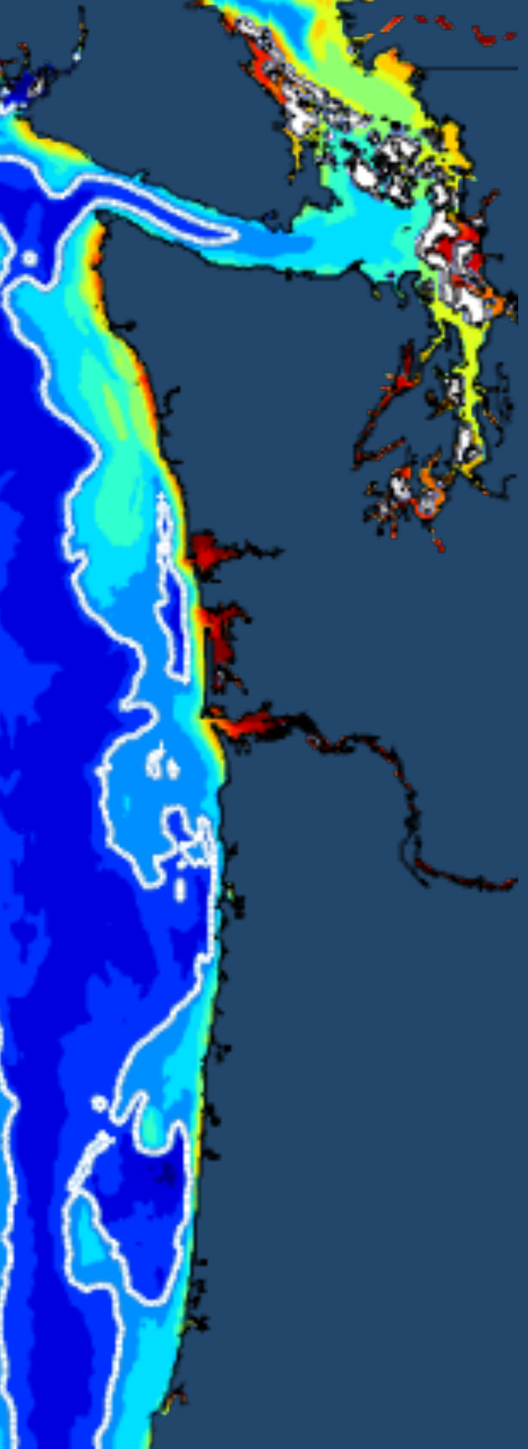


Seasonal ocean forecasts of ocean health: J-SCOPE (JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem)

Samantha Siedlecki

University of Connecticut

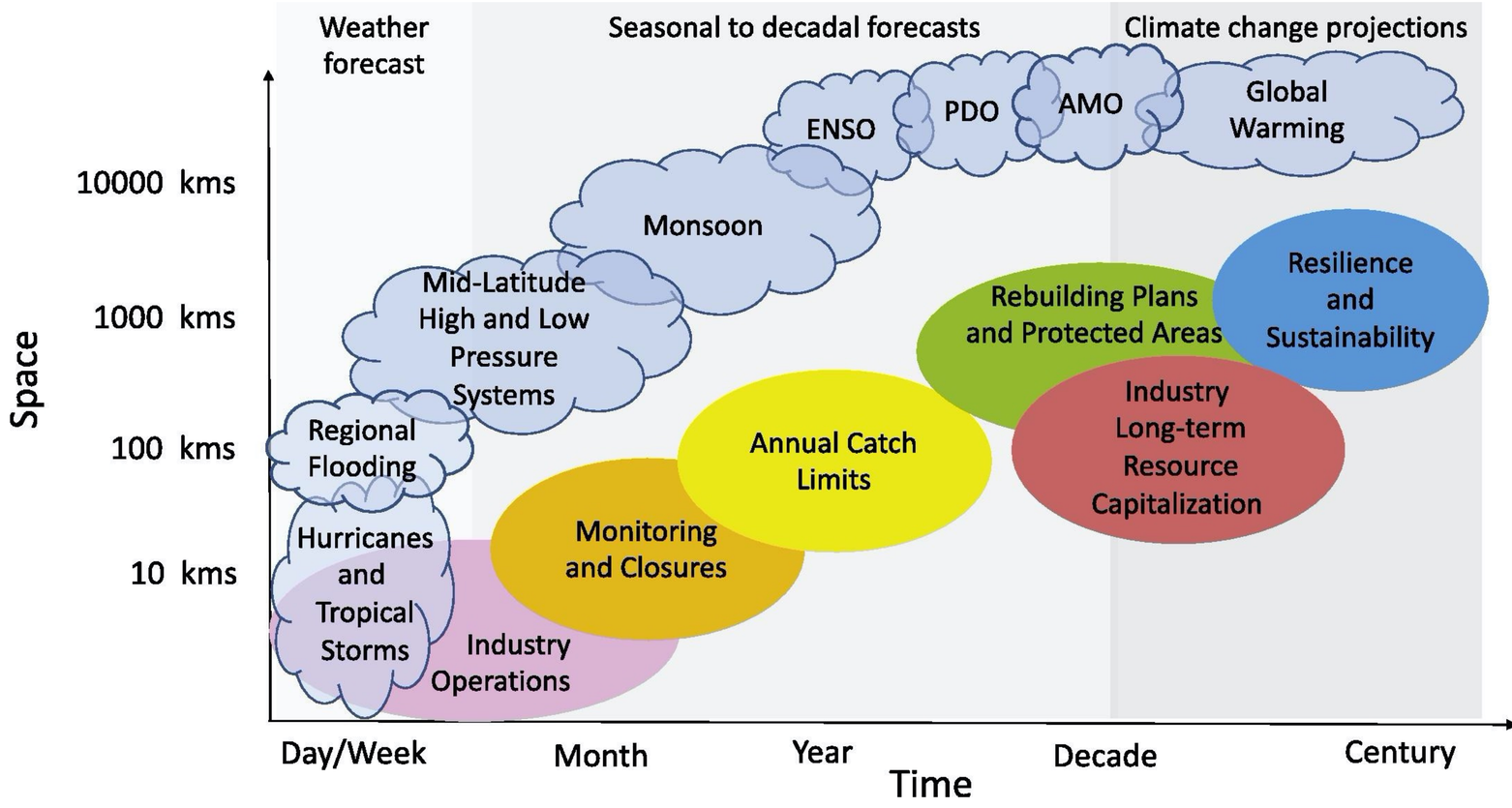
http://www.nanoos.org/products/j-scope/forecasts.php



J-SCOPE team:
Isaac Kaplan, Al Hermann, Nick Bond, Jan Newton, Simone Alin, Richard Feely, Emily Norton,

Forecasts needed for fishery management

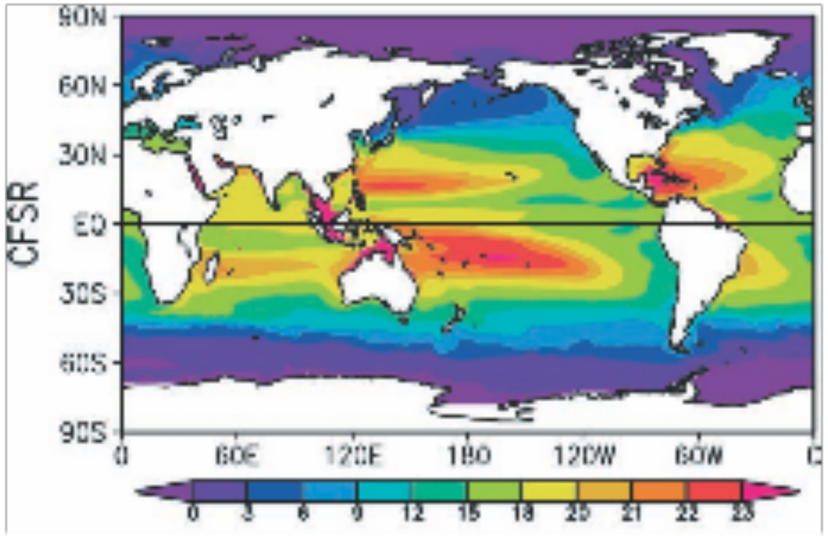
- Forecasts on any timescale need to be tailored to the particular needs.
- Each stakeholder and fishery manager requires forecast of specific variables.
- Important to test model performance of these specific variables.
- Societal benefits if model has skill.

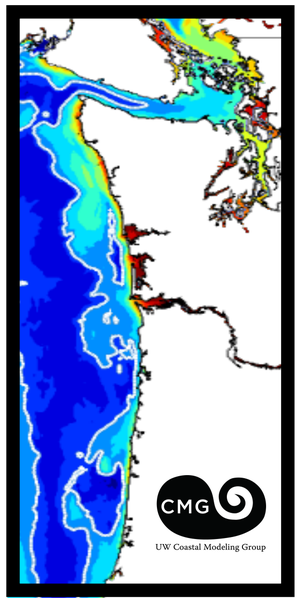


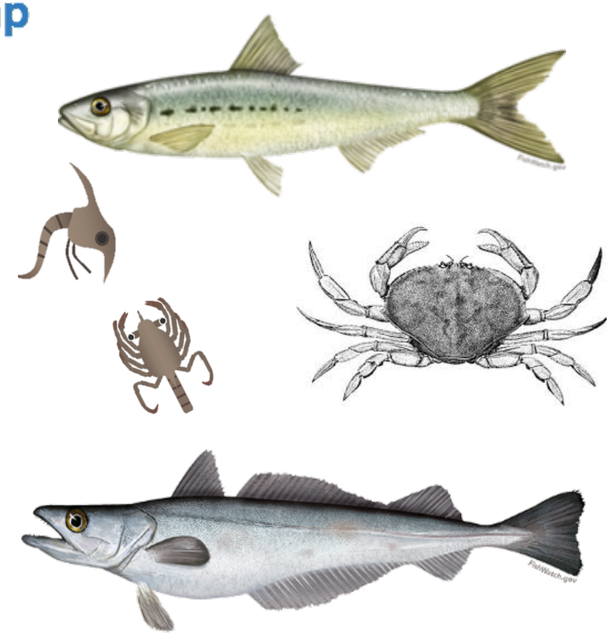
Tommasi et al., 2017

Building a forecast system

Check out our website:
http://www.nanoos.org/products/j-scope/home.php







Climate Forecast System (CFS)

~200 km atmospheric resolution

~50 km ocean resolution

Regional Ocean Model (UW Cascadia)

~1.5 km resolution

Physics and biogeochemistry (temperature, salinity, chlorophyll, nitrate, oxygen, pH, aragonite saturation state)

http://faculty.washington.edu/pmacc/cmg/cmg.html; Siedlecki et al. 2016

Habitat Models and Indices

Sardine (Kaplan et al., 2016)

Hake (Malick et al. 2020)

Juvenile crab (Norton et al. 2020)

Adult crab (Norton et al. in prep)

J-SCOPE

Home
Forecasts
Year in Review
About the Model
Climatology
Model Performance
People
Publications
Partners
Disclaimer
Contact

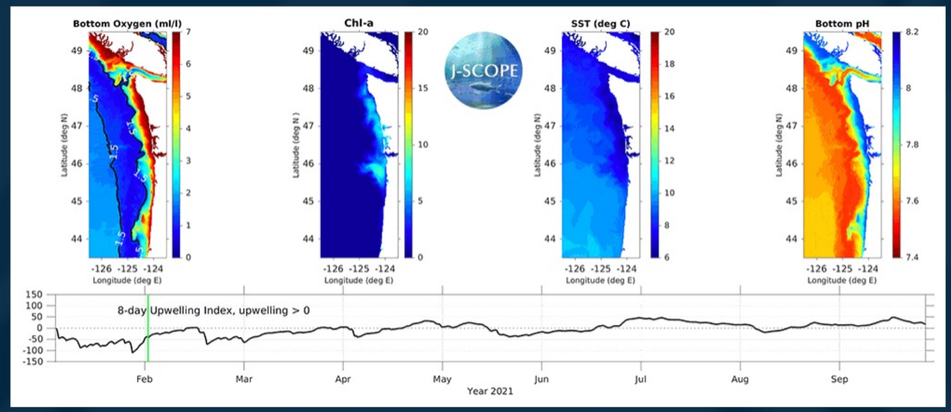
Forecast Origin Dates

Jan 2021 | Apr 2020 | Jan 2020 | Apr 2019 | Jan 2019 | Apr 2018 | Jan 2018 | Apr 2017 | Jan 2017 | Apr 2016 | Jan 2016 | Apr 2015 | Jan 2015 | Apr 2014 | Apr 2013 | Jan 2013

