CONNECTING STAKEHOLDERS TO ECOSYSTEM CHANGE WITH ECOLOGICAL FORECAST MODELS IN THE CALIFORNIA CURRENT SYSTEM

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Monterey Bay Aquarium Research Institute

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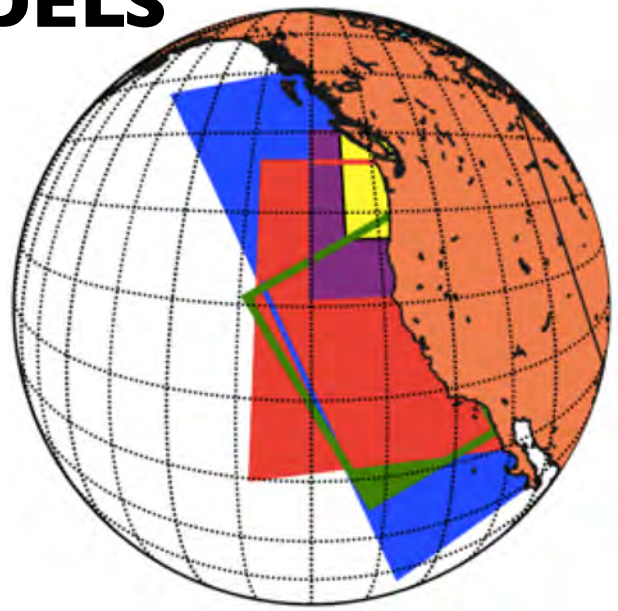
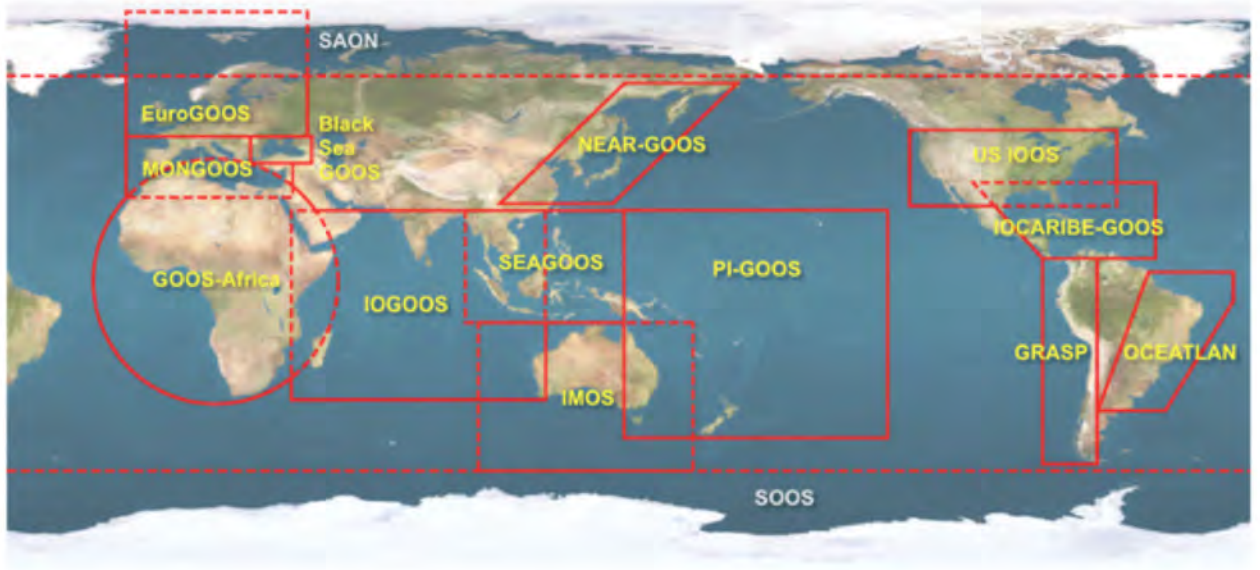
Northwest Association of Networked Ocean Observing Systems

University of Washington



NOAA Integrated Ocean Observing System (IOOS) Coastal Ocean Modeling Testbed: ROMS domains on the west coast: WCOFS, UCSC, CA, OSU, LiveOcean (UW). Despite considerable domain overlap, important differences exist between models in terms of resolution, forcing, biogeochemistry and data assimilation

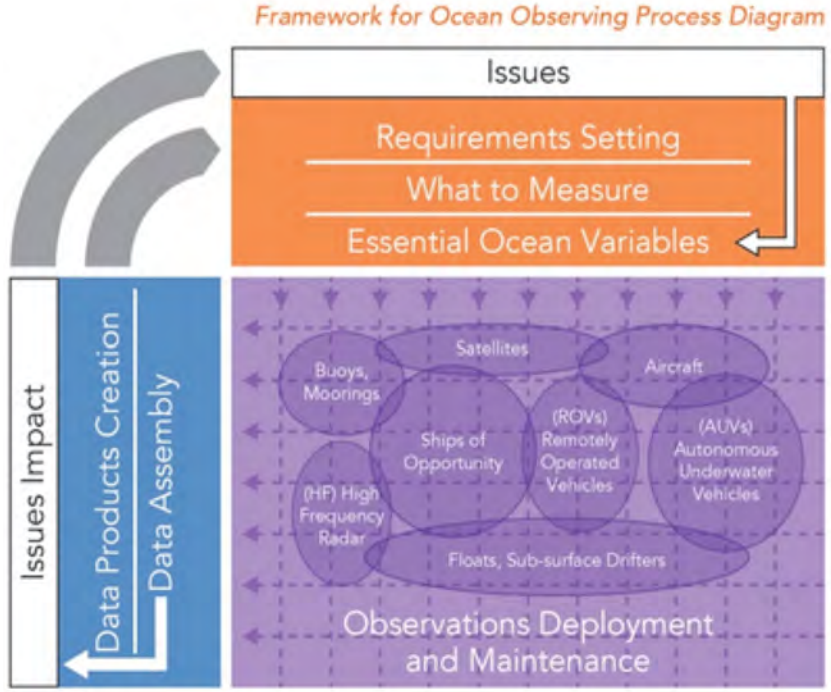
Global Ocean Observing System (GOOS)



GOOS Regional Alliances (GRAs)

GRAs are coalitions of nations and/or institutions which share GOOS principles and goals, but are mostly concerned with local priorities and organized around regional seas or coastal environments. Thirteen GRAs represent different regions of the globe, emphasizing regional priorities, differing by need, resources and culture.

GOOS utilizes the Framework for Ocean Observing to guide its implementation of an integrated and sustained ocean observing system. This systems approach, designed to be flexible and to adapt to evolving scientific, technological and societal needs, helps deliver an ocean observing system with maximized user base and societal impact.



Transforming data for the public and decision-makers

The Global Ocean Observing System
GOOS

IOOS
Integrated Ocean Observing System

CONSISTENT NATIONAL CAPABILITY

assure

Regional Associations

engage

Observations

Data Management

Forecasts/Modeling

User Products

Outreach and Education

Leverage and Link

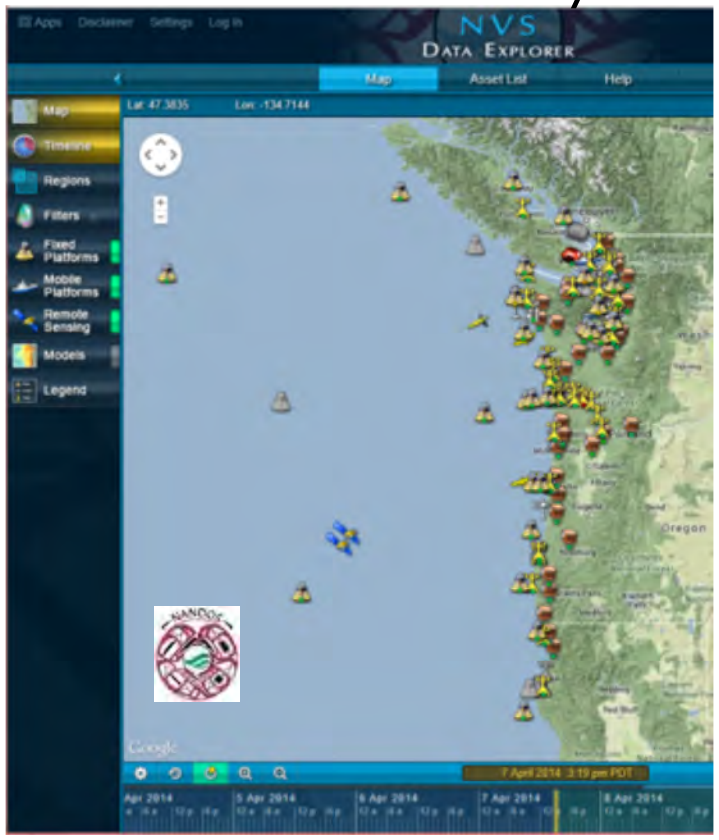
REGIONAL INFORMATION COORDINATION ENTITY
CERTIFIED

DIVERSE LOCAL STAKEHOLDERS

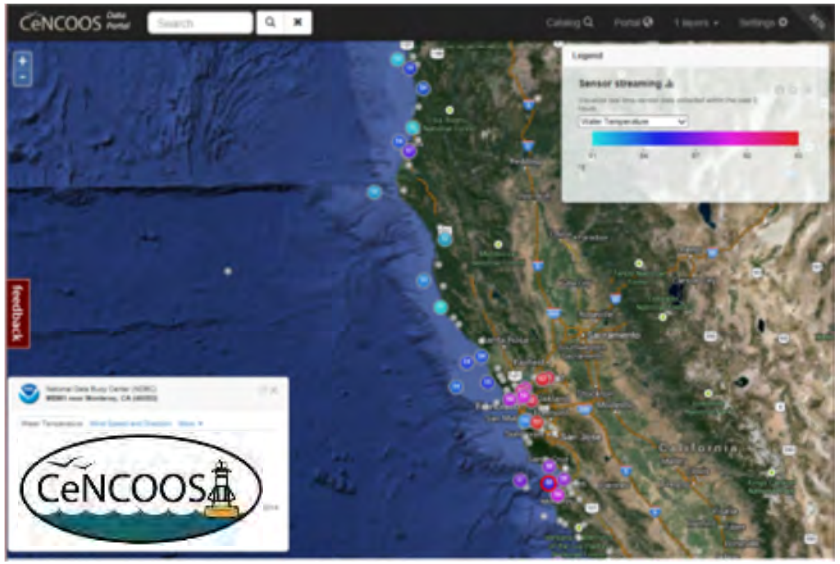
Each IOOS region supports sustained ocean observing programs

Regional data portals are the gateway to data, ecological forecasts, and derived products

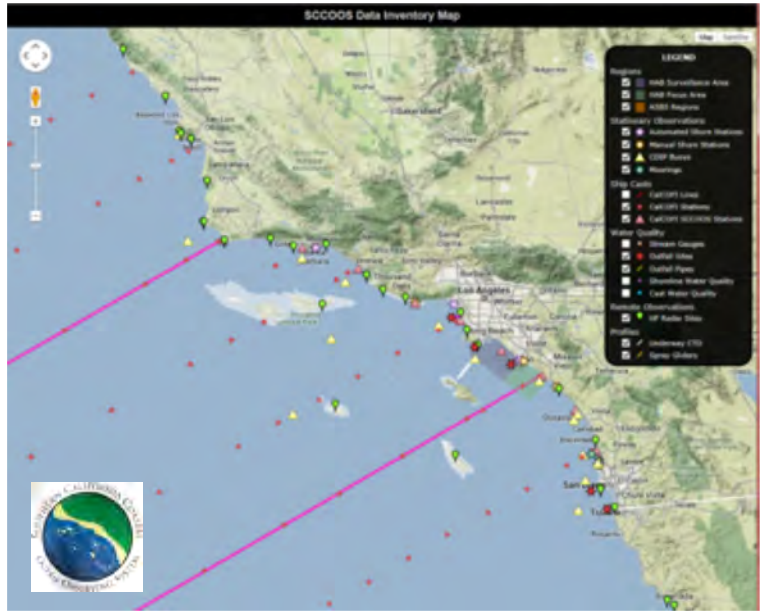
NANOOS Visualization System



CeNCOOS Data Portal



SCCOOS Data Portal

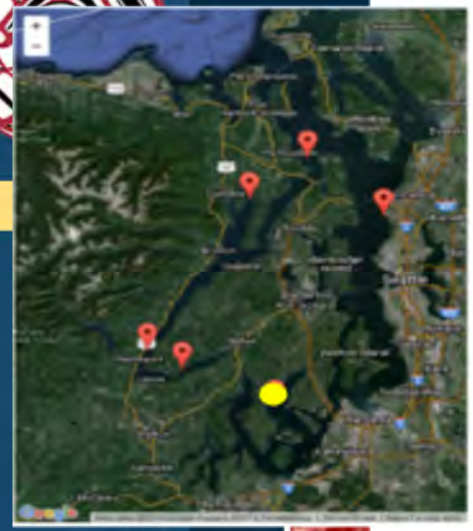


…and all are interoperable with U.S. IOOS,
thus filling regional and national needs

