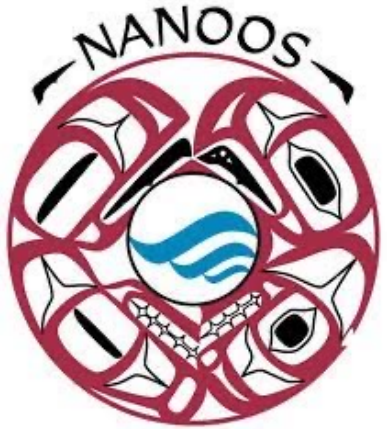
Data Collection & Integration Across Regions: The View from IOOS Regional Ocean Observing Systems

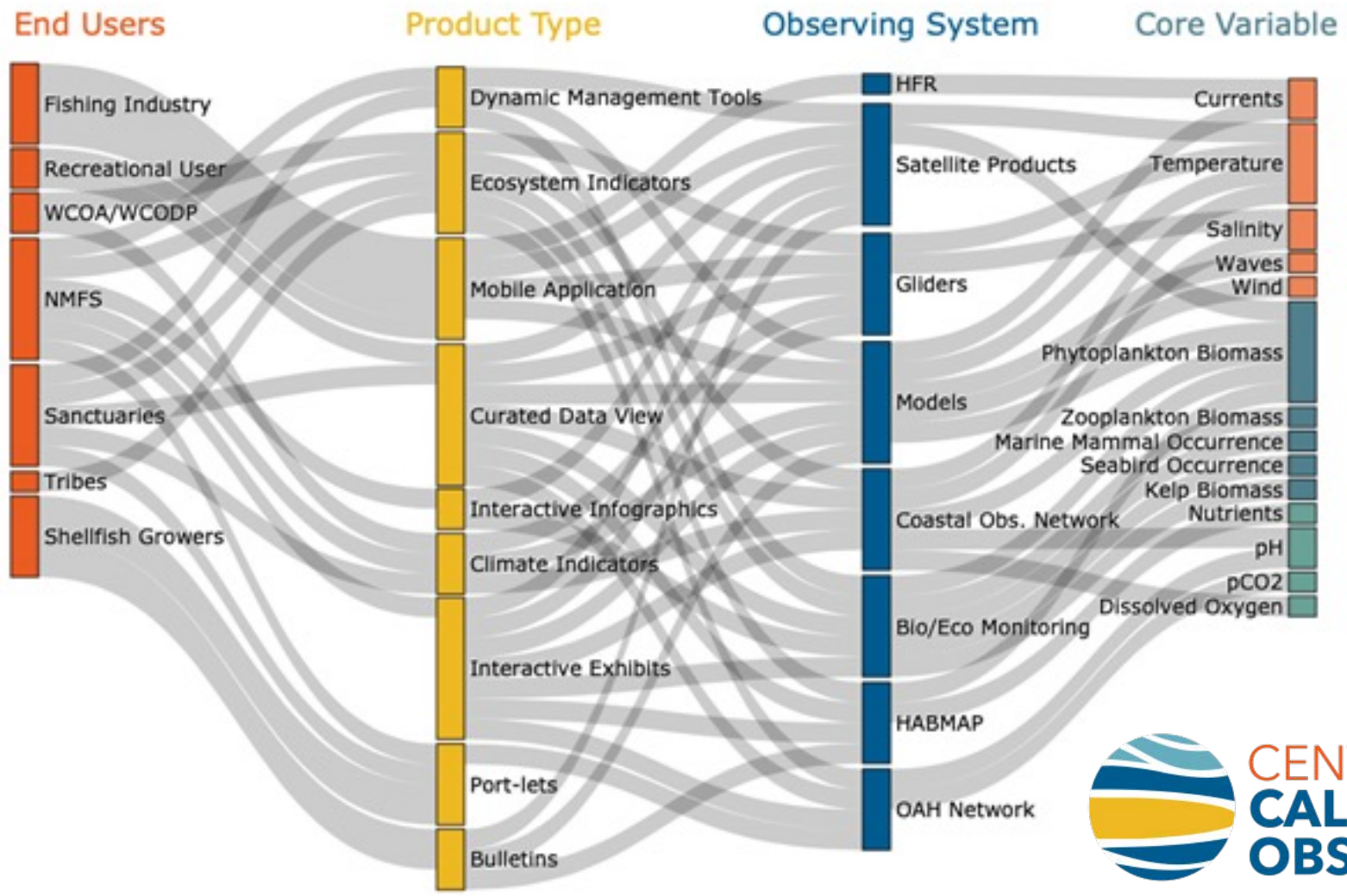
Jake Kritzer, Jan Newton, Clarissa Anderson, Henry Ruhl