Overview | Chlorophyll | Sea Surface Temperature | Sardines | Hake | Oxygen | Ω | CA Current Indicators

The J-SCOPE forecast system for Washington and Oregon coastal waters presents preliminary results for the 2021 upwelling season. The CFS forecast indicates the current La Nina (ENSO-negative) conditions are likely to persist through the Northern hemisphere winter (95% chance) but may transition to ENSO-neutral conditions during spring of 2021 (~55% chance), but forecasts of ENSO beyond the spring are more uncertain and consistent with the spring predictability barrier. In comparison to the climatological data, coastal waters in the J-SCOPE domain during the summer upwelling season (May - August) are forecast to have *near* climatological sea surface temperatures (SST) until summer (July-August) when they become *warmer* mostly offshore, and these warm anomalies do not extend to subsurface habitats. In fact, the subsurface anomalies along 47°N and 44°N are *cooler* than climatology. Bottom oxygen is forecast to be *lower* over the Washington and Oregon continental shelves early in the upwelling season with the Oregon shelf trending toward *near* climatological values later in the upwelling season with high disagreement between ensemble members during the upwelling season. Chlorophyll concentrations vary spatially and temporally but are forecast to be *lower* than climatological values early in the upwelling season, especially on the Oregon continental shelf, but trending toward *near* climatological values over the shelves later in the upwelling season, and the region associated with the Juan de Fuca Eddy with *higher* than average chlorophyll. Bottom Ω is forecast to be undersaturated throughout the upwelling season, with the exception of supersaturated conditions for nearshore regions within the Olympic Coast National Marine Sanctuary and some coastal embayments on the Washington shelf. Surface Ω is forecast to be supersaturated throughout the upwelling season (though August) for all coastal areas.

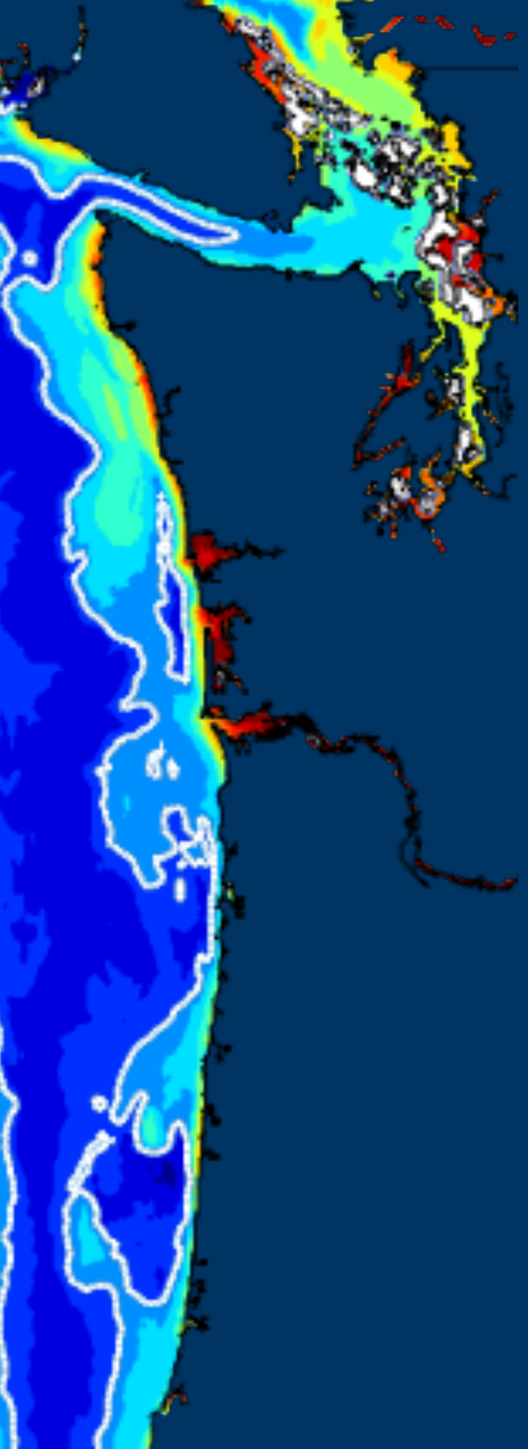
The forecast system predicts the timing of the spring transition from downwelling to upwelling, the cumulative upwelling index, sea-surface temperature (SST), primary production, chlorophyll stock, dissolved oxygen, and sardine habitat. The forecast for 2021 is composed of three model runs that make up an ensemble. Each model run is initialized at a different time (January 5, January 15, January 25), and has complementary forcing files from the large scale model, CFS. The details of the wind forcing for each model run can be found on the California Current Indicators tab. For each of the predicted quantities listed above, we report the ensemble average anomaly as well as the relative uncertainty within the ensemble, which is defined as the standard deviation of the ensemble divided by the mean of the ensemble and is reported as a percentage of the mean. All of these quantities are reported as monthly averaged anomalies from our new January-initialized reforecast climatology, which spans 2009 - 2017. An anomaly is an indication of how different conditions are to what they have been in the past. For more information about anomalies, please see the NANOOS Climatology App. These predicted quantities are key indicators for the California Current Integrated Ecosystem Assessment report.



The movie above shows the J-SCOPE forecast for 2021, from ensemble model run 1 initialized on January 5. More information about the three panels on the left can be found by navigating the Oxygen, Chlorophyll, and Sea Surface Temperature tabs above. The panel on the far right depicts the evolution of bottom water pH over the forecast period. The pH field is calculated using an empirical relationship established by Alin et al., in prep. This work is part of a collaboration between Samantha Siedlecki, J-SCOPE, and the Ocean Acidification group at NOAA PMEL. The 8-day upwelling index is calculated using the method described in Austin and Barth (2002) and can also be found under the California Current Indicators tab above.

J-SCOPE produces 6-9 month seasonal forecasts of physical conditions, Chl-*a*, O_2, pH, plankton, and Ω in addition to sardine, hake and crab habitat (in prep) all delivered to the Pacific Fishery Management Council each Spring

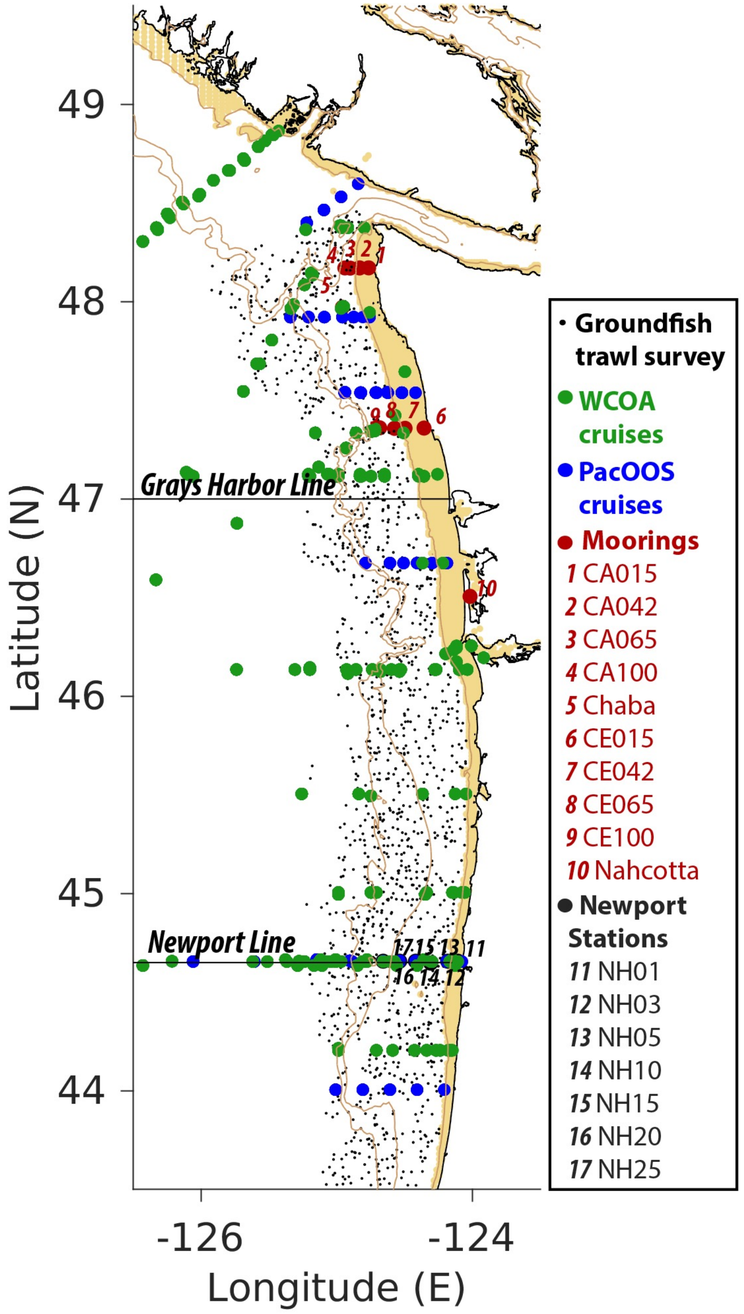
http://www.nanoos.org/products/j-scope/



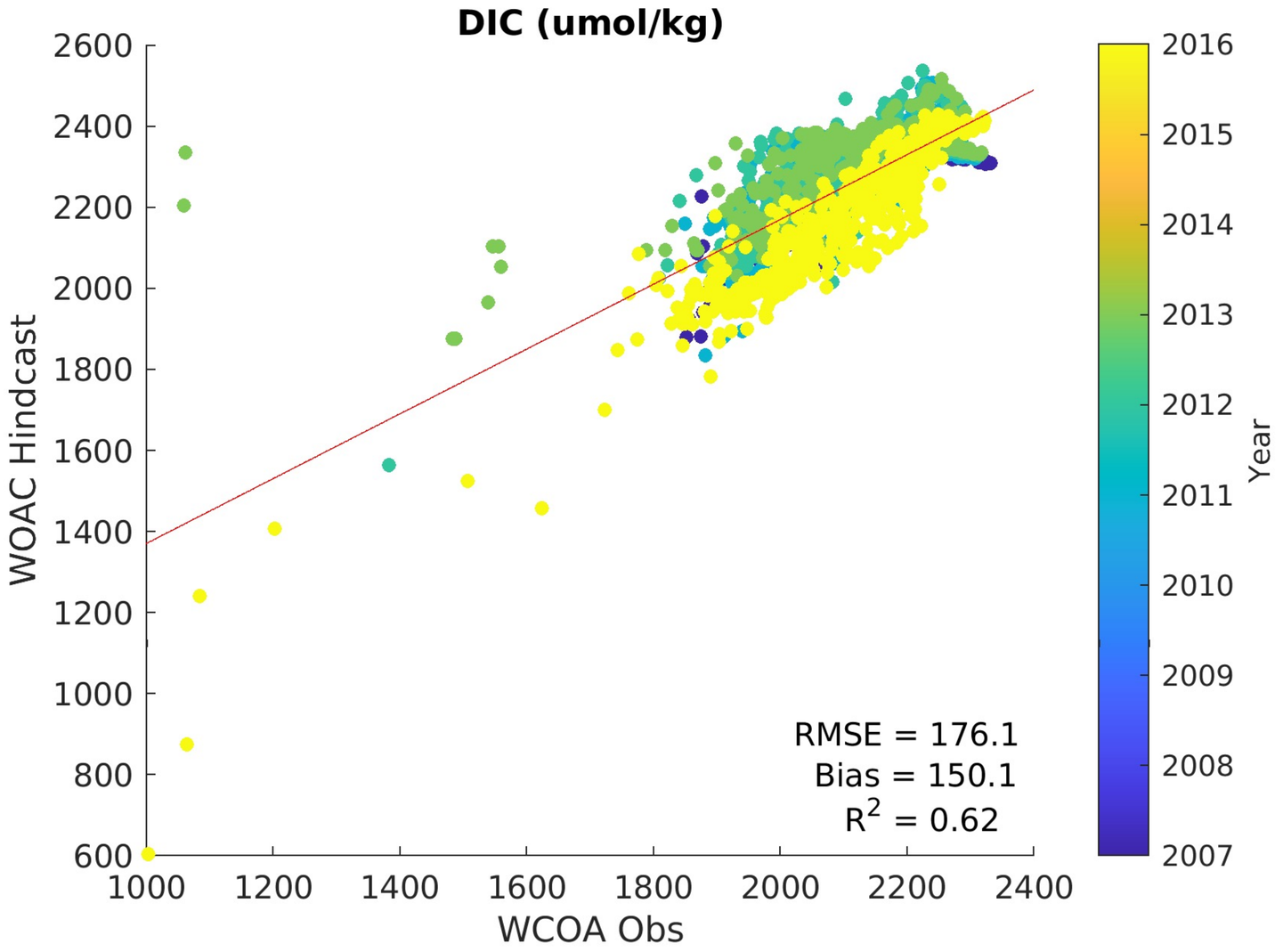
Performance testing
……with stakeholders in mind
…..using the data they trust