IOOS

CERTIFIED

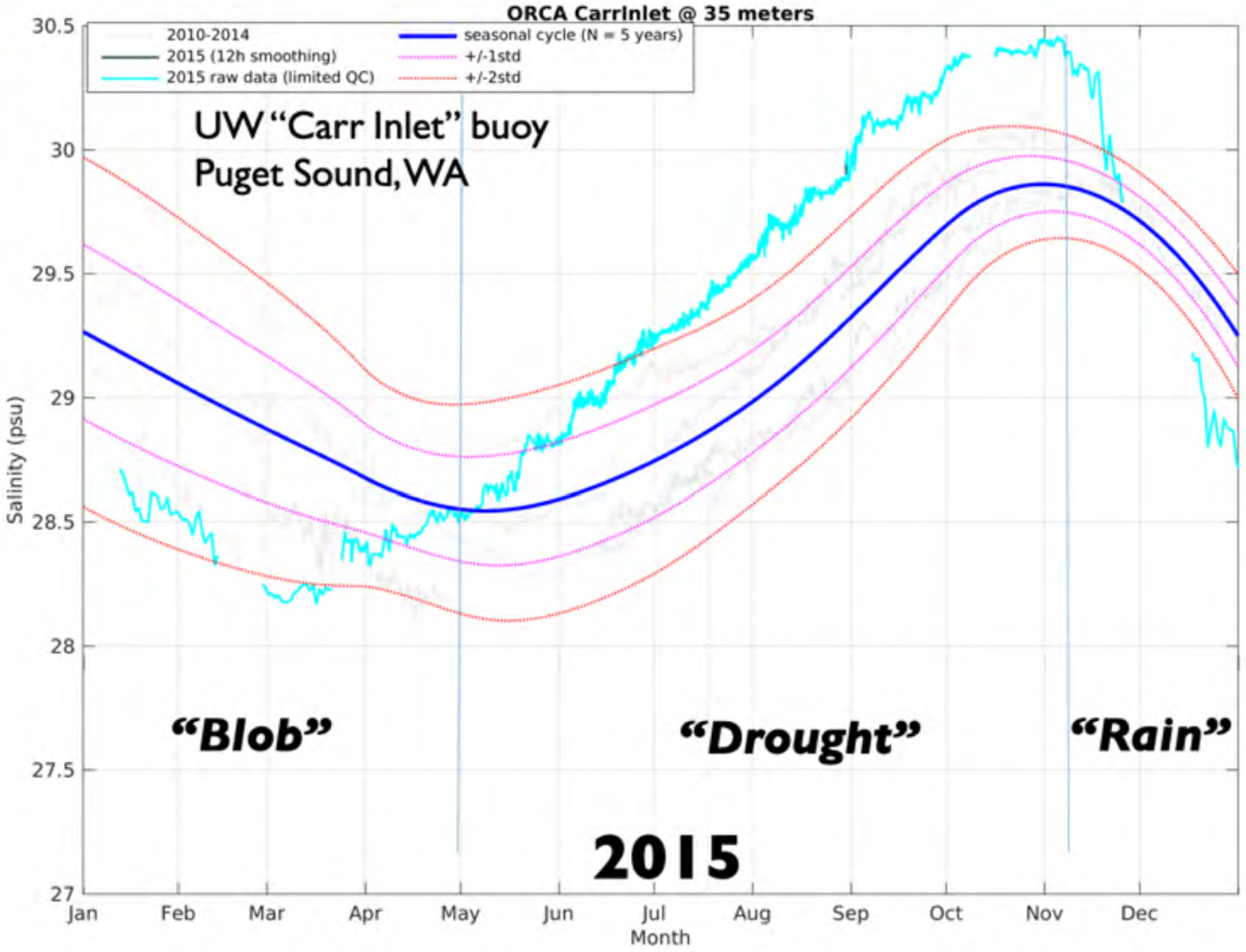
NANOOS



NVS
Products

Education
Resources
Merchandise

Log In
New Account



Observing extreme events with autonomous underwater vehicles

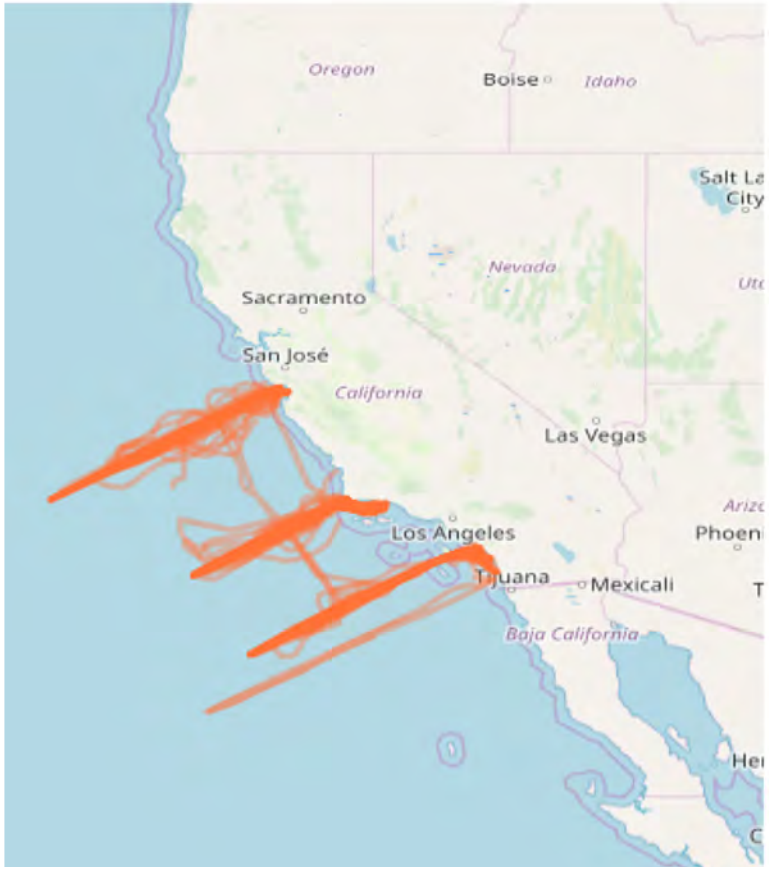
operational Spray glider lines in California – SCCOOS + CeNCOOS

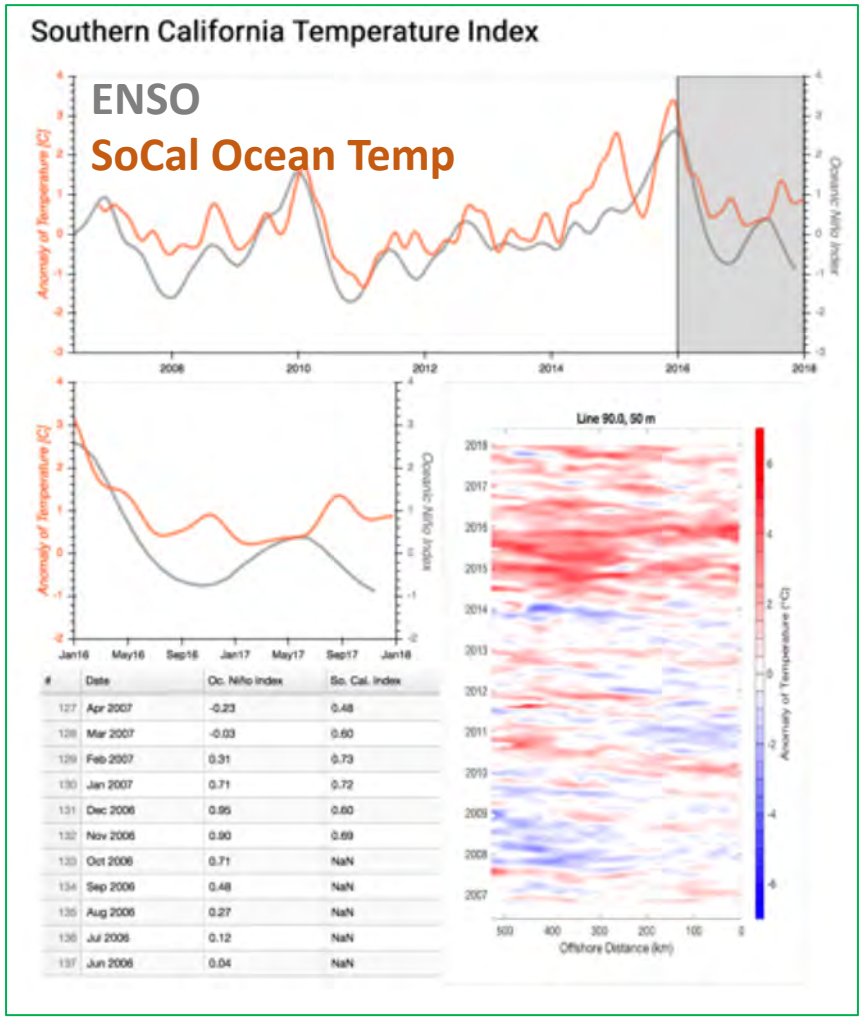
Spray Glider

California Underwater Glider Network

Longest sustained glider lines in the world

PI: Dan Rudnick





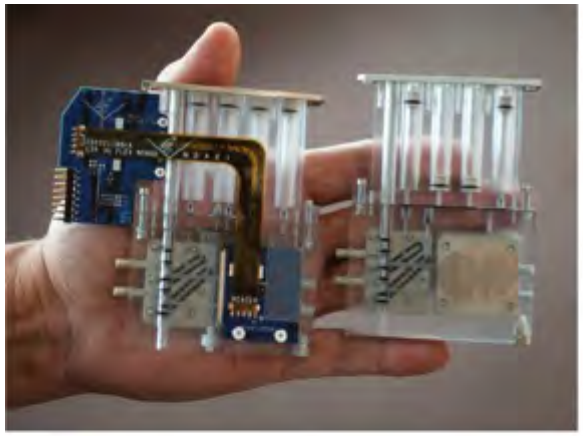
https://spraydata.ucsd.edu/SoCal-index/

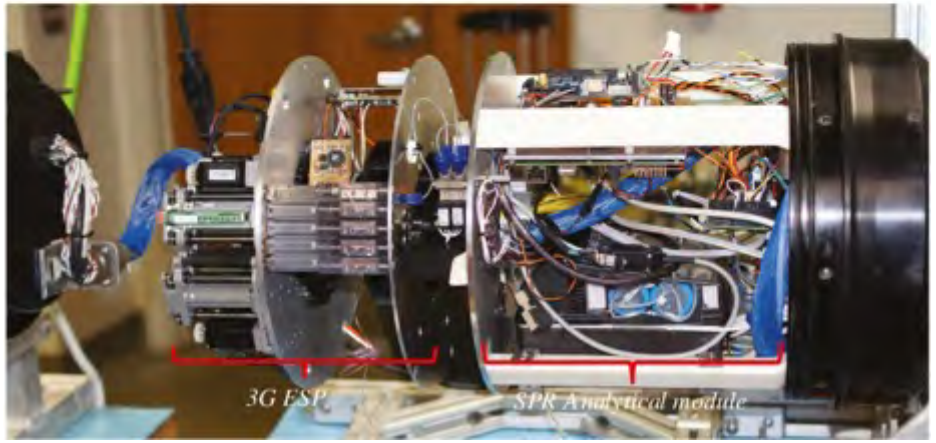
FY18 "Fill the Gaps" Funds

-added new alongshore glider line

MBON eDNA: The drive for automation

- Fleets of Long Range AUVs with Environmental Sample Processors (ESPs)
- A new window for observing life in the sea



