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.
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
CONSISTENT NATIONAL CAPABILITY

Regional Associations

assure

engage

Observations
Data Management
Forecasts/Modeling
User Products
Outreach and Education
Leverage and Link

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.
ORCA CarrInlet @ 35 meters

UW “Carr Inlet” buoy
Puget Sound, WA

“Blob”
“Drought”
“Rain”

2015
Observing extreme events with autonomous underwater vehicles

*operational Spray glider lines in California – SCCOOS + CeNCOOS*

**California Underwater Glider Network**

*Longest sustained glider lines in the world*

PI: Dan Rudnick

FY18 “Fill the Gaps” Funds

- added new alongshore glider line

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

Widespread Ecosystem Impacts!

Temperature (NDBC)

Dungeness Crab Closure
$100 M Loss
West Coast fishery
Regional Associations engage DIVERSE LOCAL STAKEHOLDERS to assure CONSISTENT NATIONAL CAPABILITY.

- Observations
- Data Management
- Forecasts/Modeling
- User Products
- Outreach and Education
- Leverage and Link

DIVERSE LOCAL STAKEHOLDERS

Regional Associations

IOOS Integrated Ocean Observing System
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.

$L_1 = \text{front/frontal jet, coastal upwelling}$

$L_T = \text{topographic-steered barotropic current}$

$L_{bt} = \text{barotropic tide}$

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).

At $1/12^\circ$ resolution, only 38 of 925 rivers meet the “permitting” criteria

High(ish)-Resolution (Nested) Coupled Models

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

Parker MacCready, University of Washington

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
**J-SCOPE** produces 6-9 month seasonal forecasts of physical conditions, Chl-α, O₂, pH, MLD, plankton, and Ω (PI Samantha Seidlecki)

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 (including DIC and TA). The TA and DIC fields are then used to calculate Ω using CO2sys.
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
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

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)

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
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.

[sccoos.org/california-hab-bulletin/](sccoos.org/california-hab-bulletin/)
HABMAP monitoring at 7 stations for HAB species and domoic acid

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)
Thanks to ASLO for this opportunity

Collaborators:

Parker MacCready
Samantha Seidlecki
Chris Edwards
Andrew Moore
Yi Chao
Jim McWilliams
Daniele Bianchi
Martha Sutula