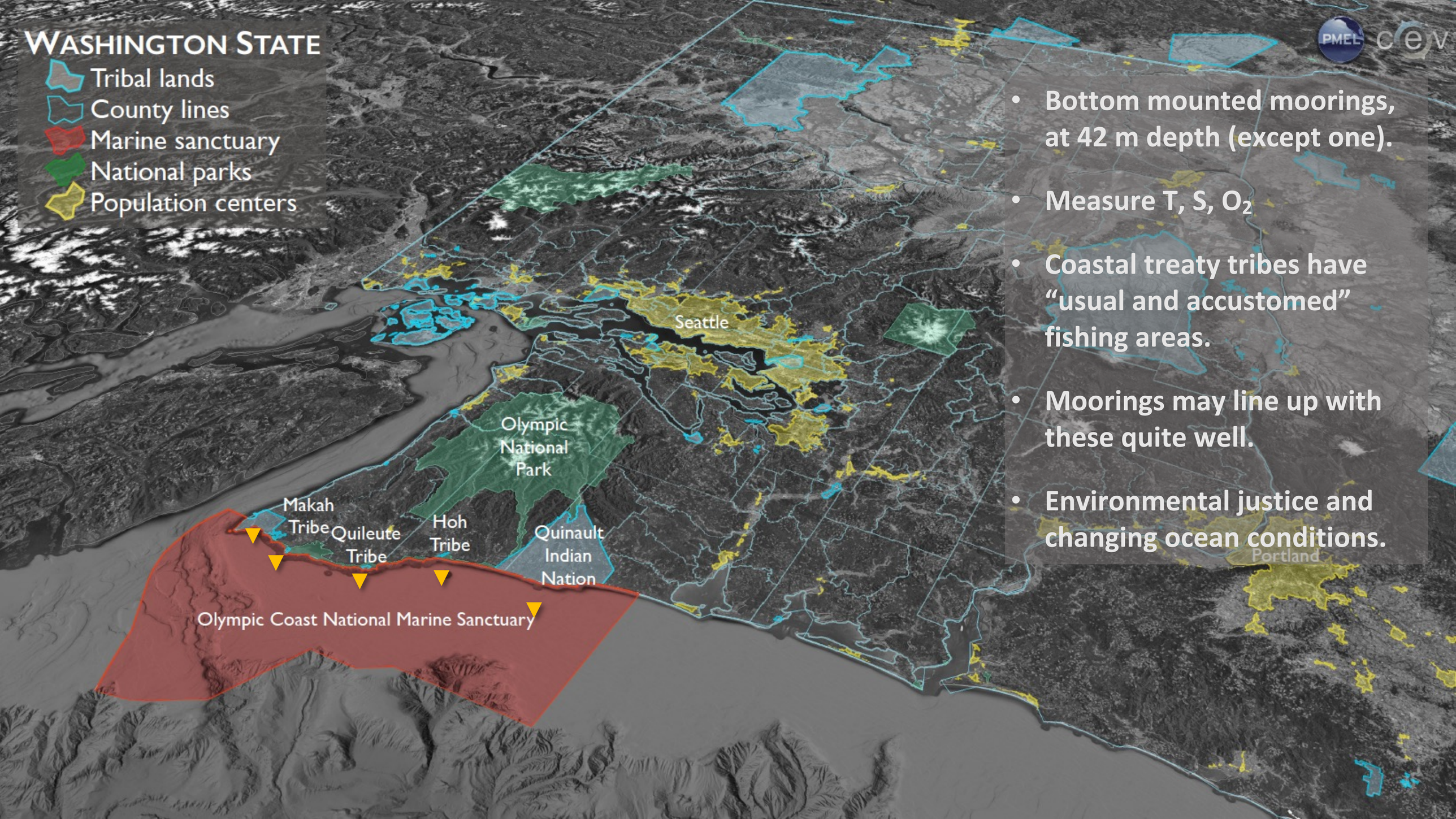
Performance tests require observations

Performance: the ability of the model to predict the seasonal cycle in the region, based on comparisons between observed and simulated *climatologies*.



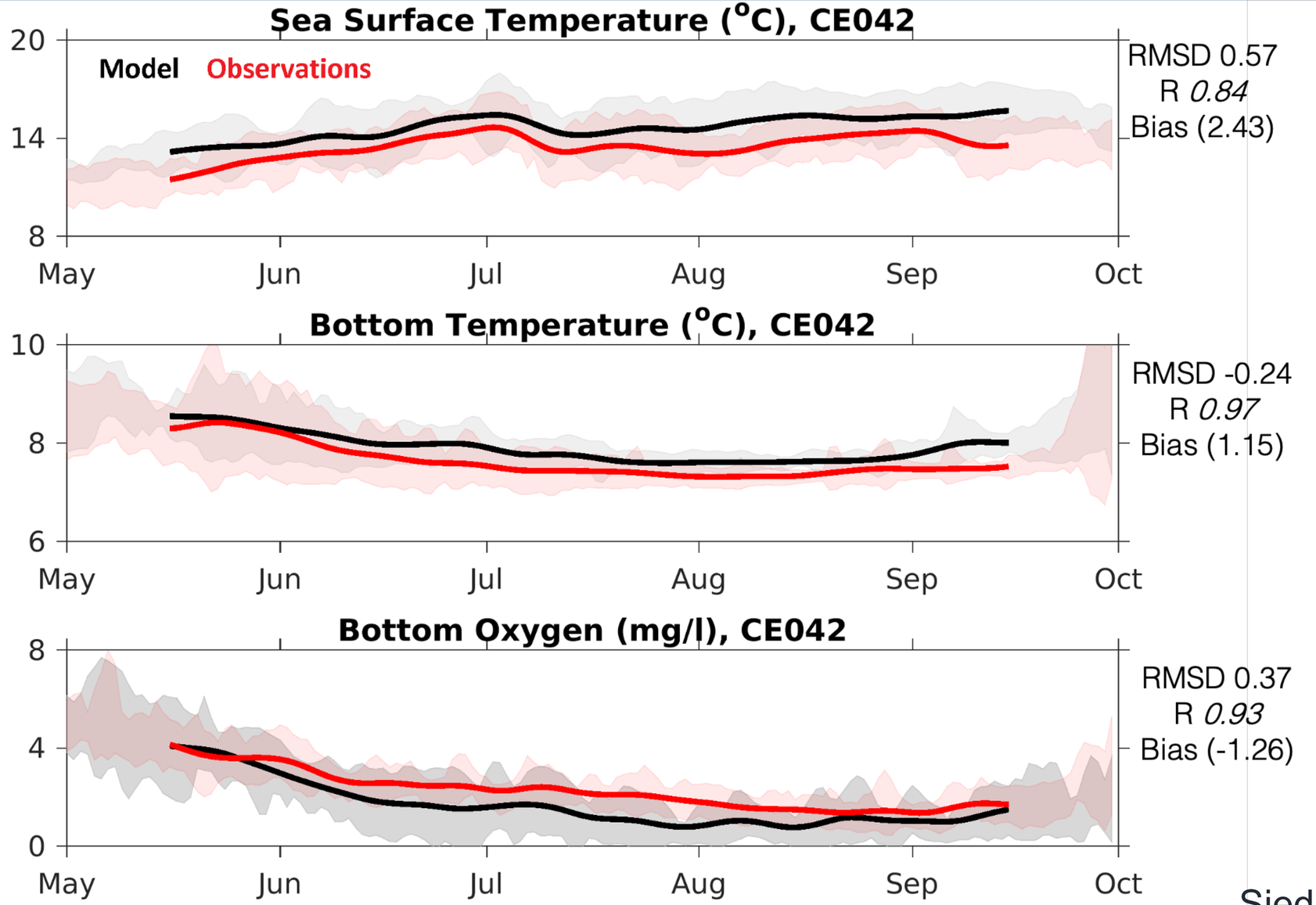
Performance of simulated historical conditions - with cruise planning stakeholders in mind



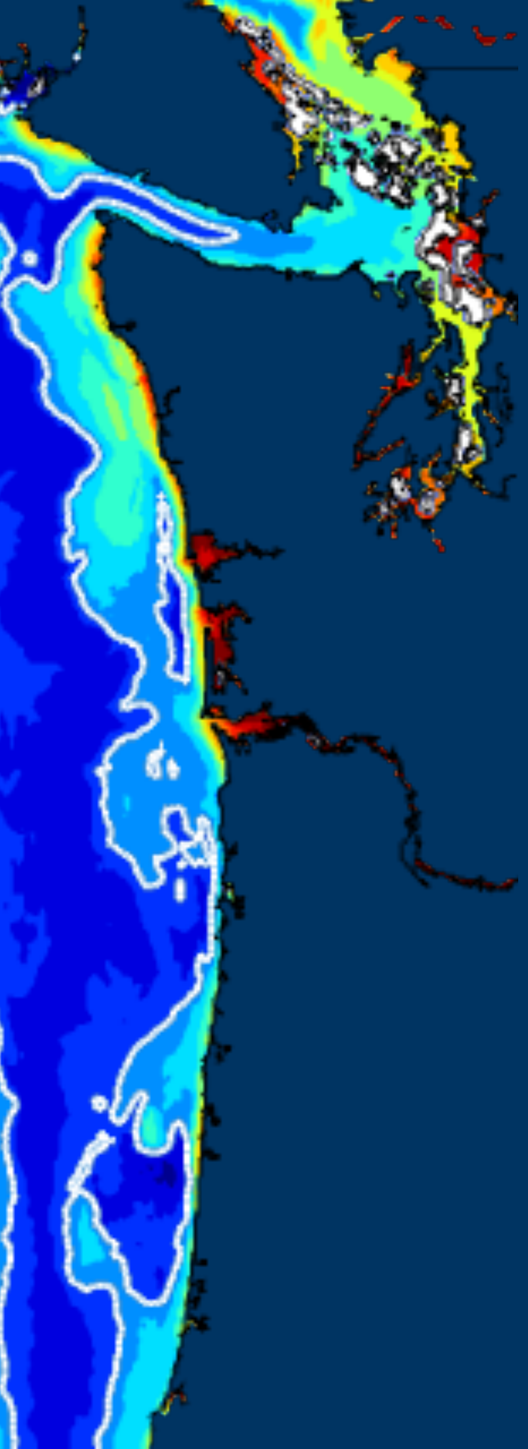


- Bottom mounted moorings, at 42 m depth (except one).
- Measure T, S, O_2
- Coastal treaty tribes have “usual and accustomed” fishing areas.
- Moorings may line up with these quite well.
- Environmental justice and changing ocean conditions.