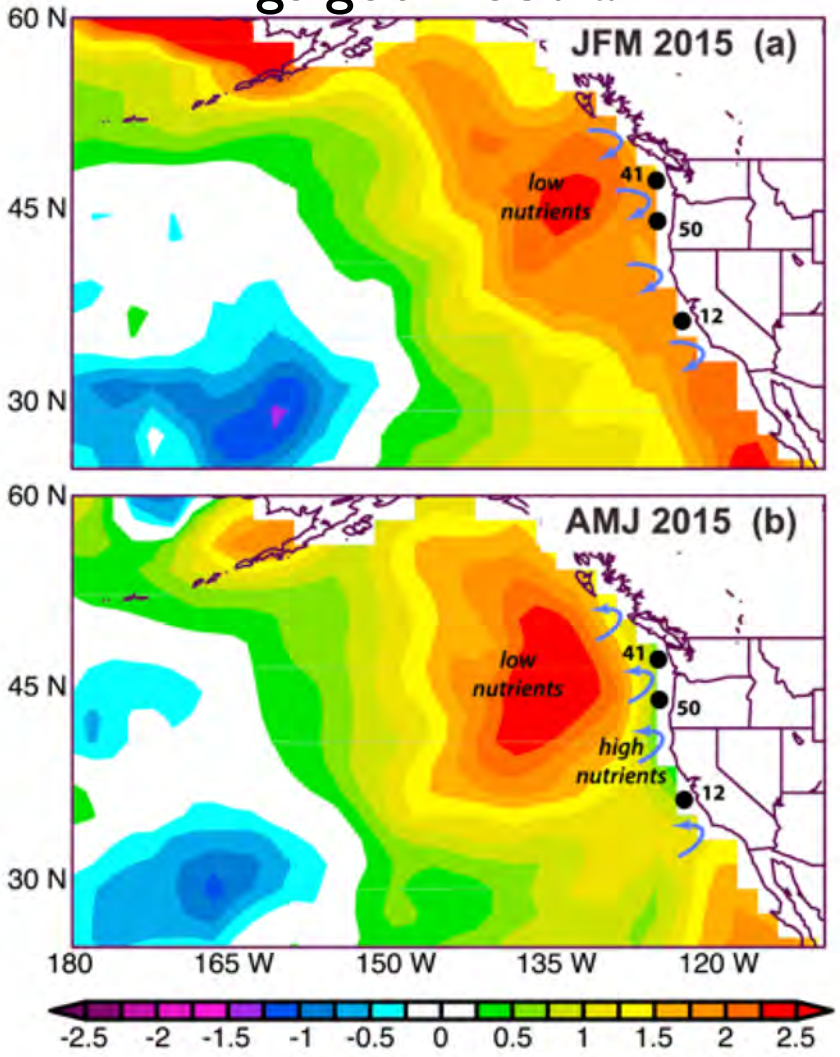


- 2,000 kilometers at one meter per second with primary batteries
- 300 m depth rating
- ANDe™ system that allows high-throughput eDNA sampling with minimal contamination
- 60 cartridges housing filters,
- 3G-ESP long-term, large scale *in situ* eDNA sample processing

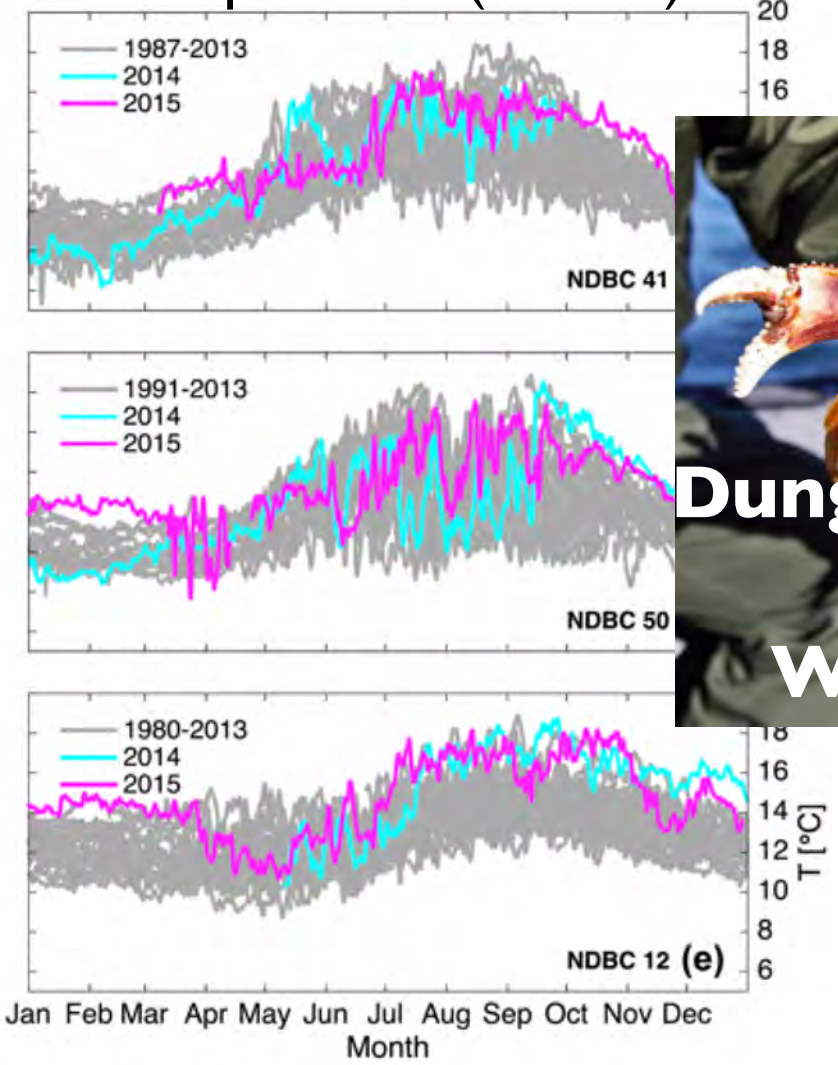
Ecosystem Impacts of Warm Blob on West Coast in 2015-2016

McCabe et al. *GRL* 2016

Things got Blobular



Temperature (NDBC)



Widespread Ecosystem Impacts!

IOOS
Integrated Ocean Observing System

CONSISTENT NATIONAL CAPABILITY

assure

Regional Associations

engage

Observations

Data Management

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User Products

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Leverage and Link

DIVERSE LOCAL STAKEHOLDERS

Challenge for Global Models: Resolving Coastal and Shelf Sea Physics

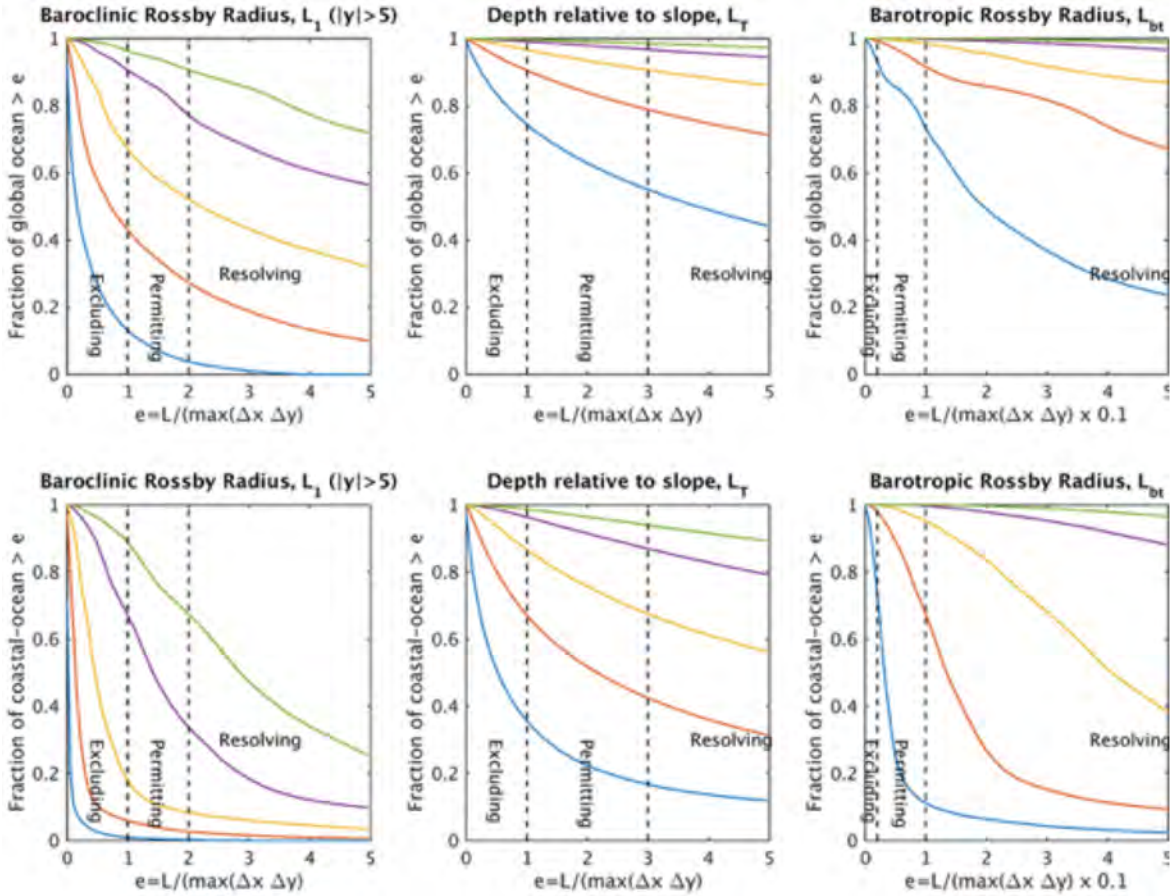


Figure 2. Cumulative distribution of the fraction of global (top) and coastal (bottom) ocean, resolving L_1, L_T, and L_{bt} for different global model resolutions.