U.S. Integrated Ocean Observing System (IOOS)

- 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



CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

Variables relevant to ecological forecasting are routinely measured across IOOS regions

	#	AOOS	CariCOOS	CeNCOOS	GLOS	GCOOS	MARACOOS	NANOOS	NERACOOS	PacIOOS	SCCOOS	SECORA
Fish, Ecosystems, Climate												
Gliders	11	X	X	X	X	X	X	X	X	X	X	X
Ecosystem/habitat monitoring	10	X	X	X	X	X	X	X	X	X	X	-
Climate data	9	X	X	X	X	-	X	X	X	-	X	X
Acoustic/Telemetry data	7	X	-	X	X	-	X	-	X	X	-	X
Biological monitoring	7	X	-	X	X	X	-	-	X	-	X	X
Fisheries	7	X	-	X	X	-	X	X	-	-	X	X
Long-term data	7	X	-	X	-	-	X	X	X	-	X	X
Coral	3	-	X	-	-	-	-	-	-	X	-	X
Seafloor/seabed	3	X	-	-	X	X	-	-	-	-	-	-
MPAs	2	-	-	X	-	-	-	-	-	-	X	-
Eco-forecasting, OA, HABS, hypoxia												
Ocean acidification	10	X	X	X	-	X	X	X	X	X	X	X
HABs	9	X	-	X	X	X	X	X	X	-	X	X
Water quality	9	X	X	X	X	X	X	X	X	X	X	X
Hypoxia	7	X	X	X	X	X	X	X	X	-	X	-

IOOS 2020 survey

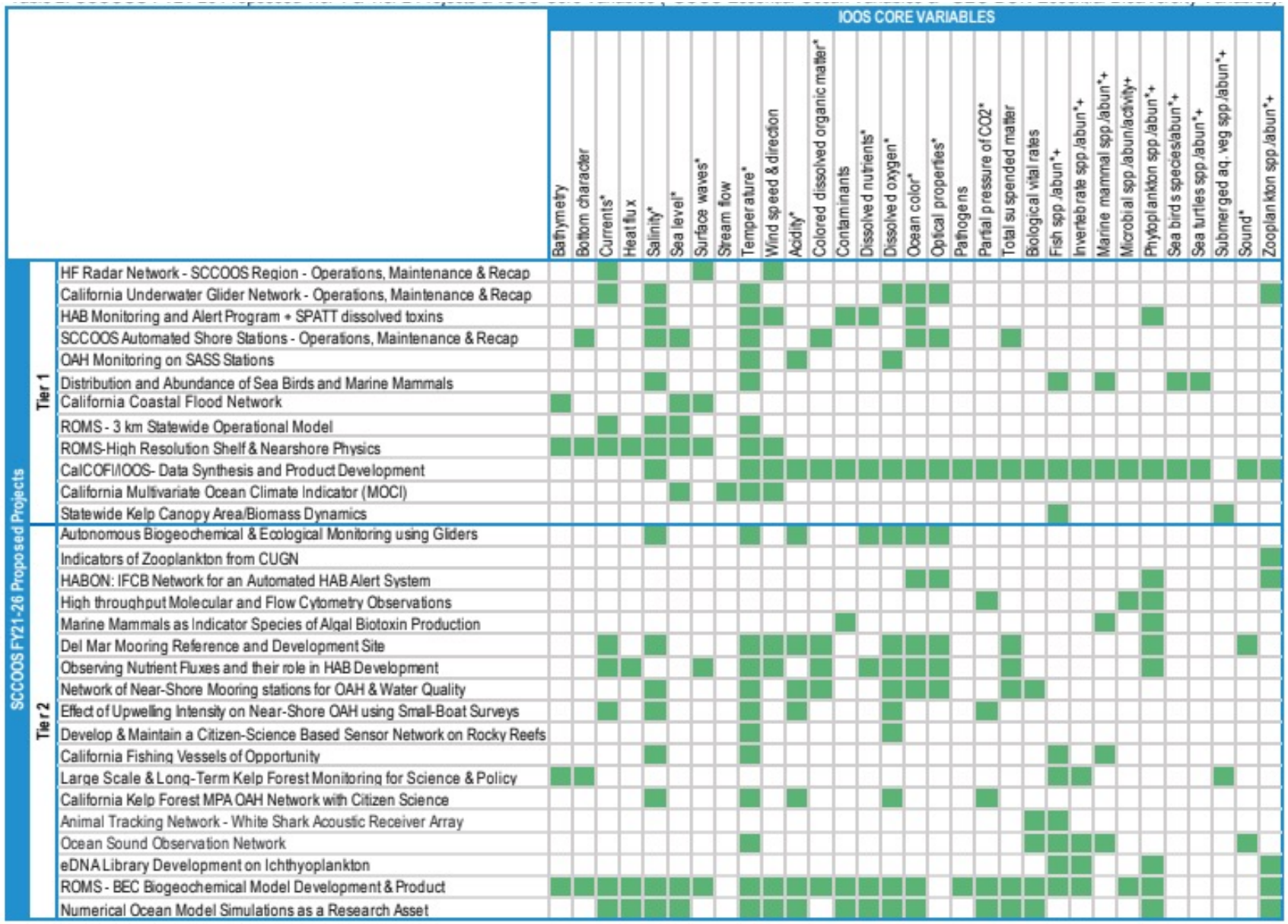
Status of measurements relevant to ecological forecasting