Performance of hindcasts: Mini Model Climatology—2009-2014

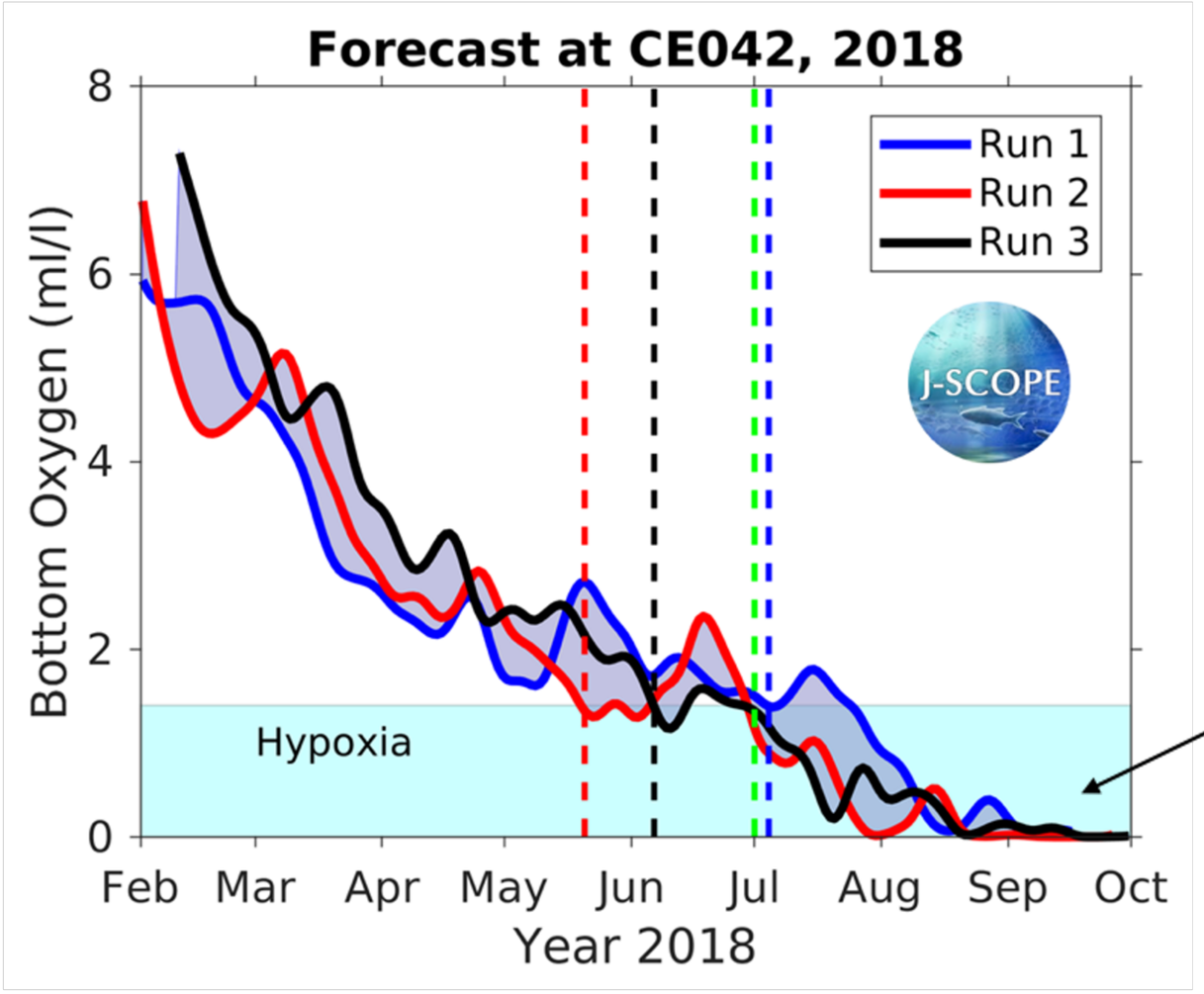


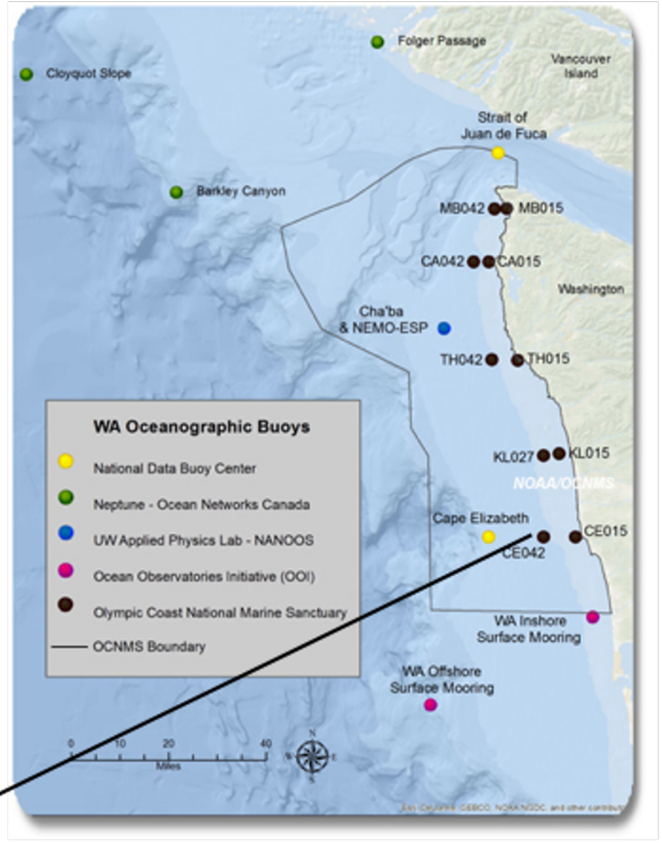
Siedlecki et al. 2016



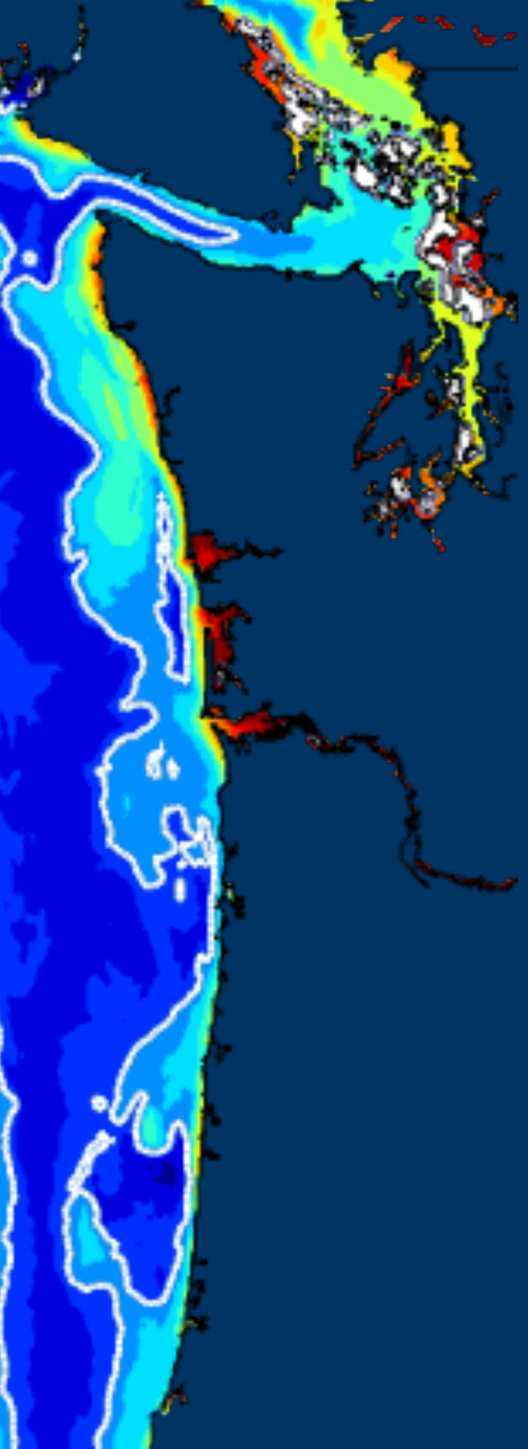
Uncertainty: The ensemble

Performance of forecasts: Model predicts summer onset of hypoxia



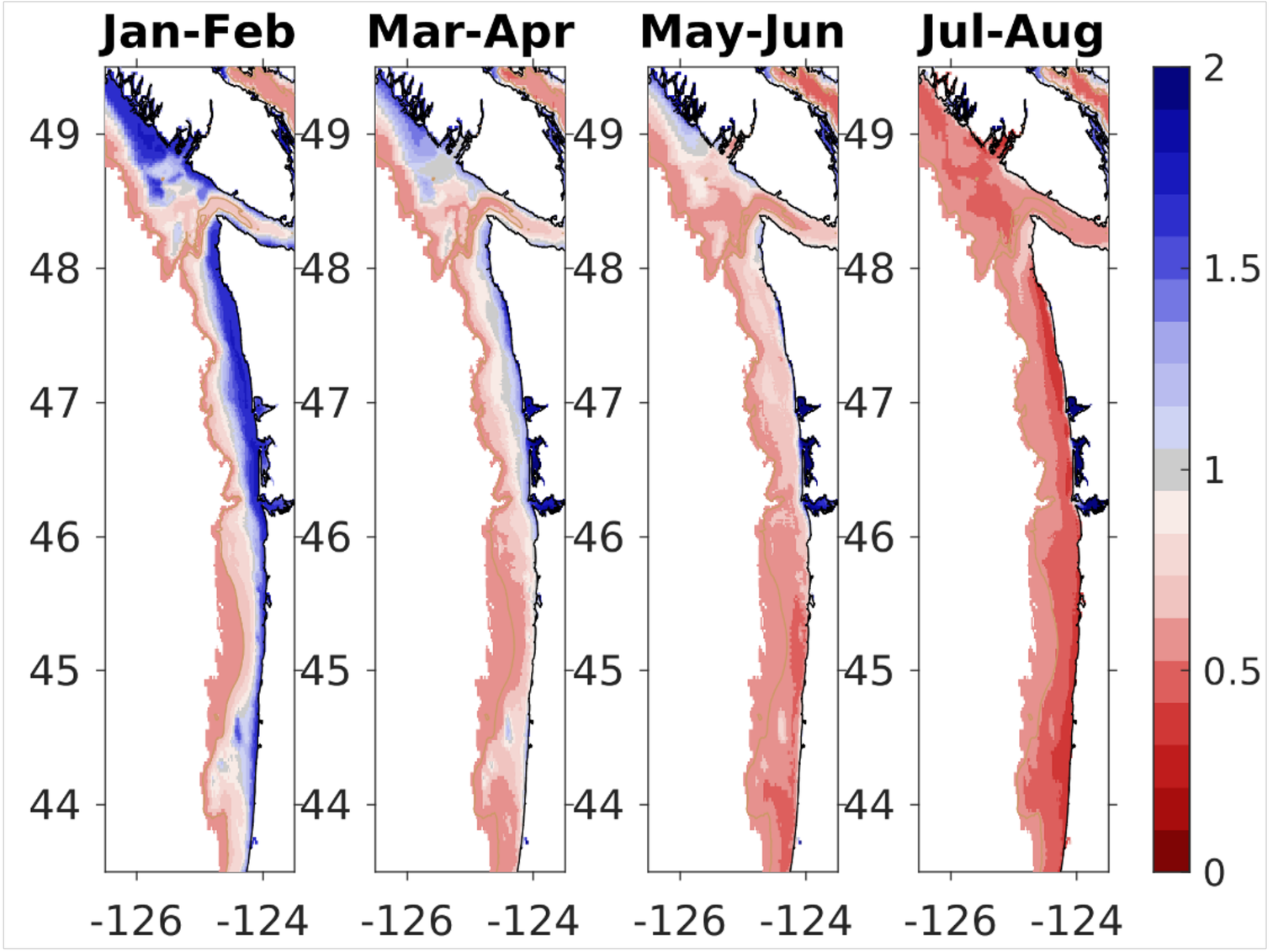


- January forecasts predict the onset of hypoxia ~10 days earlier than observed
- April forecasts predict the onset of hypoxia 1 day later than observed