L1 = front/frontal jet, coastal upwelling
L_T = topographic-steered barotropic current
L_{bt} = barotropic tide

River Scale, L_r

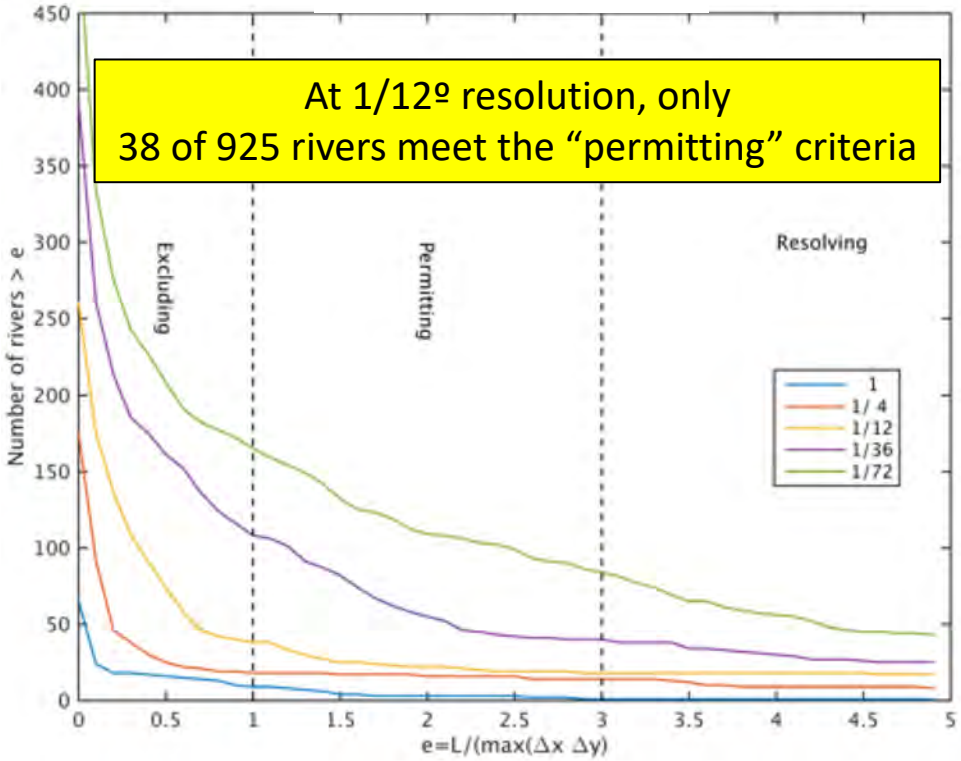


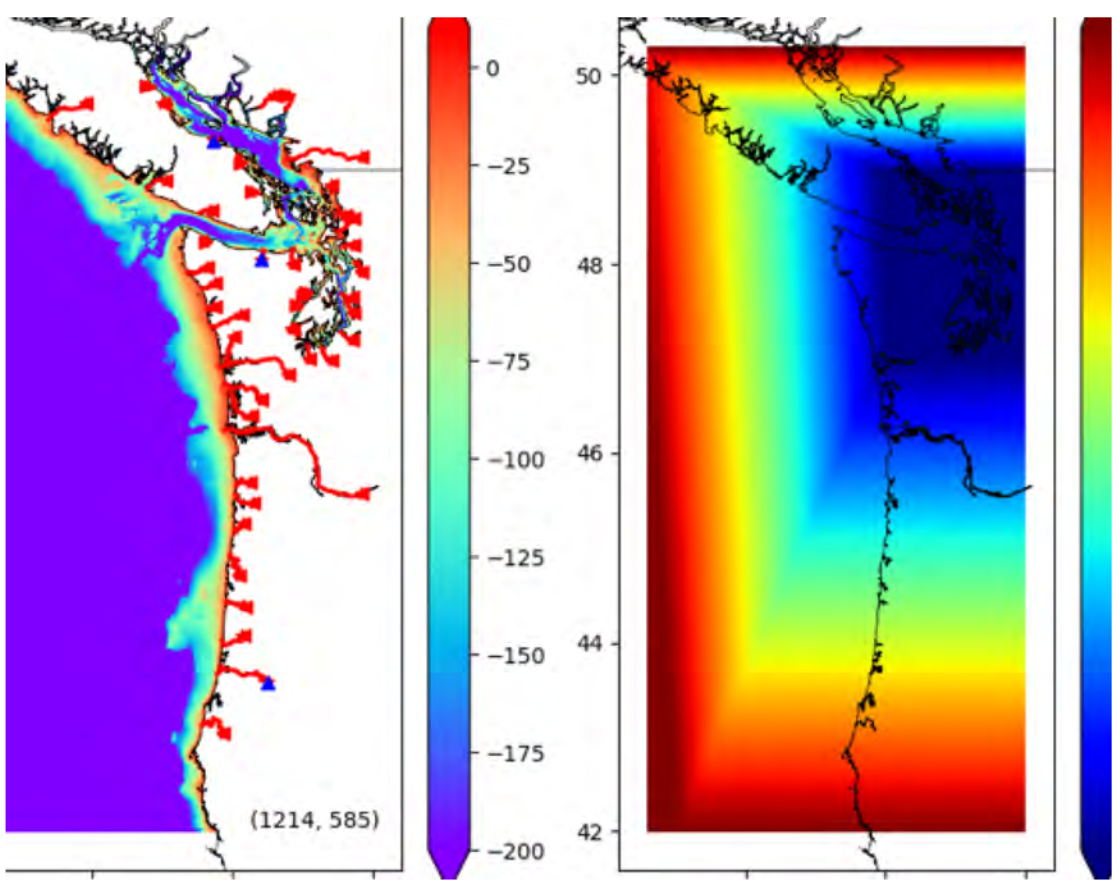
Figure 3. Cumulative distribution of number of rivers where scale L_r is resolved at a particular level (e). Based on flow data from the 925 largest ocean-flowing rivers globally (Dai et al. 2009).

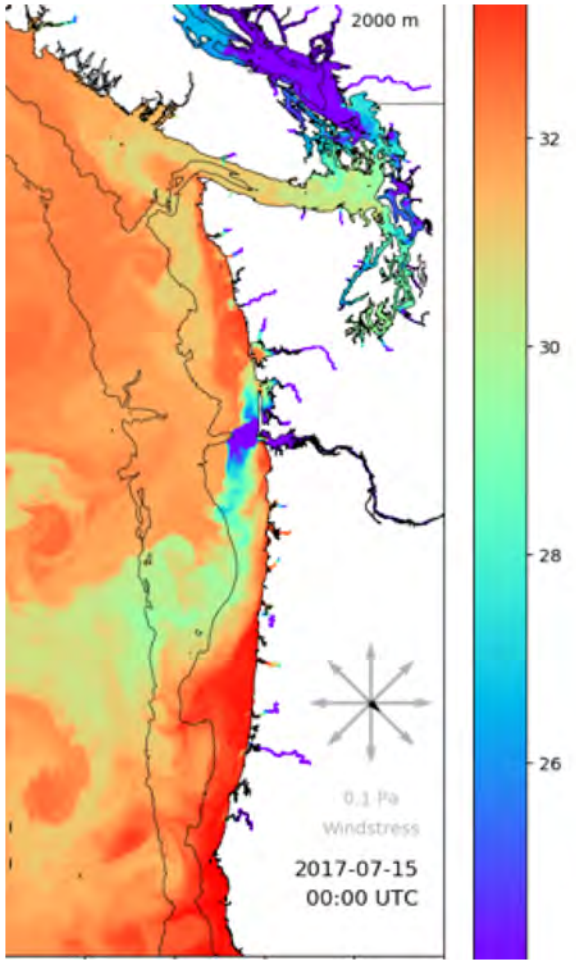
Holt et al. *Geosci. Model Dev.* (2017)

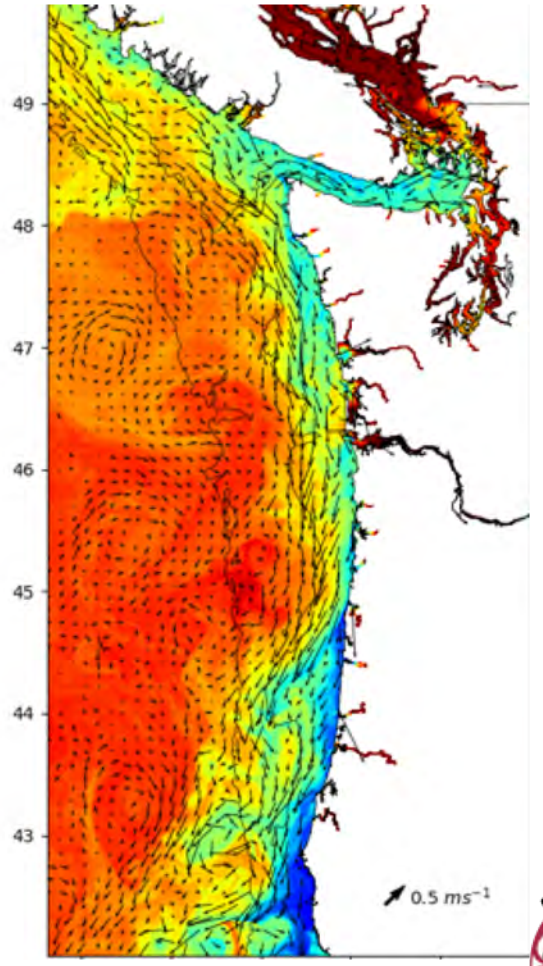
High(ish)-Resolution (Nested) Coupled Models

Pacific Northwest & Salish Sea *Live Ocean* Model (ROMS)

