Data Collection & Integration Across Regions: The View from IOOS Regional Ocean Observing Systems

Jake Kritzer, Jan Newton, Clarissa Anderson, Henry Ruhl
To produce, integrate, and communicate high quality ocean, coastal and Great Lakes information that meets the safety, economic, and stewardship needs of the Nation.

• 11 regions
• 17 federal partners
• 34 core variables
• Buoys, gliders, HFR, satellites, ship-based surveys, coastal stations, etc.
• Variety of models
• Federally-certified data management
IOOS emphasis on data, models, and products in service to end users
Variables relevant to ecological forecasting are routinely measured across IOOS regions

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IOOS 2020 survey
Status of measurements relevant to ecological forecasting

• Most at only a few locations \(\rightarrow\) research-to-operations stage

• Some measured only within a few regions:
  • eDNA
  • HAB toxins
  • Ocean sound
  • Imaging

• However, all regions aim to expand within Tier 2 budgets, which is work within fully fleshed out operations plans that is not currently funded (most RAs funded at <50% of award cap)

• Goal is to grow research into routine sustained observations in all regions
“We’re seeing an explosion of ways that we can have a look at biology in the oceans...New technologies are giving us unprecedented looks at how ecosystems function.”

- Ru Morrison
Tier 1 vs. Tier 2 Projects

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<td>HIF Radar Network - SCCOS Region - Operations, Maintenance &amp; Recap</td>
<td>CA COOS/PFZ-2A proposed Projects</td>
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</table>
| California Underwater Glider Network - Operations, Maintenance & Recap | COLA 
Autonomous biogeochemical & Ecological Monitoring using Gliders |
| HAB Monitoring and Alert Program + SPATT dissolved toxins | Indicators of Zooplankton and CLON |
| SCCOS Automated Shore Stations - Operations, Maintenance & Recap | HABON: IFER Network for an Automated HAB Alert System |
| GOH Monitoring on SASS Stations | High throughput Molecular and Flow Cytometry Observations |
| Distribution and Abundance of Sea Birds and Marine Mammals | Marine Mammals as indicator Species of Algal Blooms Production |
| California Coastal Flood Network | Del Mar Mooring Reference and Development Site |
| ROMS - 3 km Statewide Operational Model | Observing Nutrient Fluxes and their role in HAB Development |
| ROMS: High Resolution Shelf & Nearshore Physics | Network of Near-Shore Mooring stations for OAH & Water Quality |
| CoCoER/IOOS: Data Synthesis and Product Development | Effect of Upwelling Intensity on Near-Shore OAH using Small-Boat Surveys |
| California Multivariate Ocean Climate Indicator (MOCI) | Gewenick & Maintain a Citizen-Science Based Sensor Network on Rocky Reefs |
| Statewide Kelp Canopy Area/Biomass Dynamics | California Fishing Vessels of Opportunity |
| Autonomous biogeochemical & Ecological Monitoring using Gliders | Large Scale & Long-Term Kelp Forest Monitoring for Science & Policy |
| Indicators of Zooplankton from CLON | California Kelp Forest MPA OAH Network with Citizen Science |
| HABON: IFER Network for an Automated HAB Alert System | Animal Tracking Network - White Shark Acoustic Receiver Array |
| High throughput Molecular and Flow Cytometry Observations | Ocean Sound Observation Network |
| Marine Mammals as indicator Species of Algal Blooms Production | eDNA Library Development on Phytoplankton |
| Del Mar Mooring Reference and Development Site | ROMS - Bec Biogeochemical Model Development & Product |
| Observing Nutrient Fluxes and their role in HAB Development | Numerical Ocean Model Simulations as a Research Asset |

IODS CORE VARIABLES

- Bathymetry
- Current
- Heat x
- Salinity
- Sea level
- Surface wave
- Wind speed
- Wind stress
- Albedo
- Advection
- Nutrients
- Dissolved oxygen
- Chlorophyll
- Baroclinic
- Baroclinic
- Baroclinic
- Baroclinic
- Baroclinic
Are the data set up for easy access?