PFMC Materials delivered every March since 2019

Jan 2021 forecast of aragonite (Ω) saturation state along the bottom



- Aragonite on the bottom is expected to be undersaturated (i.e., more corrosive) throughout the upwelling season for most of the bottom waters in the region except for shallow nearshore Washington shelves; surface waters are expected to be supersaturated throughout the season (see the website)

Ω<1 is corrosive

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

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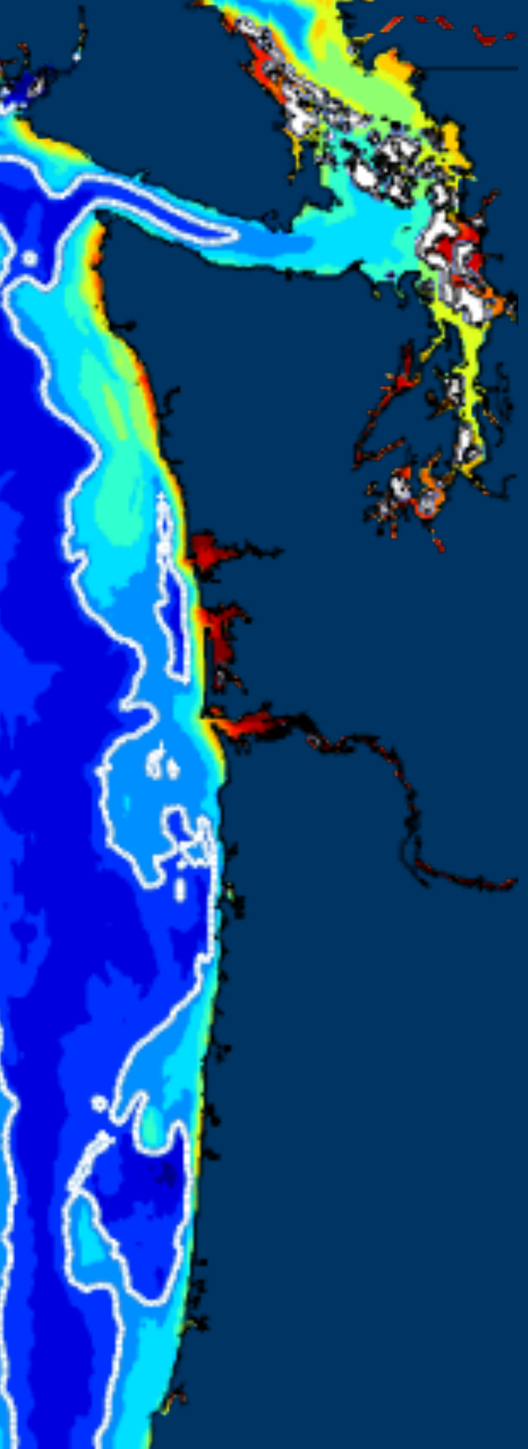


Continued evaluation and trust building - year in review

Year in Review

J-SCOPE

Home
Forecast
Year in Review
About the Model
Climatology
Model Performance
People
Publications
Partners
Disclaimer
Contact

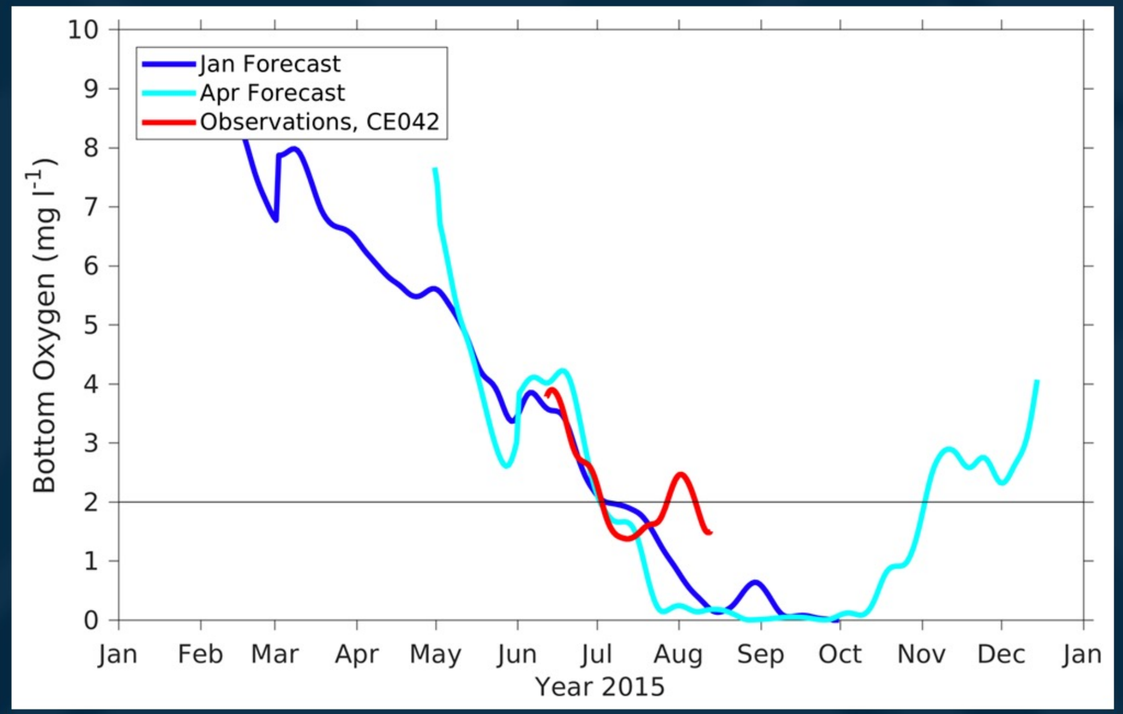
Year in Review

2013 2014 2015 2016 2017 2018

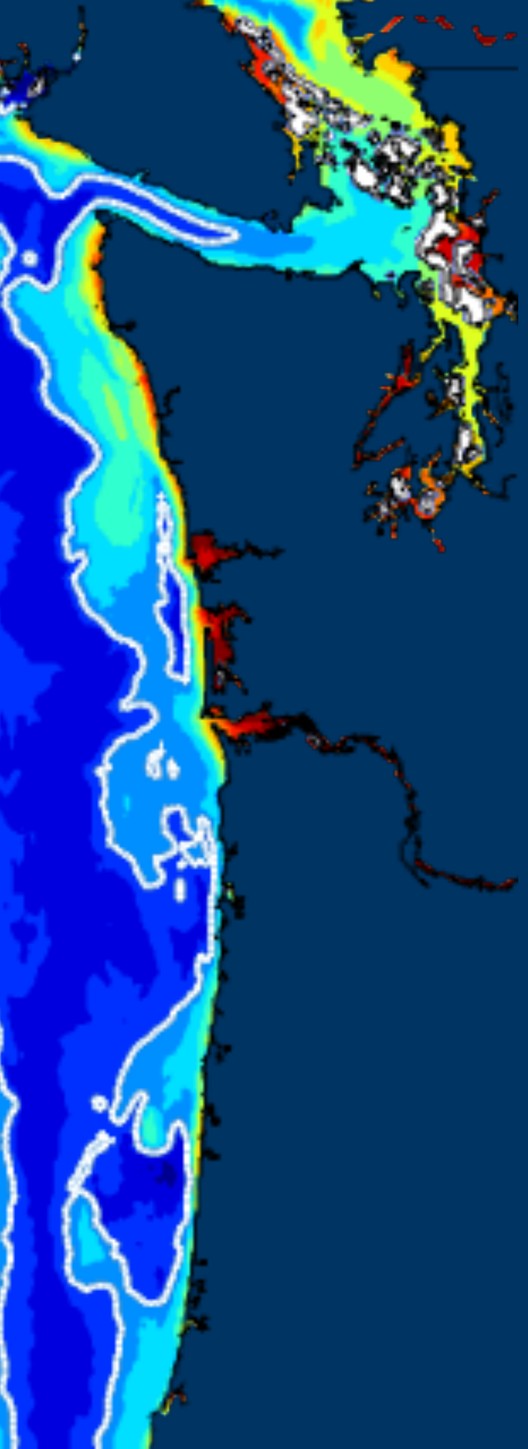
Sea Surface Temperature | Oxygen | CA Current Indicators | Profiles

At the Cape Elizabeth OCNMS mooring in 42 meters of water (~47°N), the forecasts predicted the onset of hypoxic conditions (<2 mg oxygen / L) very closely to what was observed. The April forecast predicted hypoxia for more than 8 consecutive days be
while the January forecast predicted hypoxia beginning on July 4. This location observed hypoxia beginning on July 2. The forecast predicted the location would remain hypoxic and develop anoxia in late July through mid-October. The observations show
probably remained hypoxic but likely never went anoxic.

Oxygen forecasts compared to the Cape Elizabeth 42-meter station observations.