Parker MacCready, University of Washington





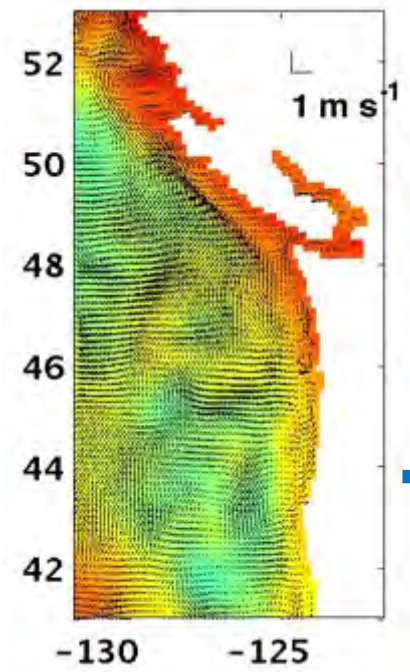


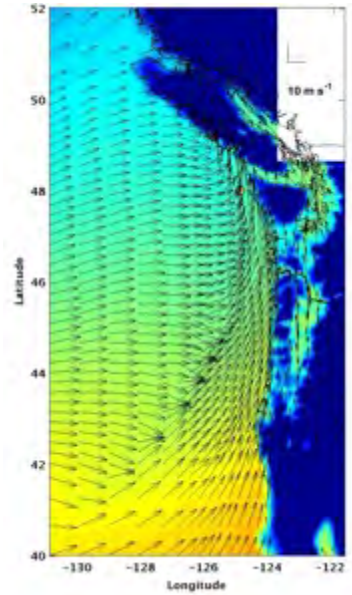
IOOS

NANOOS

Giddings et al. 2014; Davis et al. 2014, Seidlecki et al. 2015

LiveOcean Forcing and System Overview



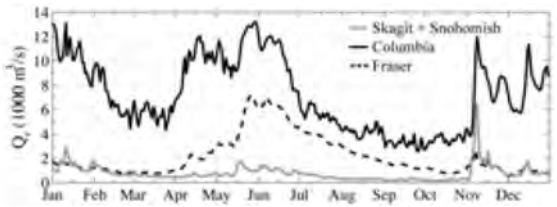


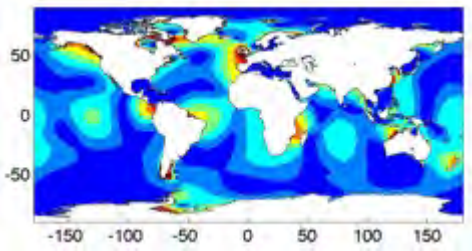
WRF Winds & Heating

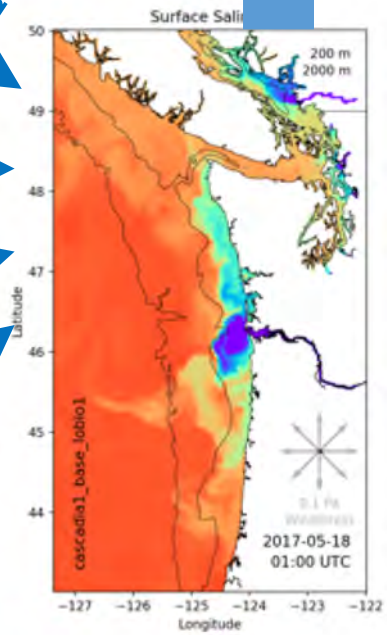
HYCOM Ocean Fields

USGS Rivers

TPXO Tides

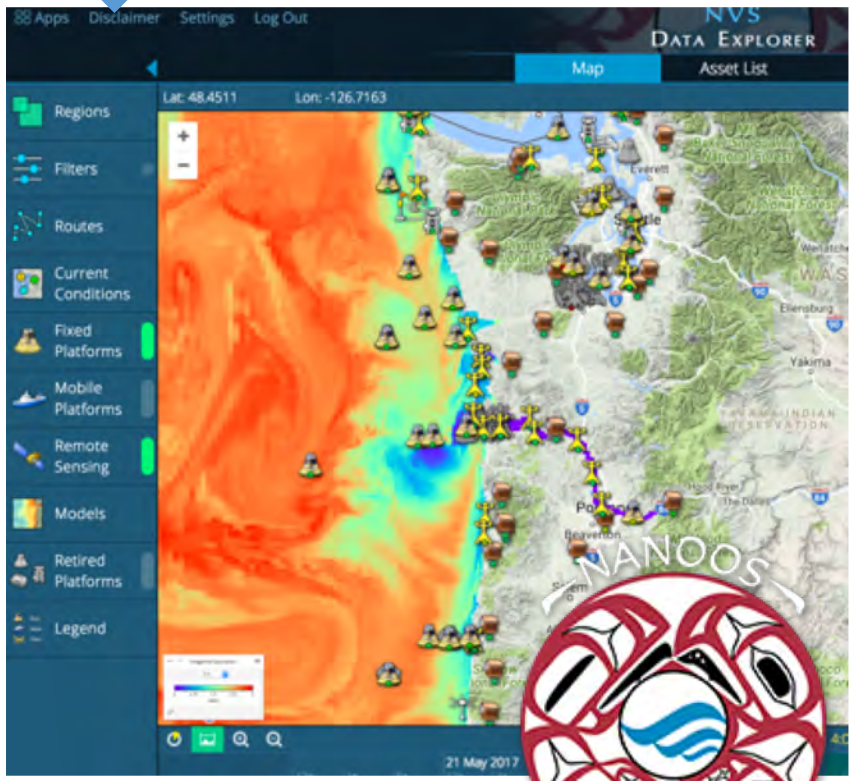






ROMS

3-Day forecast appears daily on NANOOS NVS



http://faculty.washington.edu/pmacc/LO/LiveOcean.html
http://nvs.nanoos.org/Explorer?action=overlay:liveocean_temp

J-SCOPE produces 6-9 month seasonal forecasts of physical conditions, Chl-*a*, O_2, pH, MLD, plankton, and Ω (PI Samantha Seidlecki)

J-SCOPE

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

Forecast Origin Dates

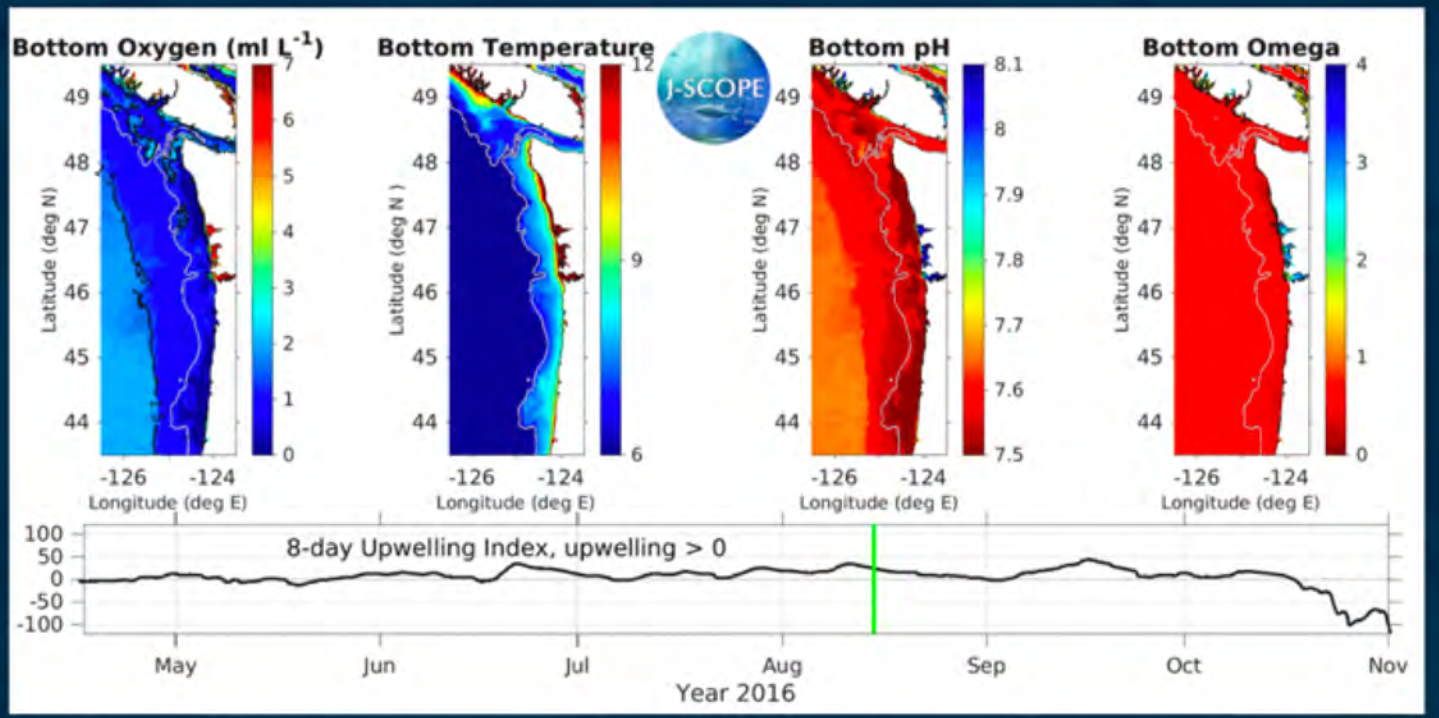
Jan 2019 | Apr 2018 | Jan 2018 | Apr 2017 | Jan 2017 | Apr 2016 | Jan 2016 | Apr 2015 | Jan 2015 | Apr 2014 | Apr 2013 | Jan 2013

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

Overview

The J-SCOPE forecast system for Washington and Oregon coastal waters presents preliminary results for the ocean acidification conditions during the 2016 upwelling season. The forecast for 2016 is composed of three model runs that make up an ensemble. Each model run is initialized at a different time (April 5, April 15, April 25), and has complementary forcing files from the large scale model CFS.

The forecasts simulate conditions in 2016 with a full carbon model (included DIC and TA). The TA and DIC fields are then used to calculate Ω using CO2sys.



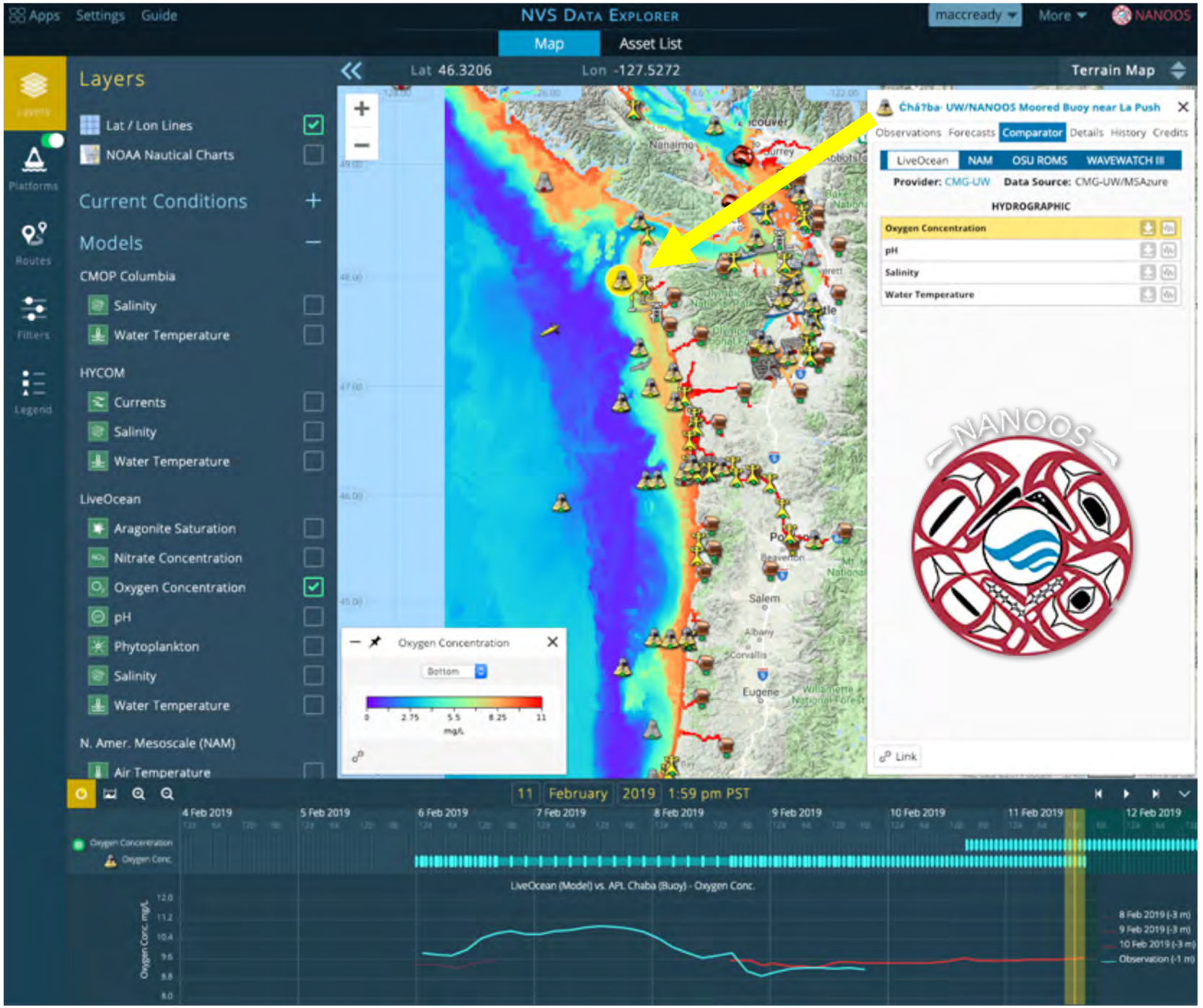
The movie above shows the J-SCOPE forecast for 2016, from ensemble model run #2 initialized on April 15. The 8-day upwelling index is calculated using the method described in Austin and Barth (2002) and can also be found under the California Current