- Most at only a few locations → **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



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?

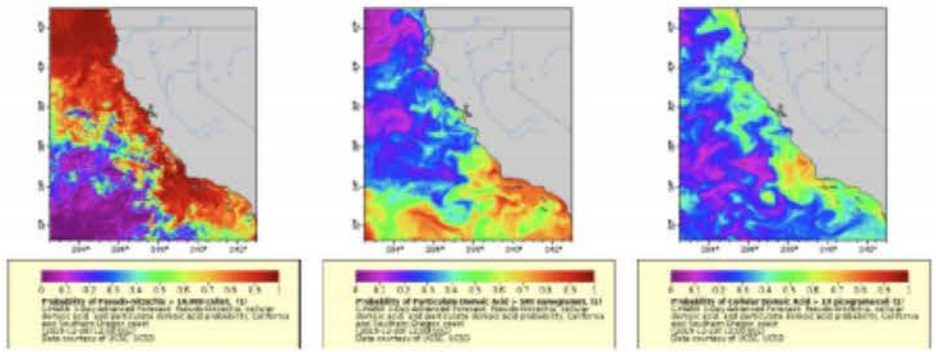
- Yes!
- Here are several, but not all, examples…

California HAB Bulletin

What is the CA HAB Bulletin?

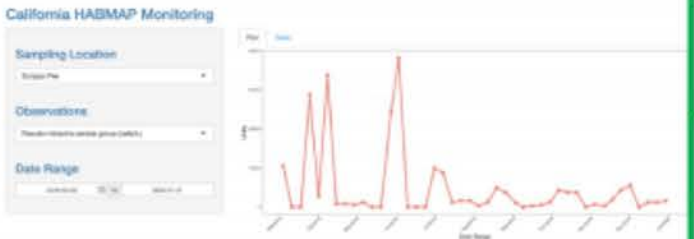
The purpose of the CA HAB Bulletin is to give the public and resource managers a quick outlook of recent toxic (marine) algal blooms in coastal California from models and aggregate data sets. Monthly reports synthesize model output, near real-time observations, marine mammal strandings and public health 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 CeNCOOS 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.