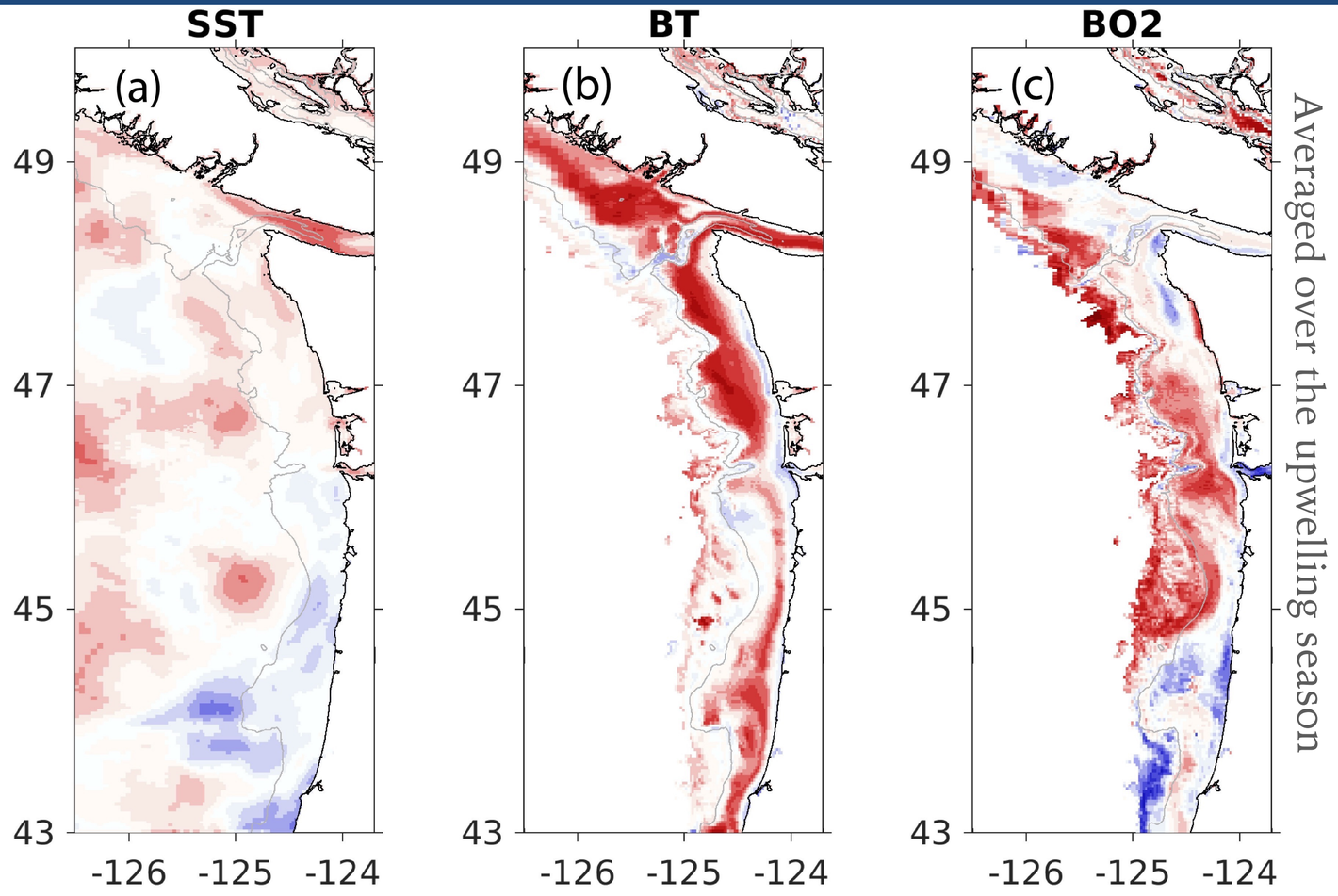


The emergence of anoxia in the model in late summer is caused by a bias associated with the lack of relaxations in the winds (found to be important in a paper by Adams et al, 2013) in the Climate Forecast System input files as well as a bias in the shortwave radiation (see 2013, Year in Review). The model does have skill in predicting the emergence and severity of hypoxia, while it is biased low for these reasons. Given the difficulty in predicting the fall transition in prior forecasts (see 2013, Year in Review), the forecast for low oxygen levels forecast well into August is highly uncertain.



Predictability - a different skill measure
Stakeholders want to know we know why it works

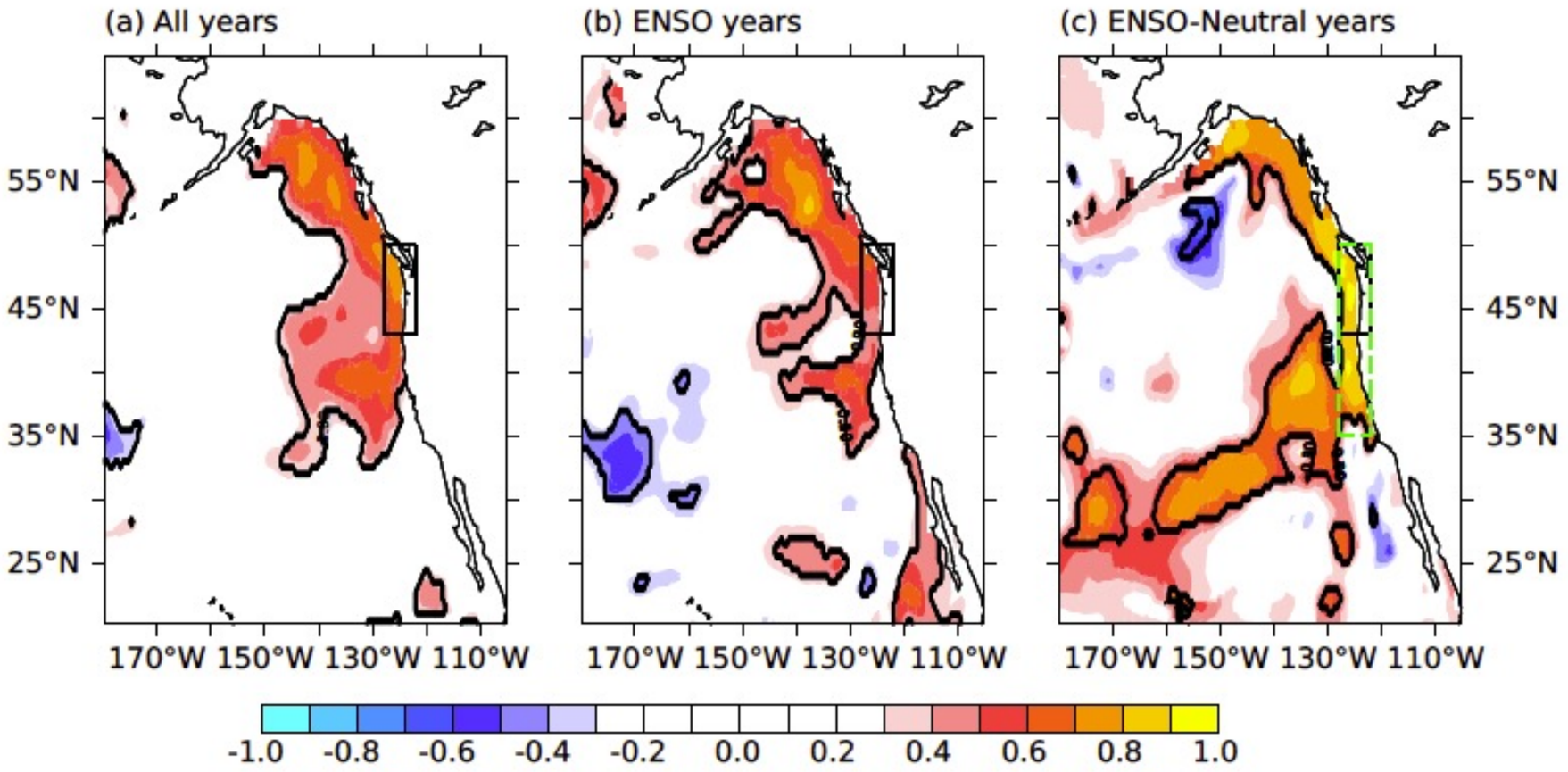
J-SCOPE Forecasts show ocean conditions are predictable on seasonal timescales

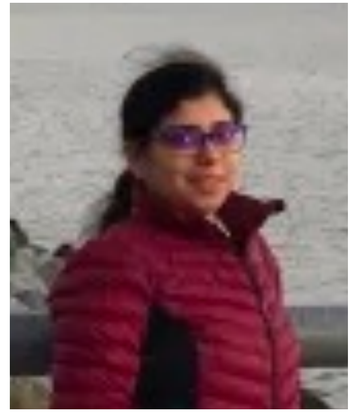


Check out our website:
http://www.nanoos.org/products/j-scope/home.php

Siedlecki et al., 2016

CFS indicates summer subsurface temperatures are highly correlated to the subsurface temperatures the winter prior - this is stronger in neutral years





Correlations of MJJ averaged summer N-CCS temperature at depth to prior OND averaged temperature along 26.4 from CFSR 1979-2017 for (a) all years (b) ENSO years (18); and (c) ENSO-Neutral years (12).

Ray et al., in review

Experiments with Seasonal Forecasts of ocean conditions in the Pacific Northwest to aid the crab fishery

Samantha Siedlecki

Principal Investigators: Isaac Kaplan (NOAA NWFSC), Nicholas Bond (JISAO, UW) Al Hermann (JISAO, UW), Jan Newton (APL, UW), Mike Alexander (NOAA/PSL), Simone Alin (NOAA PMEL)

Postdoc - Sulagna Ray

Advisory Council: Joe Schumacker (Quinault Department of Fisheries), Dan Ayers (Washington Department of Fish and Wildlife), Kelly Corbett (Oregon Dept Fish and Wildlife)

Dungeness crab: West Coast economic powerhouse

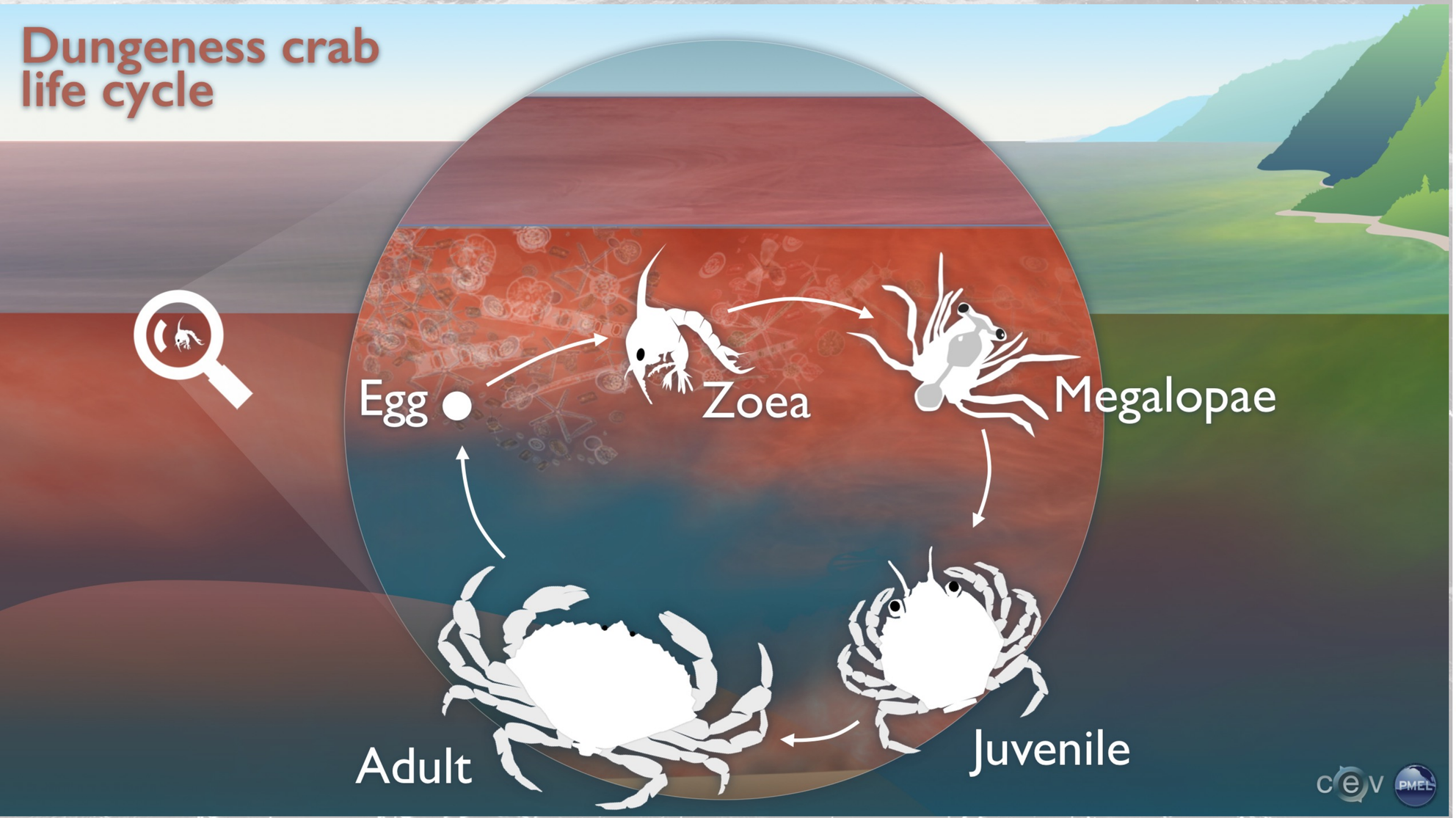


Figure by Simone Alin and Hunter Hadaway (CEV)