LiveOcean Bottom Oxygen in the NANOOS NVS

The "Comparator" allows real-time comparison with observations

nvs.nanoos.org/Explorer

Seidlecki et al. 2015



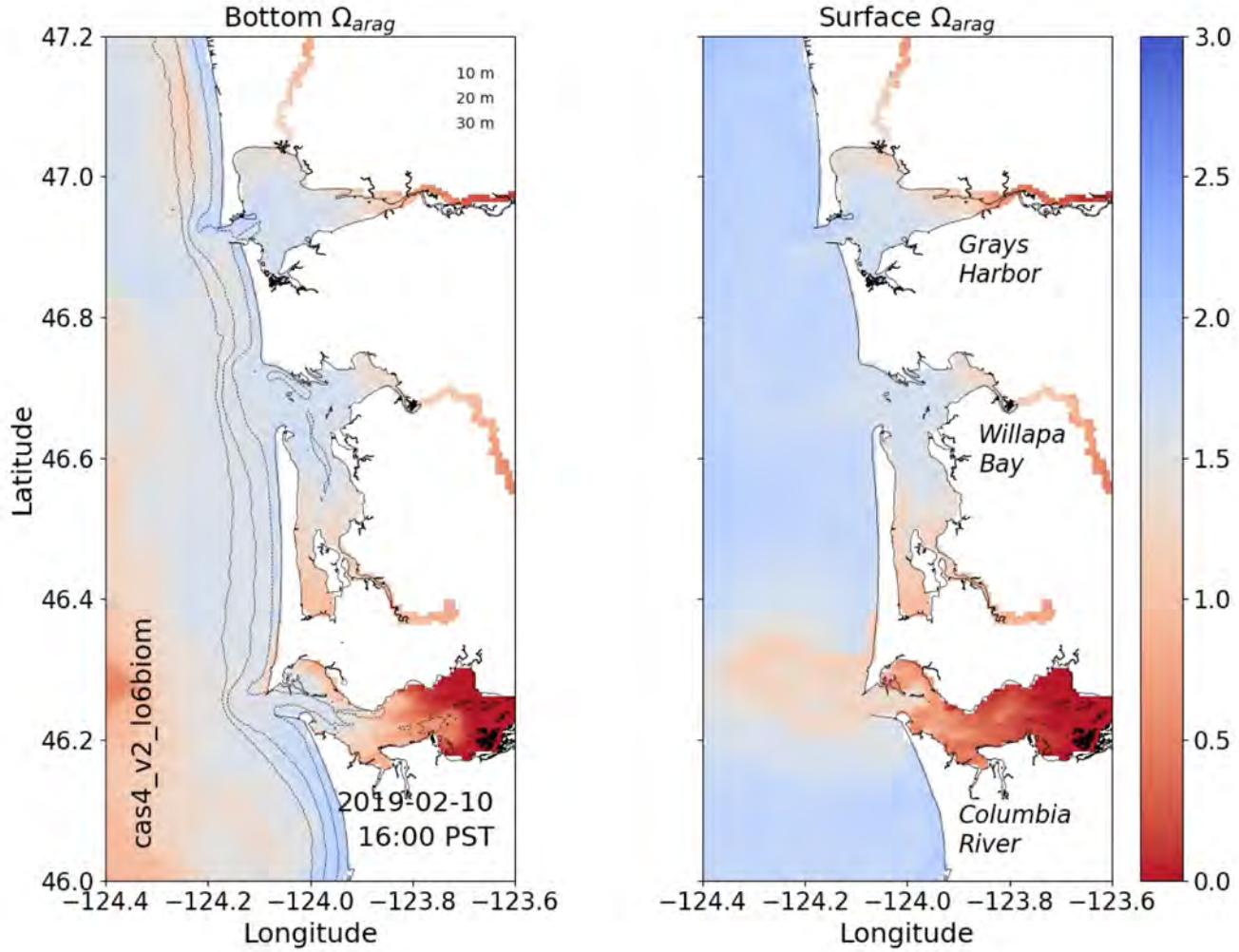
APPLICATION to STAKEHOLDERS:

Forecast of corrosive water due to Ocean Acidification that harms shellfish aquaculture (WOAC)

The annual value of the shellfish industry in Washington State is $108 million.

One in eight oysters consumed in the US comes from Willapa Bay.

Often larval oysters in Willapa Bay do not survive – due to Ocean Acidification.

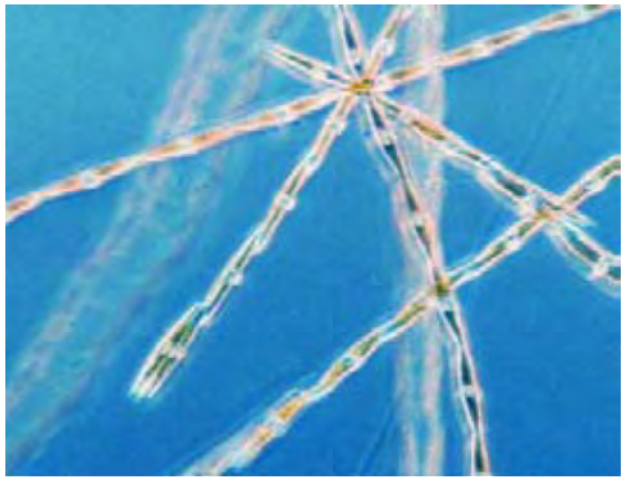


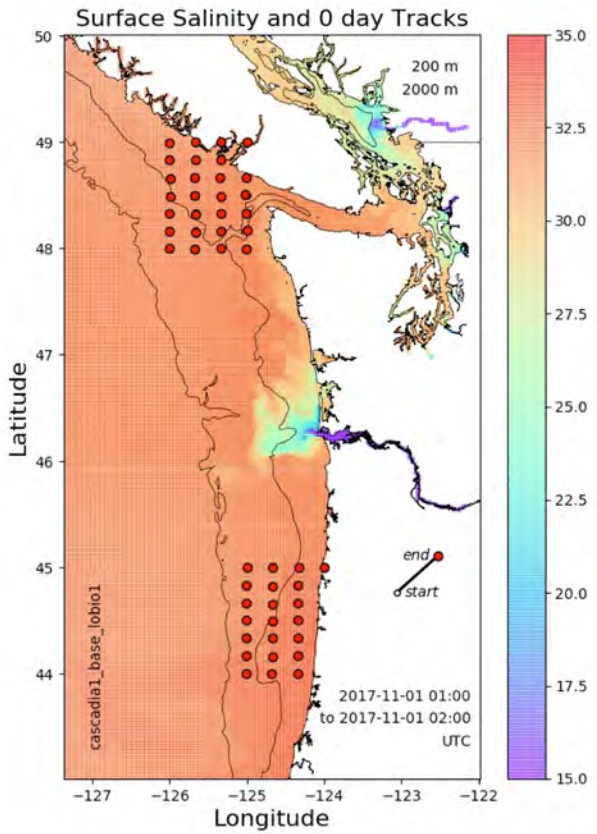
Model forecast of surface aragonite saturation state – corrosive waters from the Columbia River plume are a key feature.

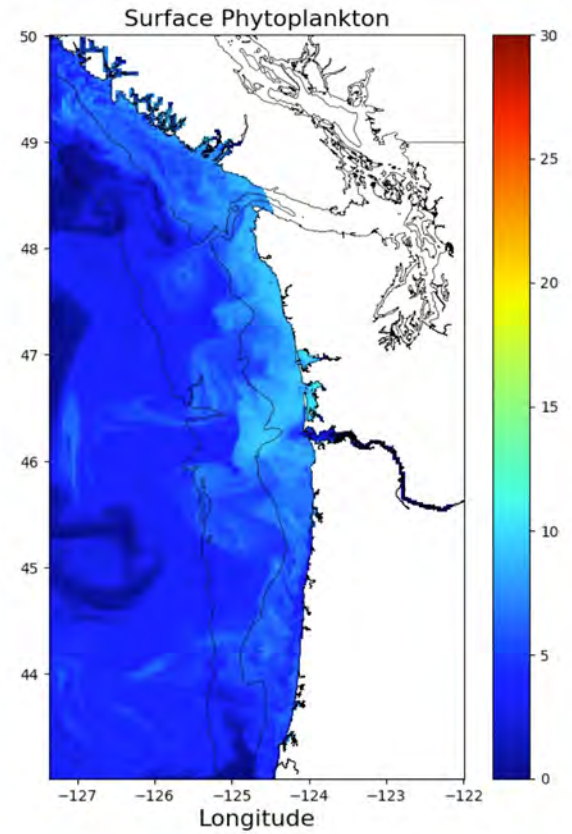
APPLICATION to STAKEHOLDERS:

Short-term forecasts of phytoplankton blooms and surface water advection from known *Pseudo-nitzschia* HAB hotspots.

-customized for razor clam recreational harvests





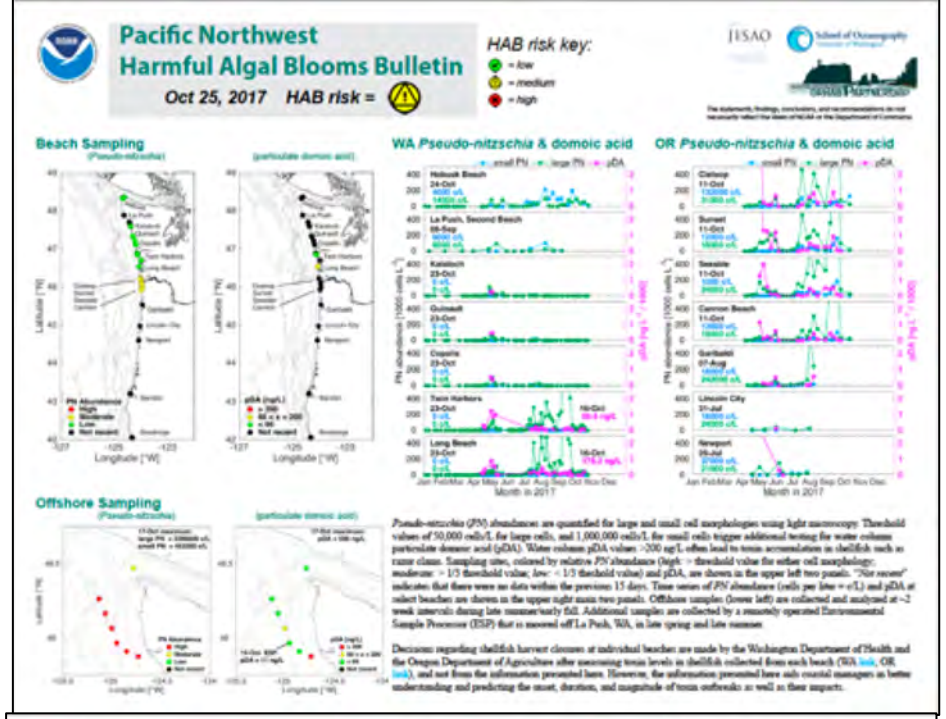


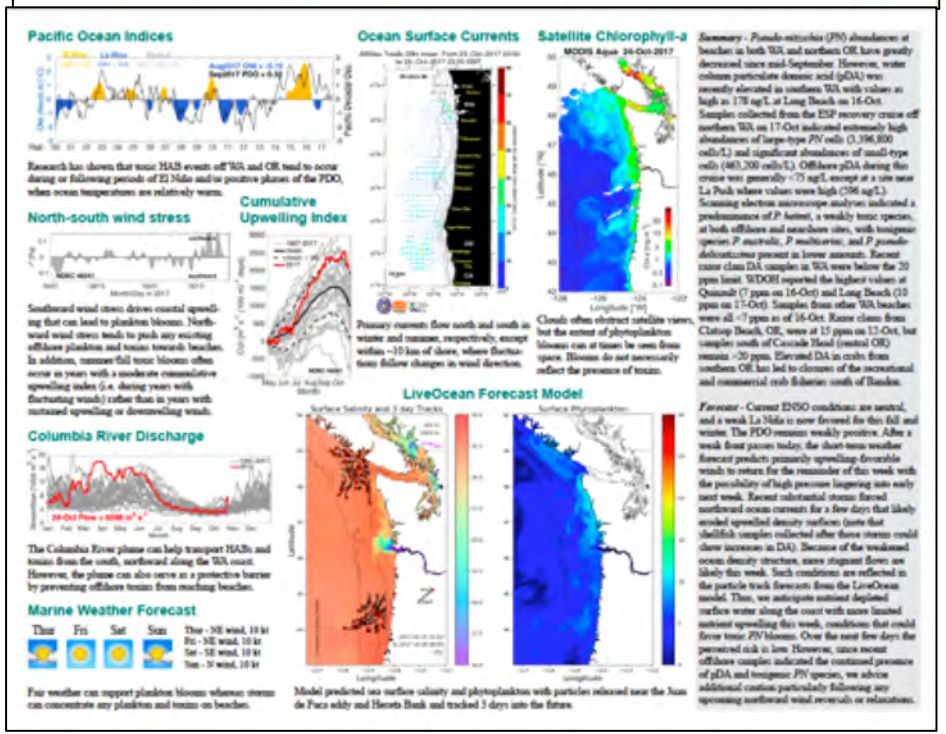
Pacific Northwest Harmful Algal Blooms Bulletin