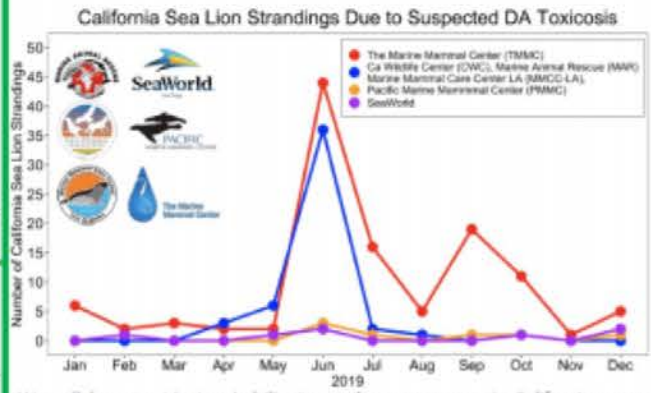
SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

https://sccoos.org/california-hab-bulletin/

California Department of Public Health (CDPH)

SCCOOS provides maps and a summary of California Department of Public Health (CDPH) Marine Biotoxin Quarantines and Health Advisories that serve as warnings for recreational seafood harvests, as well as Health Advisories and Closures from the California Department of Fish and Wildlife.

Marine Mammal Strandings Suspected Due to DA Toxicosis



We collaborate with six rehabilitation and rescue centers in California to report monthly marine mammal and seabird strandings suspected due to domoic acid toxicosis.

What is next for the CA HAB Bulletin?

SCCOOS will soon be incorporating data from Imaging Flow CytoBots (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.