• Yes, but accessibility varies among regions and data sets
• Newer and more complicated data types makes management slower
  → plankton ≠ temperature
• Some DAC systems are in development including:
  • SanctSound
  • HAB DAC (incl. IFCB images)
  • MBON & ATN for tagging & telemetry
  • FathomNet for AI/ML
• Data standards and data integration protocols are established within
  individual DACs
Are IOOS regions engaged in integrating physical-biological-BGC variables for easy analysis by external users?

• Yes!

• Here are several, but not all, examples...
California HAB Bulletin

What is the CA HAB Bulletin?
The purpose of the CA HAB Bulletin 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, marine mammal strandings and public health alerts to provide a more complete picture of the regional variability in harmful algal blooms.

California Harmful Algae Risk Mapping (C-HARM)

C-HARM system creates daily nowcasts and three-day forecasts of domoic acid risk through simulations of the physical circulation using a Regional Ocean Model System (ROMS) to predict water temperature, salinity, upwelling, advection.

CA Harmful Algal Bloom Monitoring Alert Program (HABMAP)

The CA HABMAP funded by SCCOOS and CaNCOOS provides a near real-time picture of which HAB species might be blooming in the very nearshore environment, if domoic acid is present as well as other water quality parameters (e.g., nutrients, chl-a, and temperature). Stearns Wharf, Newport Pier and Scripps Pier also use SPATT bags to measure for additional toxins.

What is next for the CA HAB Bulletin?
SCCOOS will soon be incorporating data from Imaging Flow Cytoblotets (IFCBs) to monitor HABs in near real-time with funding from the CA Ocean Protection Council and NOAA research grants from collaborating Principal Investigators. The IFCB takes high resolution images of phytoplankton and with machine learning algorithms are then used to categorize images to taxonomic groups of interest.

https://sccoos.org/california-hab-bulletin/
J-SCOPE: Upwelling & Other Oceanography

- Bottom Oxygen (ml/l)
- Chl-a
- SST (deg C)
- Bottom pH

8-day Upwelling Index, upwelling > 0
MBON – A Systems Approach

Ruhl et al., https://doi.org/10.5670/oceanog.2021.221
Northeast Coastal Ocean Forecast System (NECOFS)
Pelagic Food Webs

Suca et al. 2021

Ross et al. in prep.
SBNMS as Sentinel Site

• Model *Calanus* abundance in SBNMS as a function of abundance at upstream (CMTS) and overwintering (WBTS) sites, mediated by ocean currents.

• Model sand lance abundance as a function of *Calanus*, herring, and oceanographic conditions.
Are IOOS regions coordinating integration of physical-biological-BGC variables for easy analysis by external users?

• Somewhat, but limited; e.g., HAB DAC in California, which will extend across the Pacific coast, as regionally-relevant libraries are developed

• IOOS is exploring how the cloud might be used to improve cross regions access

• IOOS Animal Telemetry Network
Animal Telemetry Network

IOOS Integrated Ocean Observing System

Map of animal telemetry locations in the Gulf of Maine with data fields showing species and project measurements.
What are limitations we are struggling with for collecting sufficient physical-ecological-BGC data that if overcome would significantly increase our ability to assess and predict the ecological states at IOOS sites?

• Funding for Tier 2 activities!

• IOOS RAs are funded at <50% of capacity proposed, and much of the ecological & BGC activity is what is not funded.

• Notable is that the connections (people, budgets, proposals, etc.) to do the work have been made.
IOOS RAs: To fulfill the aim of addressing climate change, we are not sufficiently funding ecological forecasting currently.

- **IOOS Association-led “Detecting the coastal climate signal” white paper**
  - A priority includes ecological forecasting
- **IOOS-led OceanShot poster for U.S. UN Ocean Decade**

http://www.ioosassociation.org/sites/nfra/files/IOOS_CoastalClimateSignal_Final.pdf
How can we work together?

• Do we know enough about what is needed in terms of variables, validation, and parameterizing for ecological forecasting?

• Define what is most important and how can we work together to highlight, and fund, the observations, integration, models, products, etc., of highest priority.

• Develop a stronger use case; e.g., J-SCOPE is used by tribal fisheries managers to advise fishers on expected conditions and set closures