Apr 13, 2018 HAB risk =

HAB risk key:

- *= low*
- *= medium*
- *= high*





PNW HAB Bulletin

Short-term risk

- Beach *Pseudo-nitzschia* abundance & pDA
- Small boat at hotspots (PN, DA)
- ESP moored off La Push, WA
- Ocean currents, Columbia River discharge, satellite chlorophyll
- Marine weather
- Cumulative upwelling index
- LiveOcean forecast model

Steph Moore w/ ESP

Partnership with NANOOS

Long-term forecast

- Pacific Ocean Indices

(warmer T years associated with increased DA risk)

Slide courtesy Vera Trainer, NWFSC

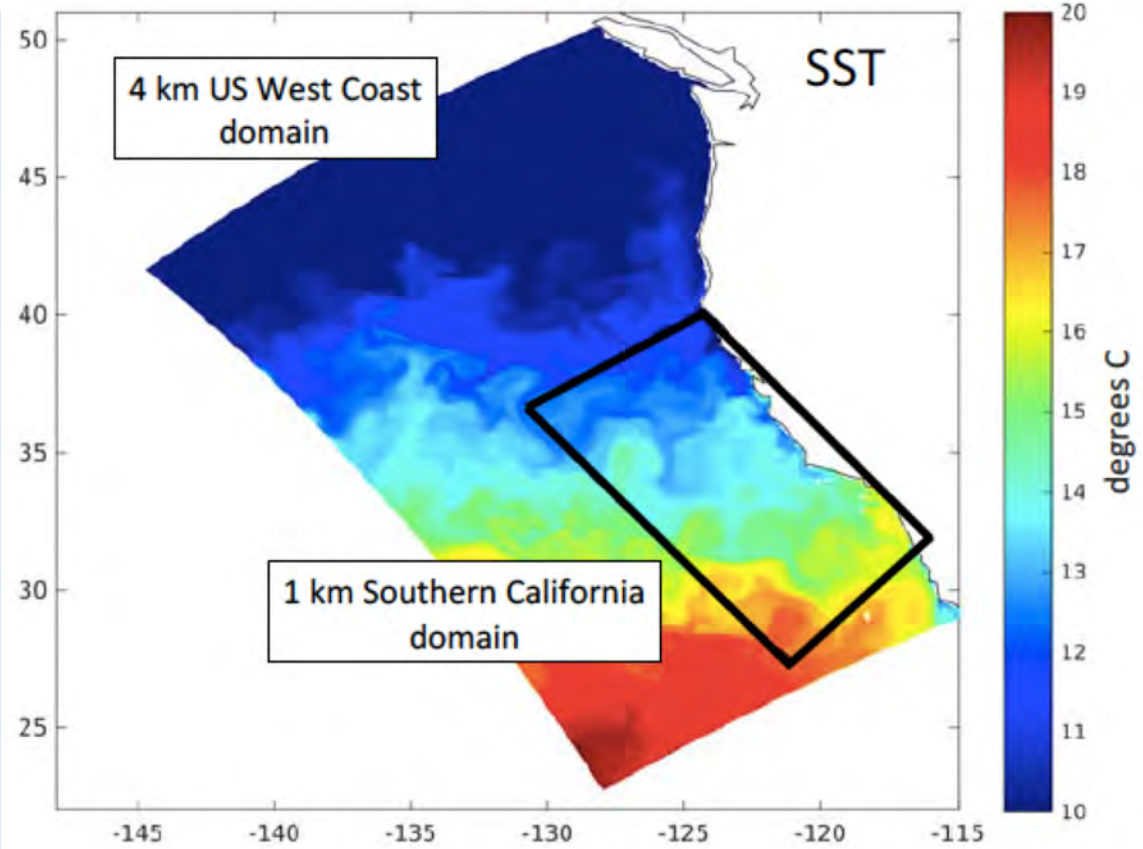
Near Real-Time and Research Models for the California Current System

regional downscaling of the physics

REGIONAL OCEAN MODEL SYSTEM (ROMS)

Operational 3-km ROMS
with 3DVAR data assimilation
Yi Chao, UCLA
-used for HAB forecasts

Operational 9-km ROMS
with 4DVAR data assimilation
Chris Edwards & Andy Moore, UCSC
-used for EcoCast



Research-mode ROMS
nests down to 500m

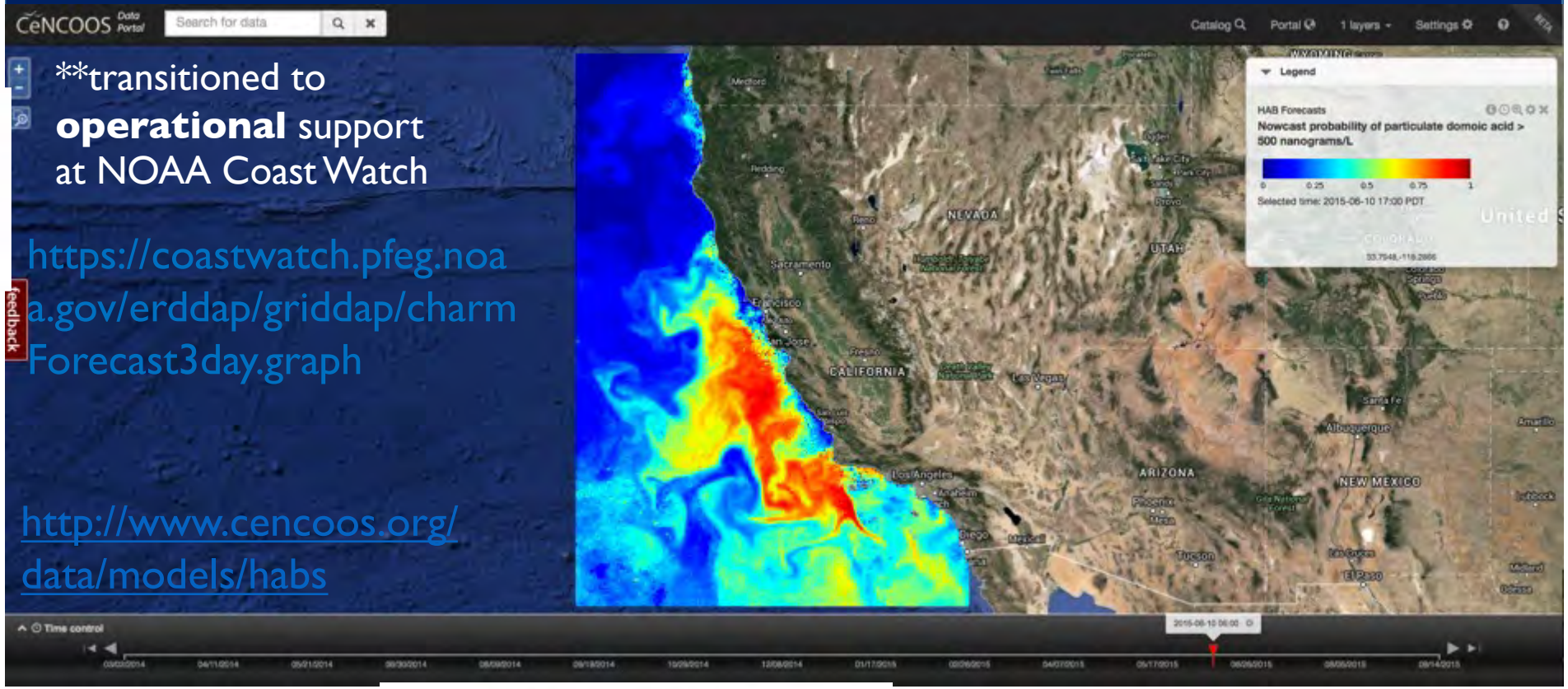
Jim McWilliams, UCLA

-used to test next-gen ecological forecast models
(D. Bianchi, C. Deutsch)

uses nested grids to move across scales
(e.g. Shchepetkin and McWilliams, 2003)
-atmospheric boundary conditions from WRF

California Harmful Algae Mapping (C-HARM) System

Anderson et al., *Harmful Algae* (2009), *GRL* (2011), *Harmful Algae* (2016)

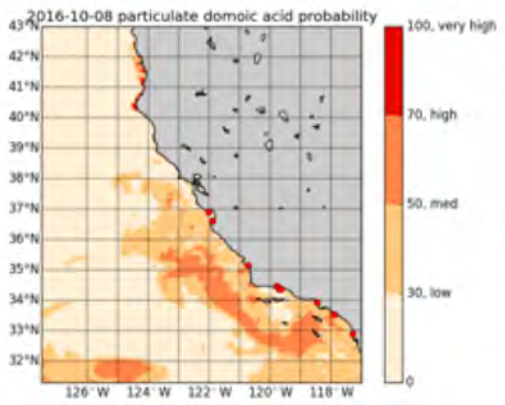


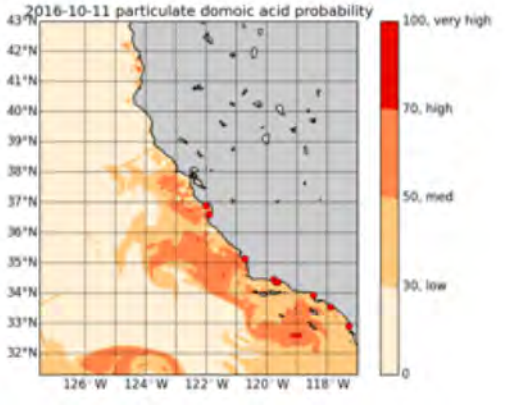
transitioned to **operational support at NOAA Coast Watch

https://coastwatch.pfeg.noaa.gov/erddap/griddap/charmForecast3day.graph

http://www.cencoos.org/data/models/habs

Extensive collaboration with all partners on creation of a monthly **CA HAB Bulletin** distributed via listserv and SCCOOS & HABMAP

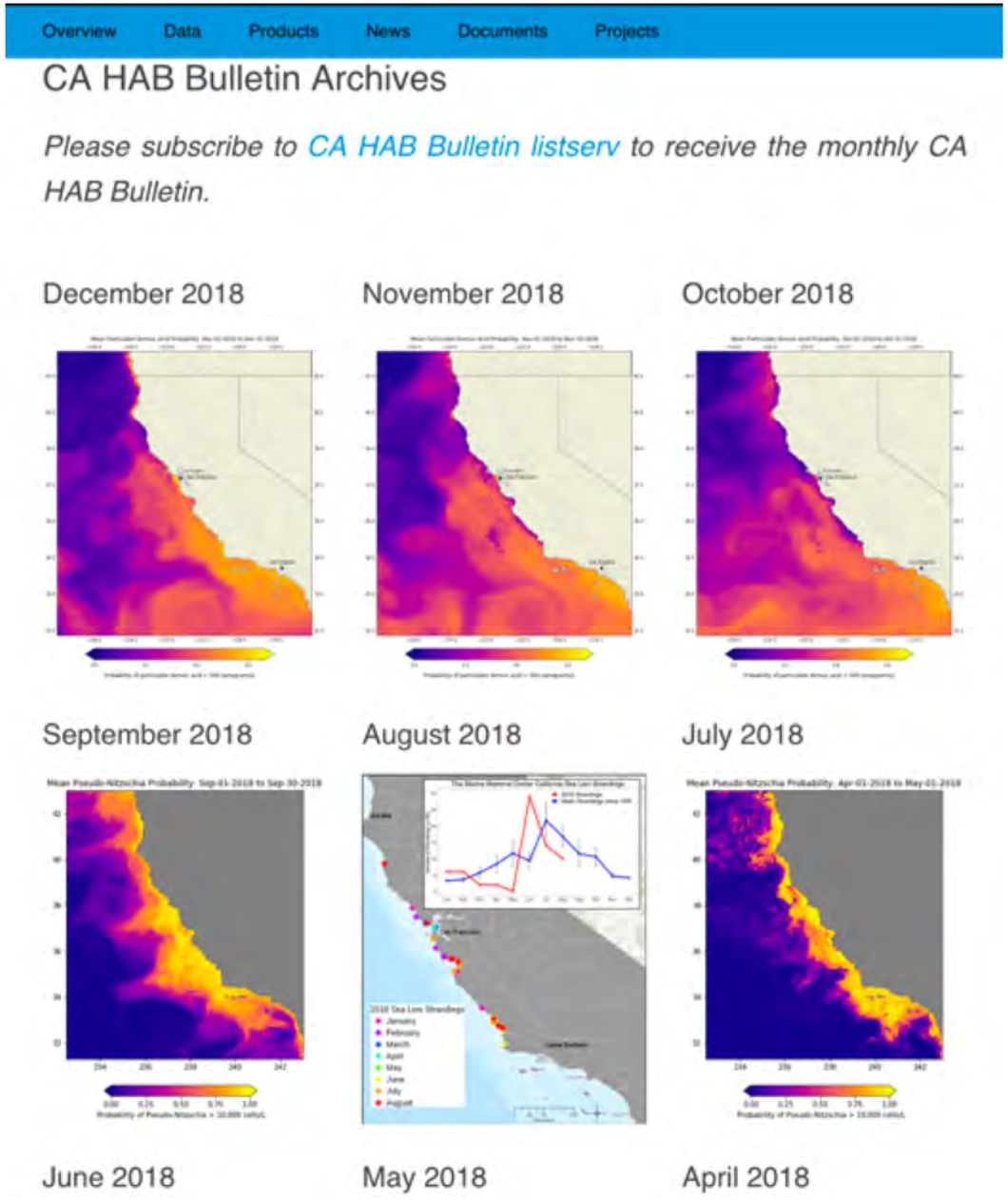




Stakeholder engagement is done via web surveys and continual outreach to super end-users