Imaging Flow CytoBot

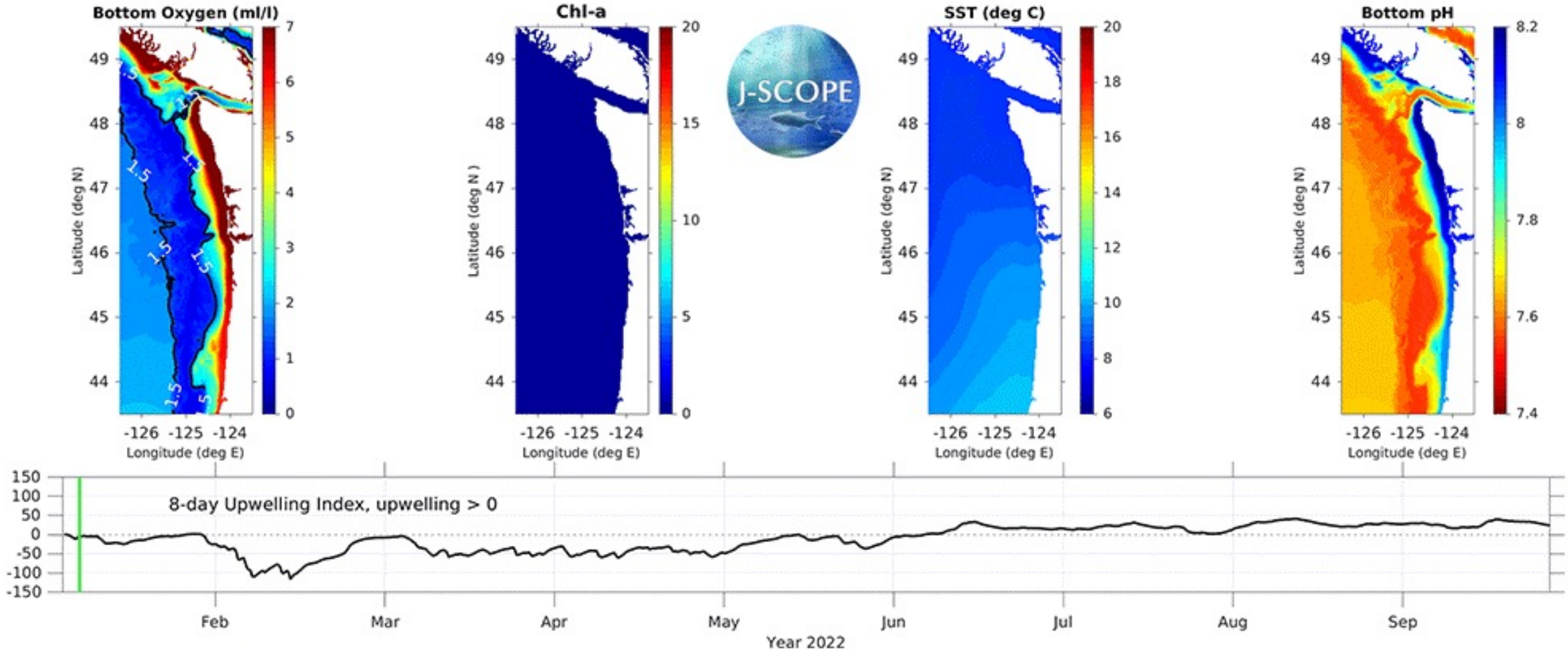
sccoos.org/california-hab-bulletin/

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

NANOOS

Northwest Association of Networked Ocean Observing Systems