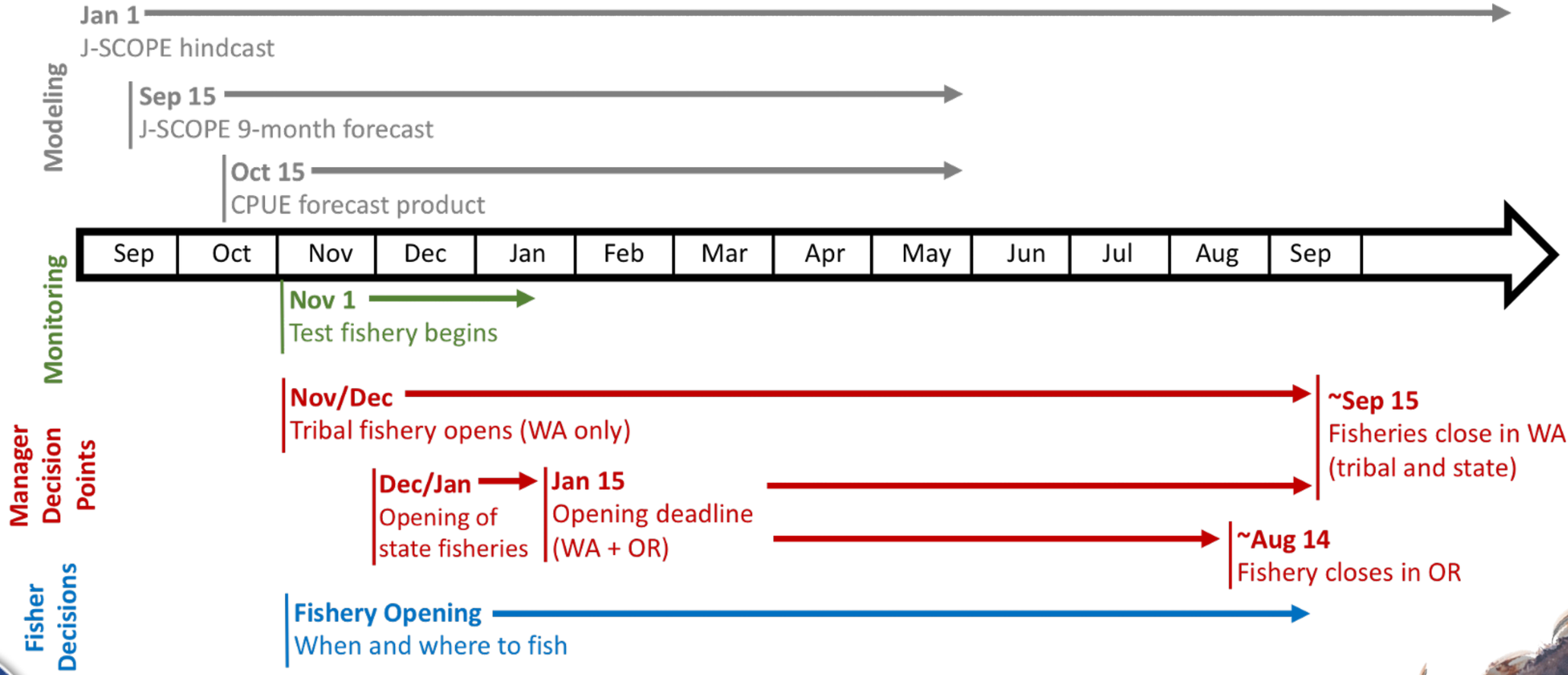
TABLE 5. Commercial landings[1] for most economically valuable fisheries on the US West Coast (California, Oregon, Washington) from 2003 to 2012.[2] Gray shaded entries represent invertebrates with some calcium carbonate hard parts.

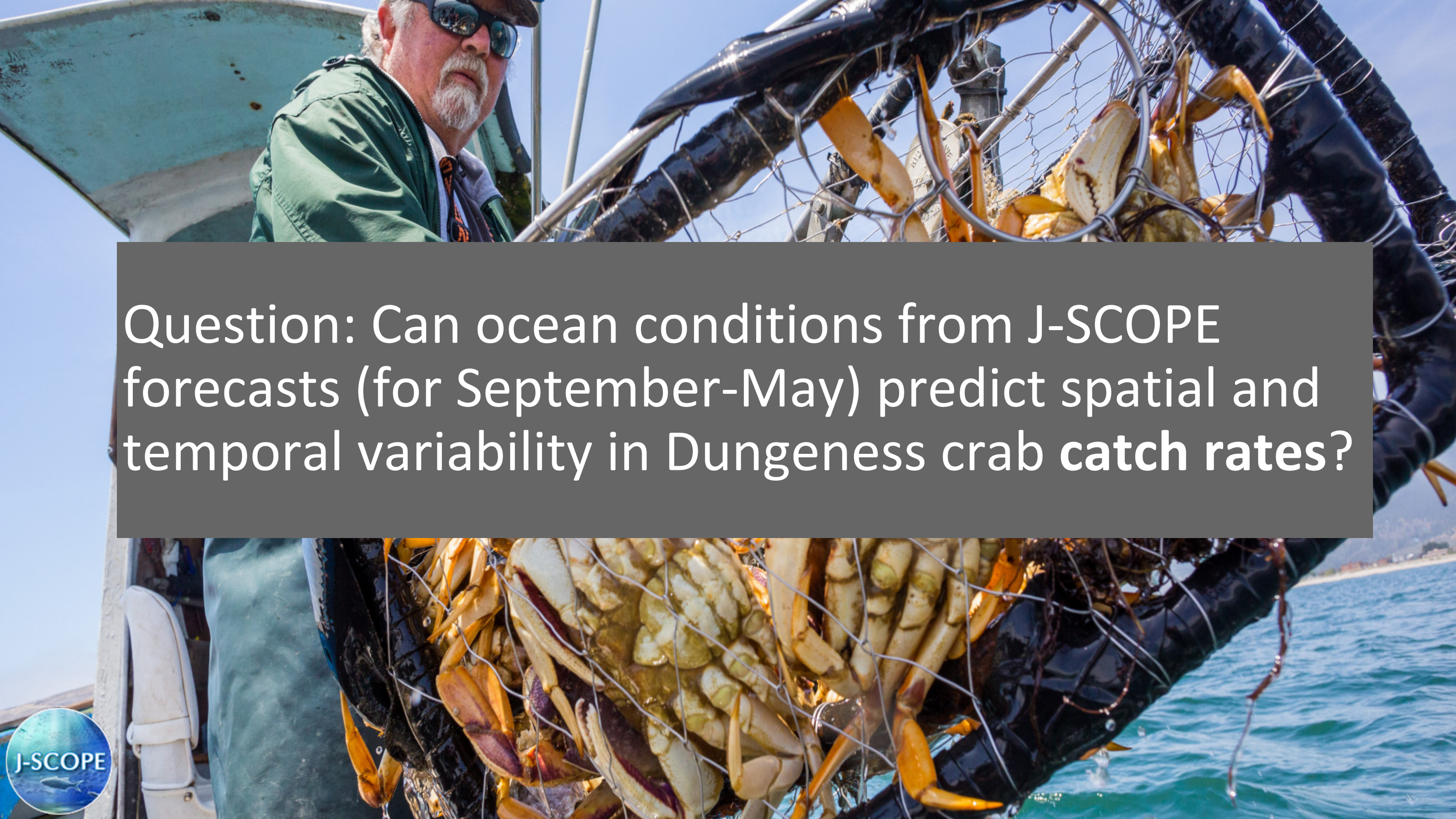
Species	Total value (2003–2012)
Dungeness crab	$1,312,233,926
California market squid	$417,528,455
Pacific oyster	$411,768,620
Pacific geoduck clam	$400,817,096
Pacific hake (whiting)	$334,971,917
Albacore tuna	$291,808,355
Sablefish	$271,104,039
Chinook salmon	$220,238,947
Manila clam	$199,346,707
Ocean shrimp	$152,899,359
Pacific sardine	$120,332,152
California spiny lobster	$86,553,611
Dover sole	$68,031,185
Sea urchin	$75,240,059

[1] Note: This database does not include the value of all aquaculture or of non-commercial tribal or recreational fisheries.
[2] Source: http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index.

Alin et al. Oceanography 2015

Dungeness crab state and tribal decisions





Question: Can ocean conditions from J-SCOPE forecasts (for September-May) predict spatial and temporal variability in Dungeness crab **catch rates**?

What to add to our Dungeness crab catch model?

"S"

"D"

"L"

1a. Fishing behavior

Pelagic

2. Dynamic oceanography

3. Lagged conditions - temp, oxygen, chlorophyll

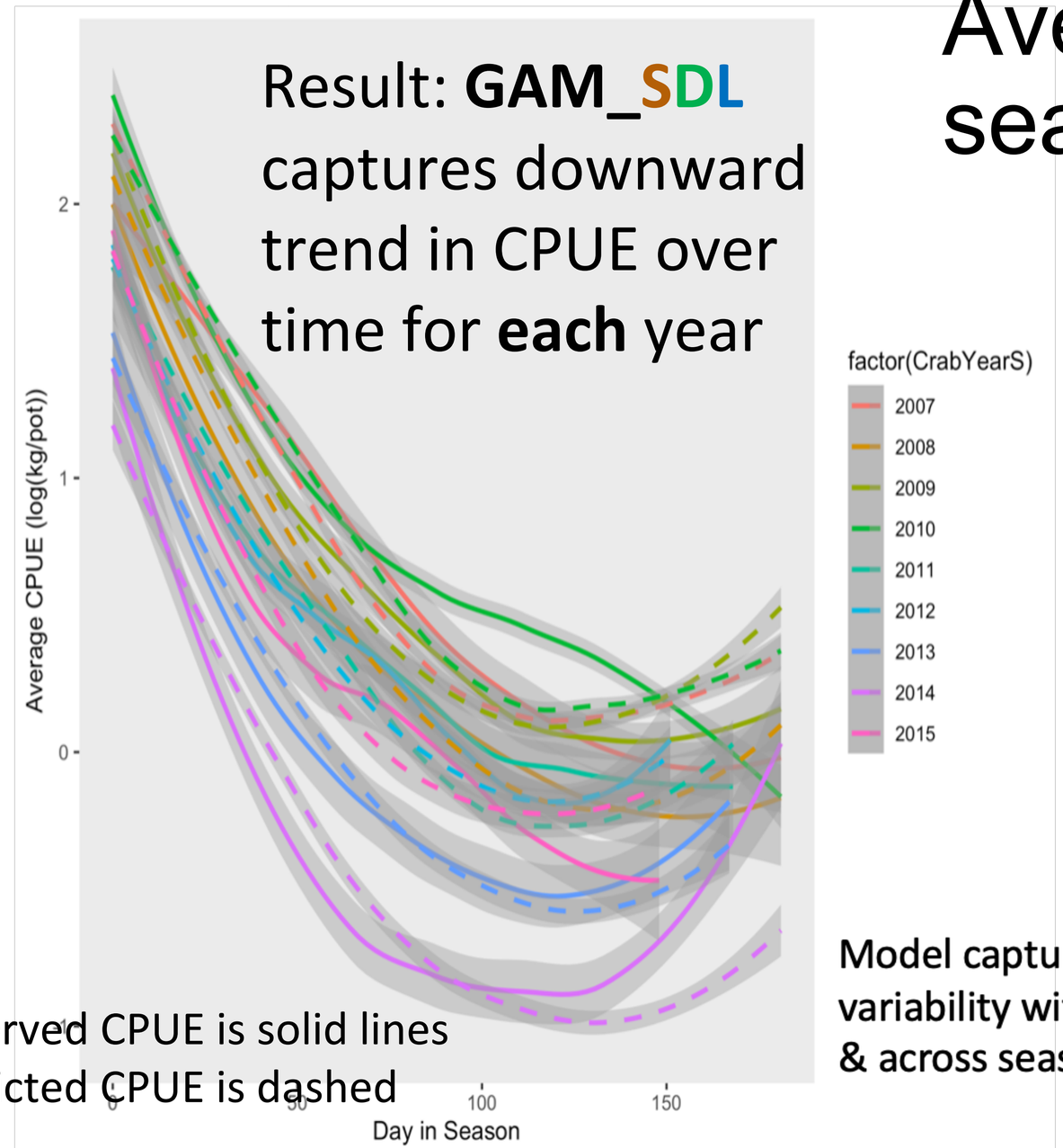
1b. Static environment

Benthic

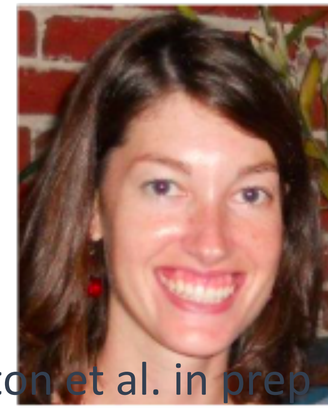
Adult (4-5 yrs old)