California HAB Bulletin

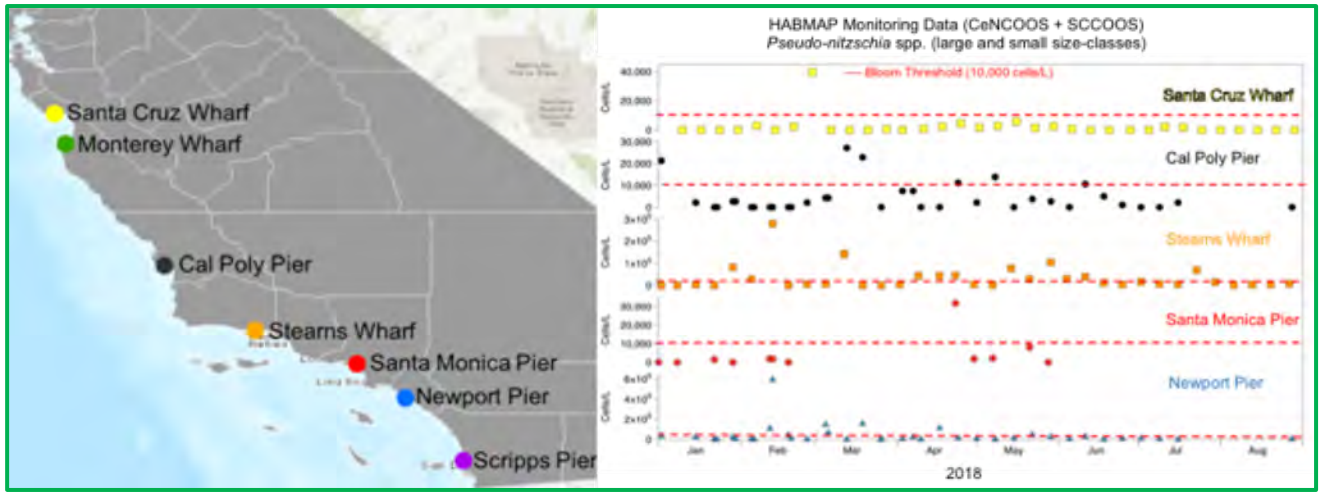
sccoos.org/california-hab-bulletin/



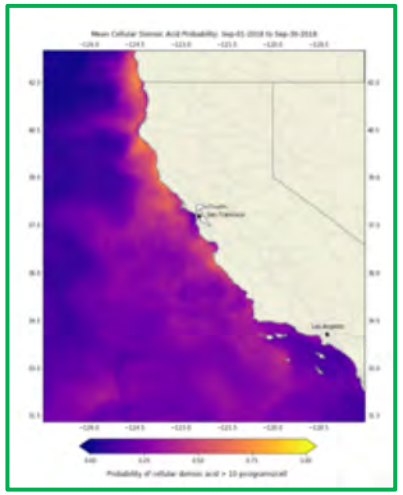
What is the CA HAB Bulletin?

The purpose of this *experimental* product is to give the public and resource managers a quick outlook of recent toxic (marine) algal blooms in coastal California from models and aggregate data sets. **Monthly reports synthesize model output, near real-time observations, animal strandings, and public health alerts** to provide a more complete picture of the regional variability in harmful algal blooms for stakeholders.

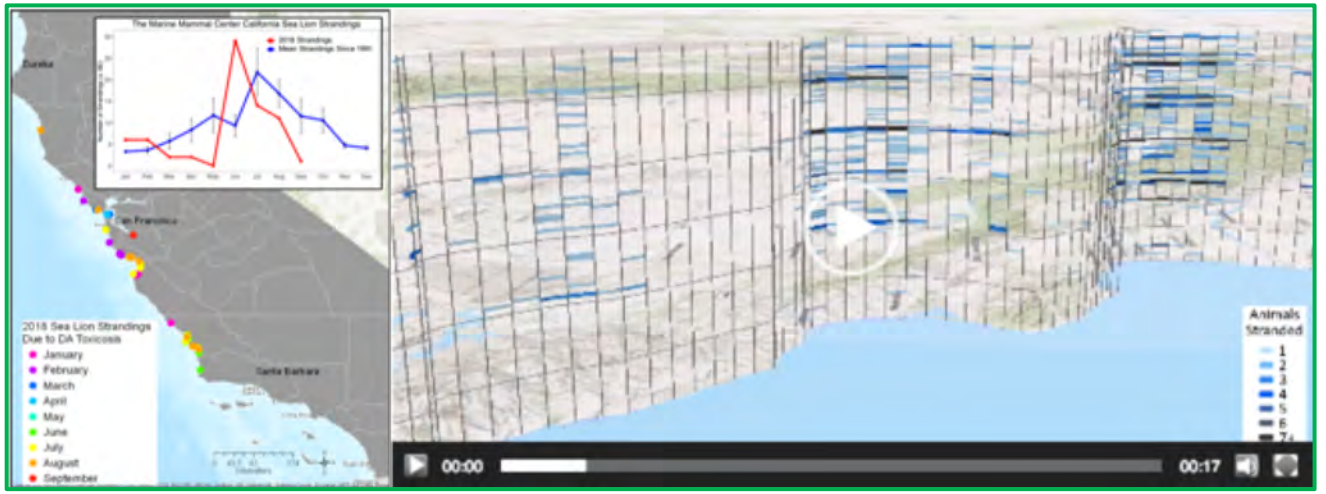
California HAB Bulletin



HABMAP monitoring at 7 stations for HAB species and



C-HARM



The Marine Mammal Center (TMMC) – Sea lion strandings due to domoic acid toxicosis

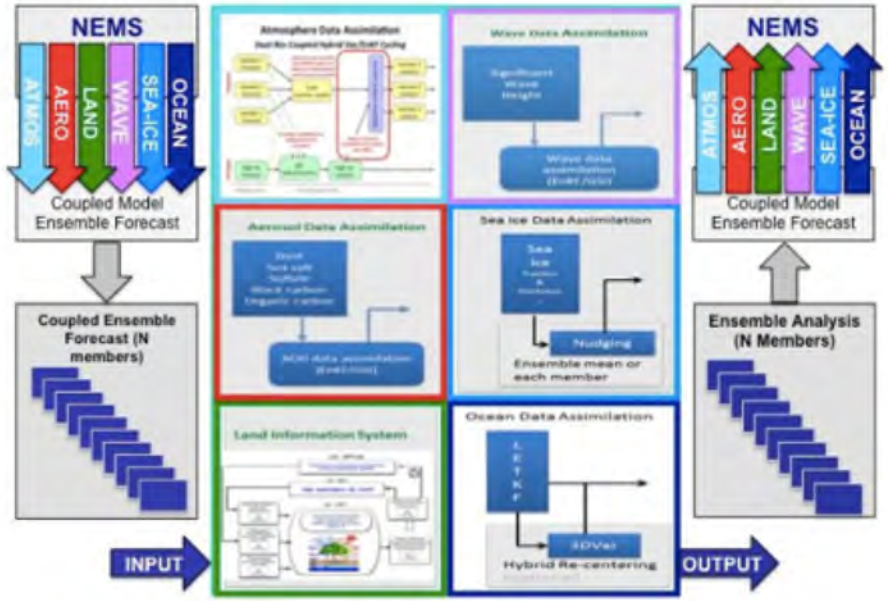
California Department of Public Health (CDPH)

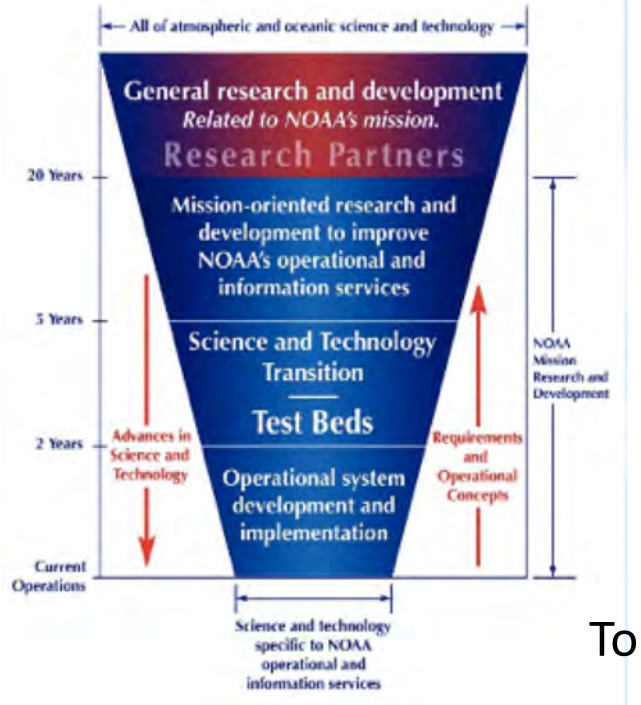
sccoos.org/california-hab-bulletin/

Lessons Learned & Next Steps

- Stakeholders mostly need the higher-resolution, granular predictions, preferably with seasonal outlooks; must have an iterative feedback loop
- Will we ever be able to move seamlessly from global to nested coupled models **at nearshore scales relevant to stakeholders**?
  - Requires innovations in physical coupling schemes
  - Requires more progress predicting HABs, OA, Hypoxia impacts in the food web and at nearshore-estuarine scales
- Can one model actually help (or run) them all?
  - Testing the **West Coast Ocean Forecast System (WCOFS)** as a universal backbone for various ecological forecasting efforts on the U.S. West Coast (IOOS COMT)

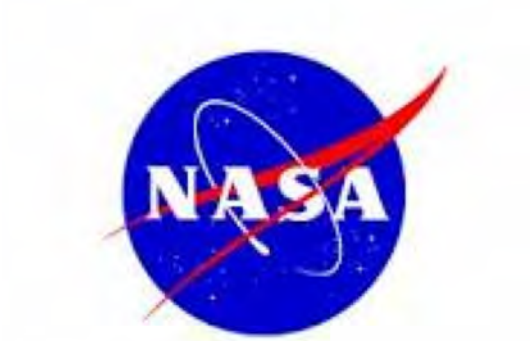
The Future of Coupled Modeling at National Weather Service





Tolman 2018

Thanks to ASLO for this opportunity



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