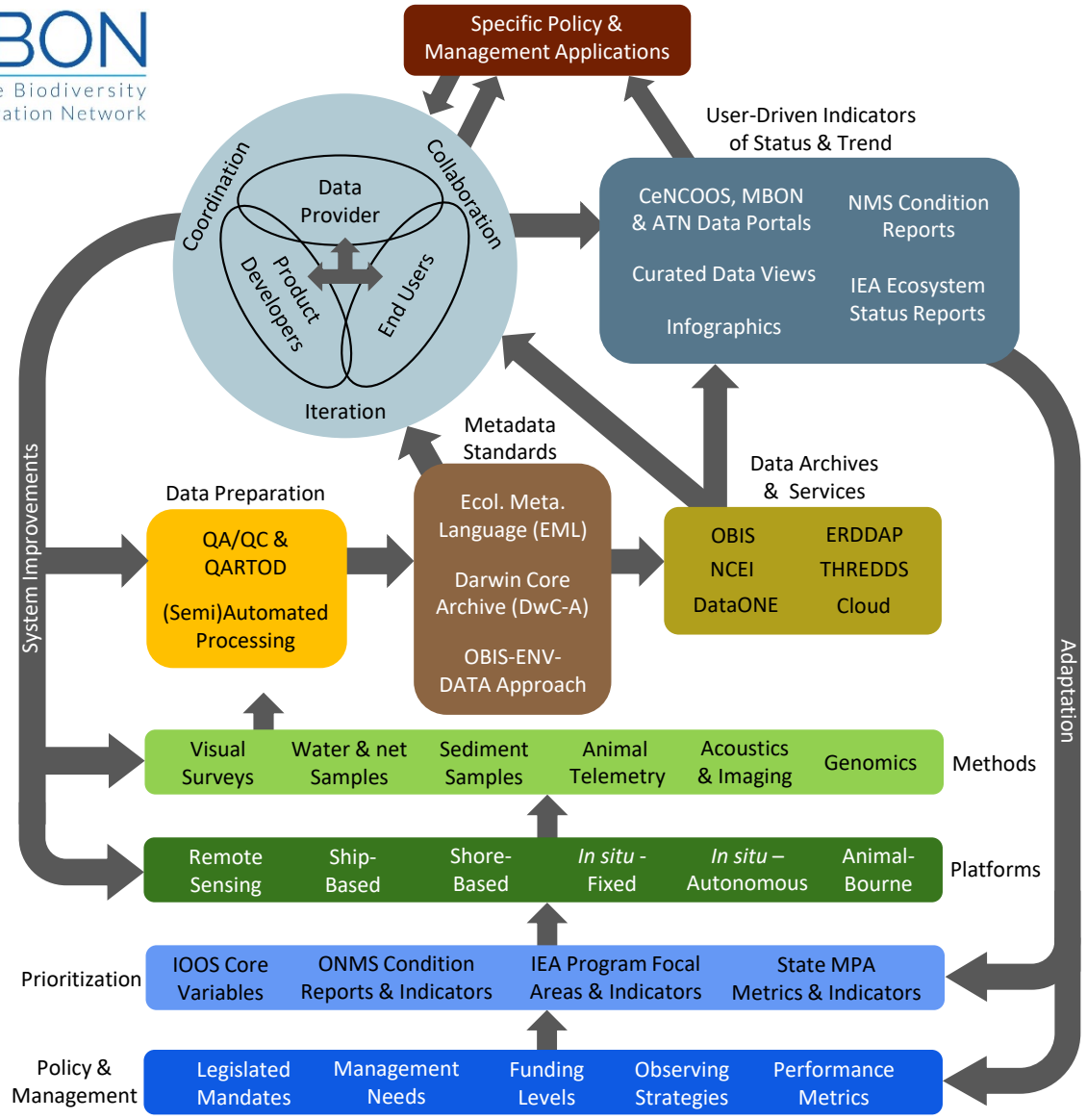
J-SCOPE: Upwelling & Other Oceanography

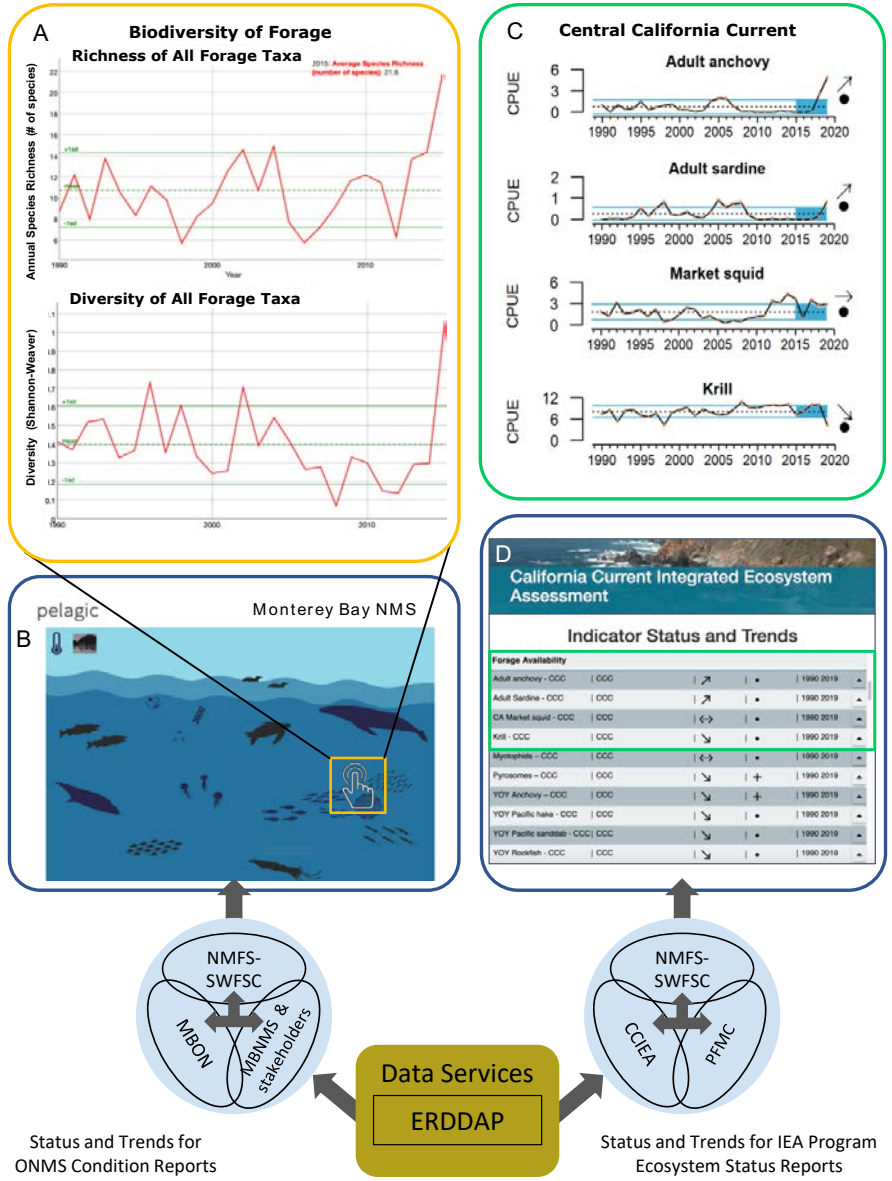


CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

MBON – A Systems Approach