Research Scientist at UW: Emily Norton

Average CPUE versus day in season for each year



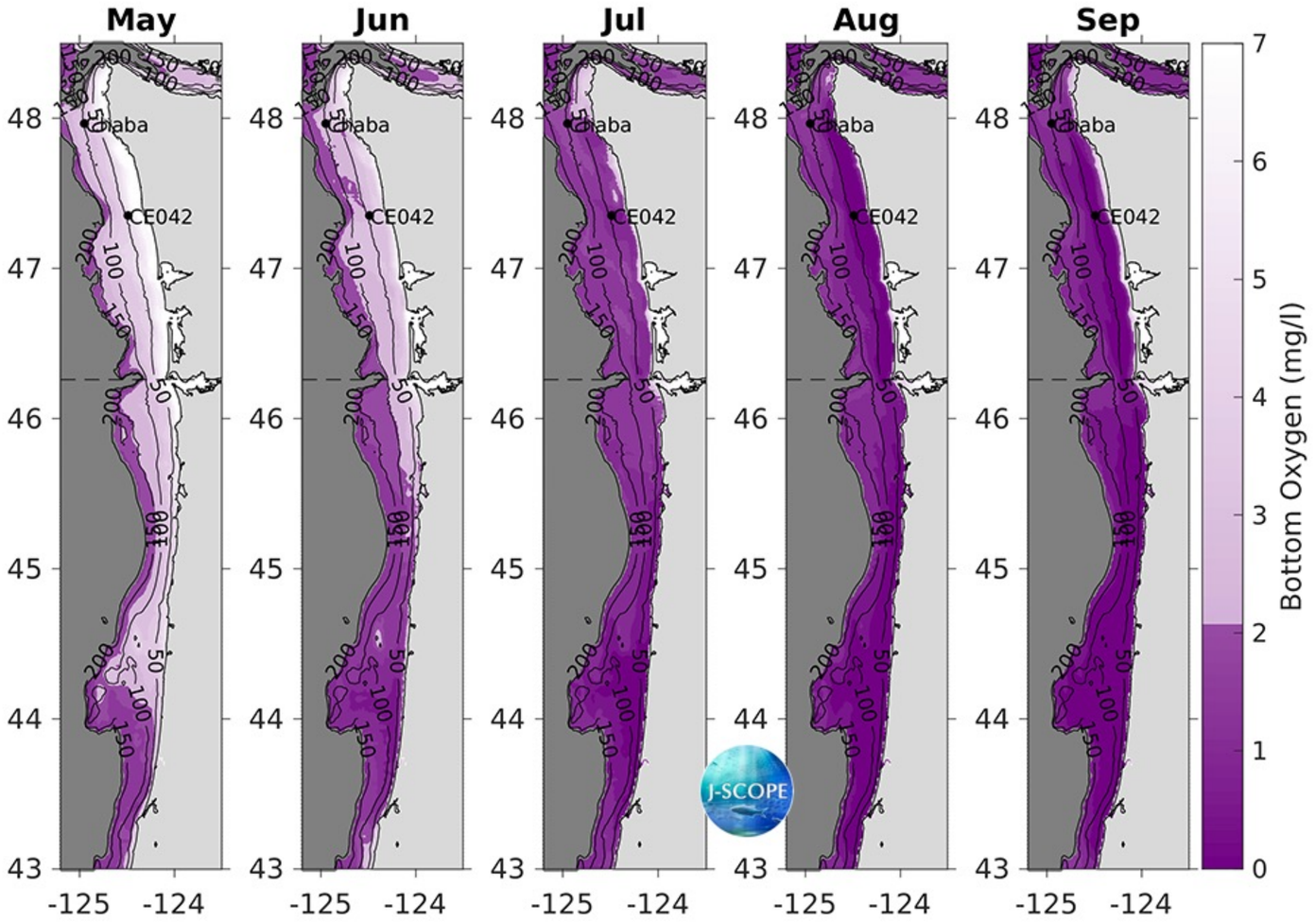
- **Ocean conditions are important drivers of interannual variability in crab catch** because the inclusion of dynamic and lagged ocean conditions, in addition to static conditions, generated the model with the best fit (i.e. lowest AIC)
- The **model skillfully reforecasts crab catch patterns** in space and time
- However, improved **forecasts of fishing behavior are necessary to provide true forecasts of crab catch**



Research Scientist at UW: Emily Norton

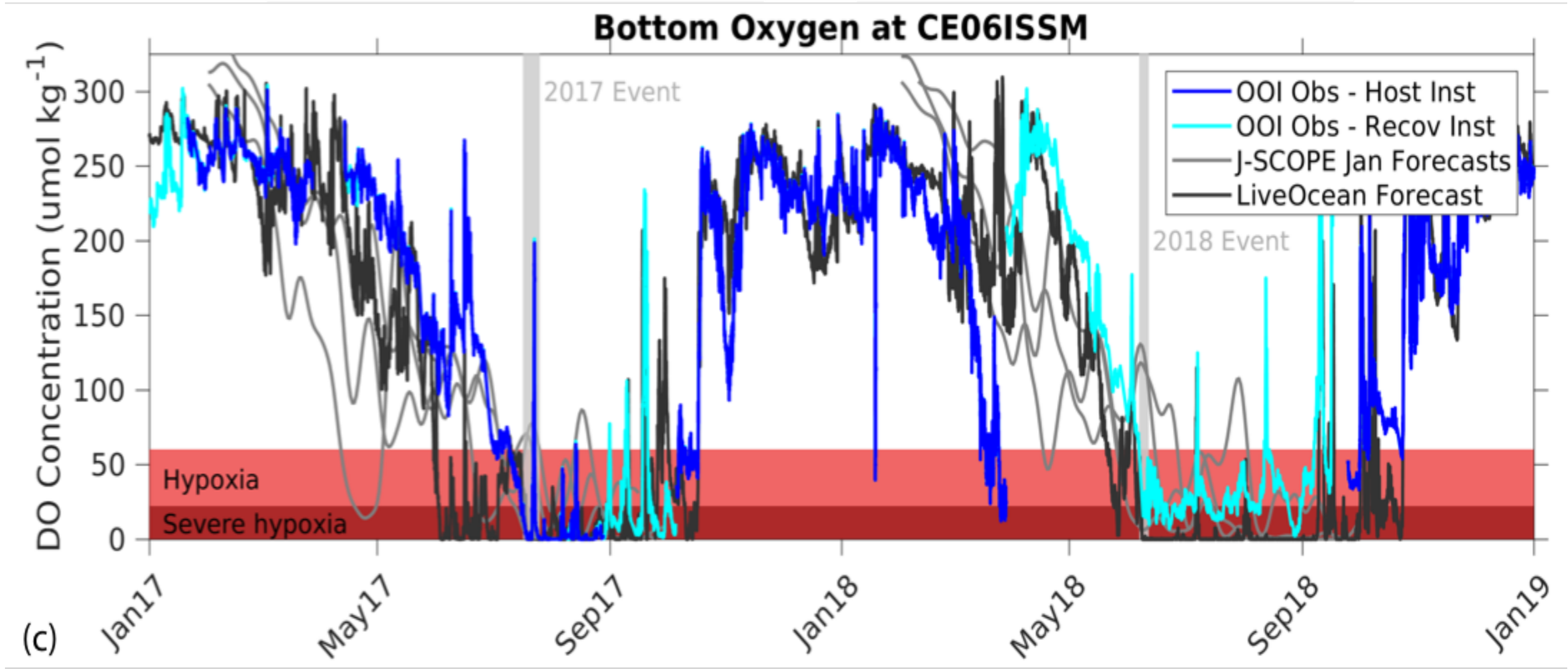
Norton et al. in prep

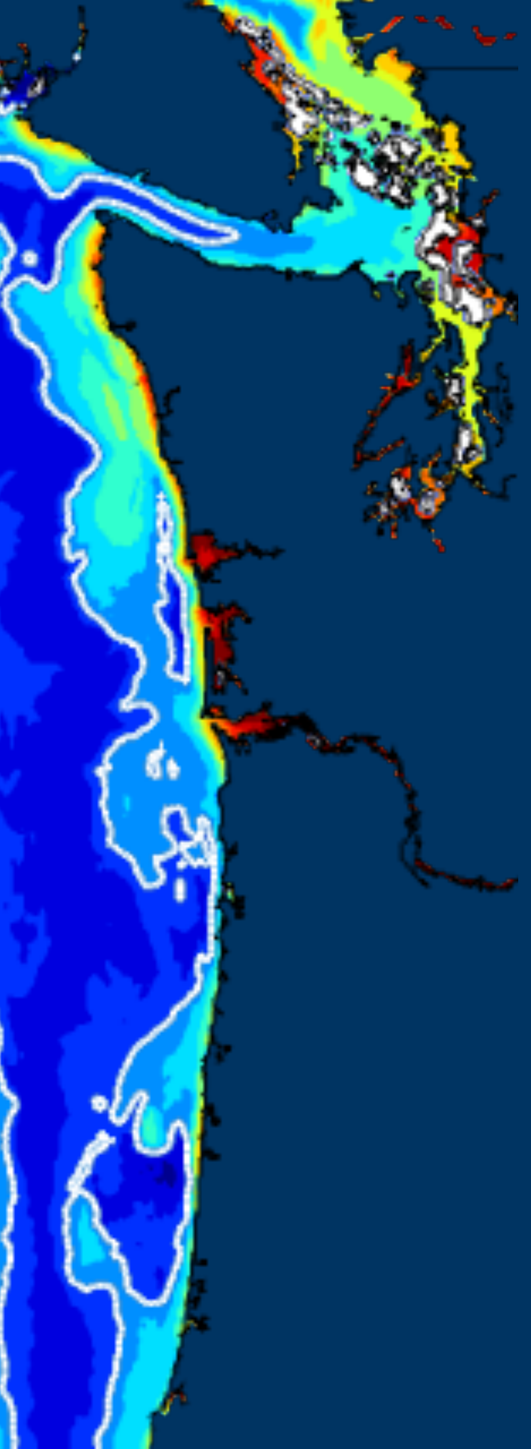
Dungeness crab state and tribal co-designed products targeting summer hypoxia



Management Decision Point - Crabs and O_2

The Quinault Indian Nation did take management action based on observations and J-SCOPE forecasts to close the 2018 fishery early due to recurring hypoxic conditions in the summer.





Key Takeaways

- J-SCOPE forecast products Co-developed with and used by Washington Department of Fish and Wildlife and Quinault Indian Nation resource managers as well as the NOAA NWFSC and Integrated Ecosystem Assessment partners
- Predictability and performance testing suggest best skill for bottom conditions - preliminary results indicate mainly during ENSO neutral years
- Bottom conditions include both temperature and saturation state – directed our habitat toward benthic species - both variables to crabs
- J-SCOPE forecasts ocean conditions already included in the Ecosystem Status report and presented to the Pacific Fishery Management Council
- **Ocean conditions are important drivers of interannual variability in crab catch**
- The model skillfully reforecasts crab catch patterns in space and time. However, improved forecasts of fishing behavior are necessary to provide true forecasts of crab catch
- Through iterative collaborative conversations with regional managers -both state and tribal - proactive adaptive strategies informed by robust science can be established, prioritized, and implemented to aid management in sustaining marine resources

Acknowledgements

Funding for J-SCOPE provided by NOAA Fisheries And The Environment (FATE) program and NOAA OAP and NOAA MAPP

For More Information

Please contact me at
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or check out our website:
http://www.nanoos.org/products/j-scope/