MBON
Marine Biodiversity Observation Network

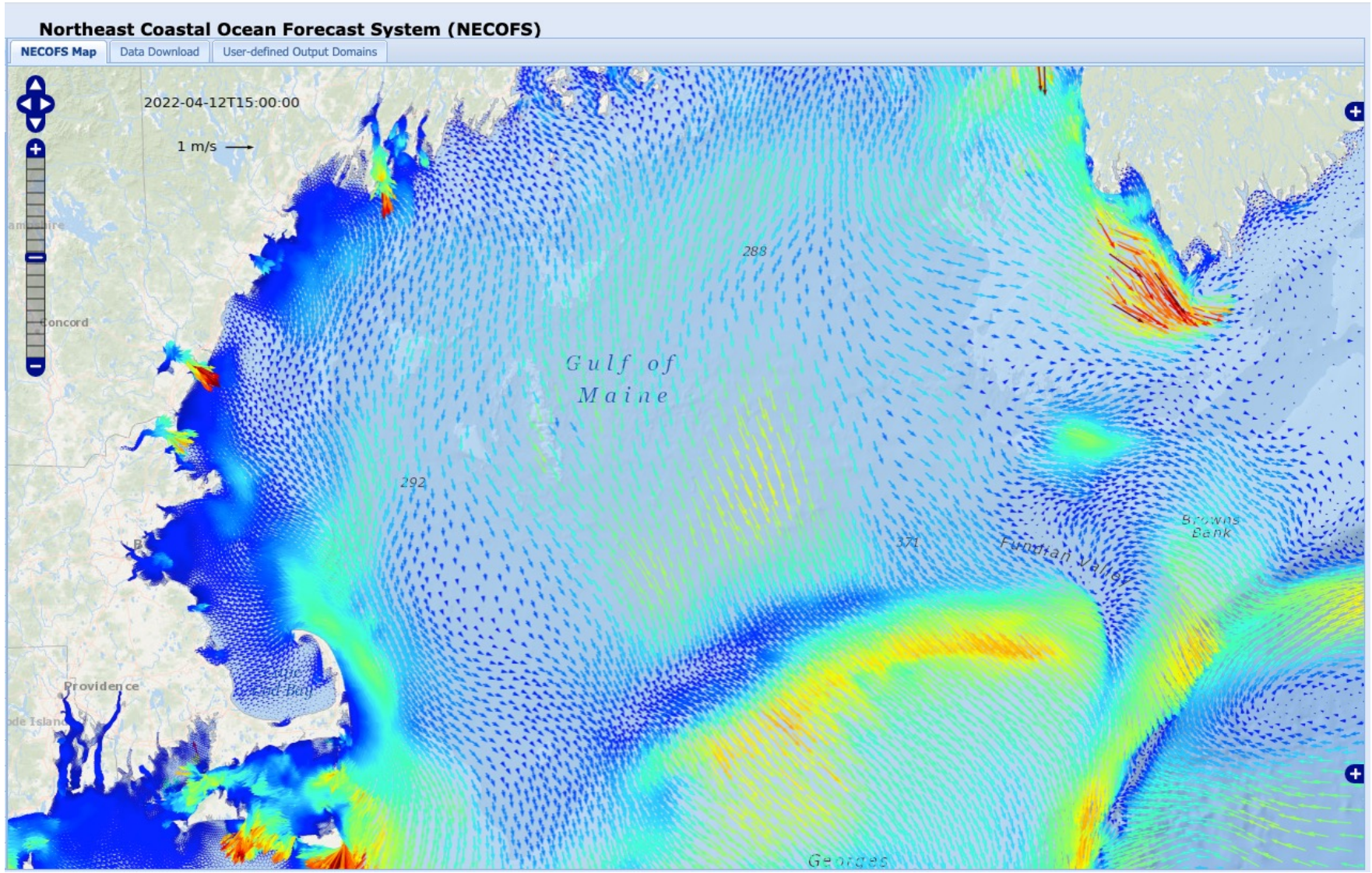




Ruhl et al., https://doi.org/10.5670/oceanog.2021.221

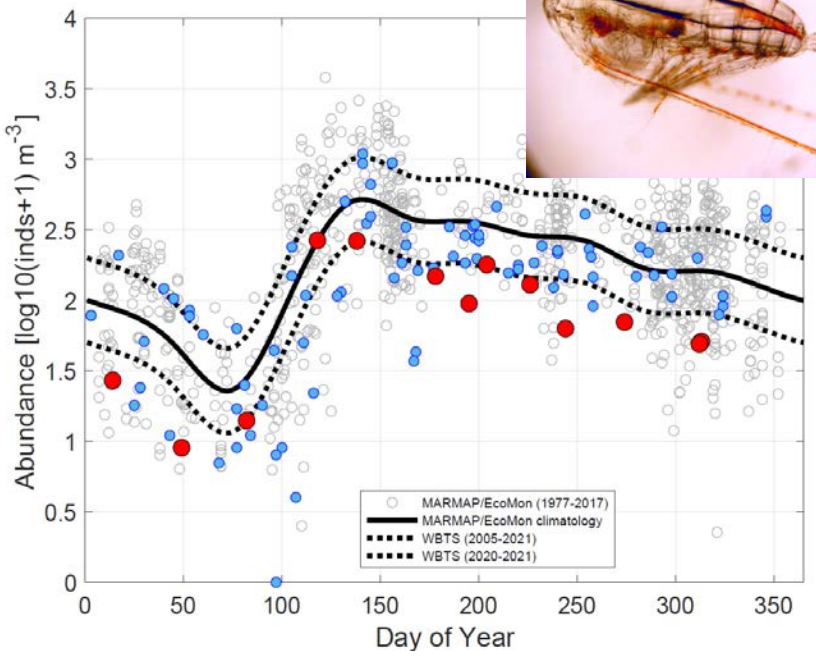
NECOFS

NERACOOS
NORTHEASTERN REGIONAL ASSOCIATION OF COASTAL OCEAN OBSERVING SYSTEMS

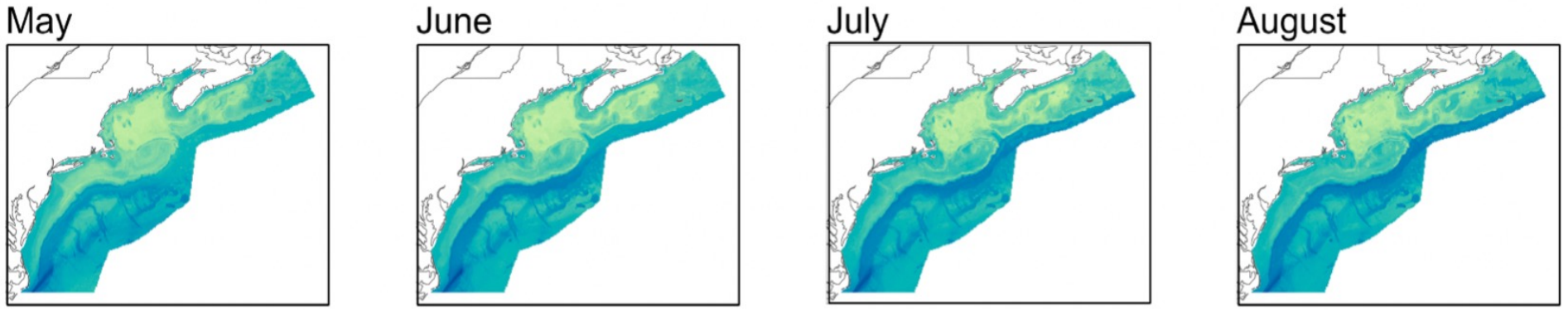


Pelagic Food Webs

NERACOOS
NORTHEASTERN REGIONAL ASSOCIATION OF COASTAL OCEAN OBSERVING SYSTEMS

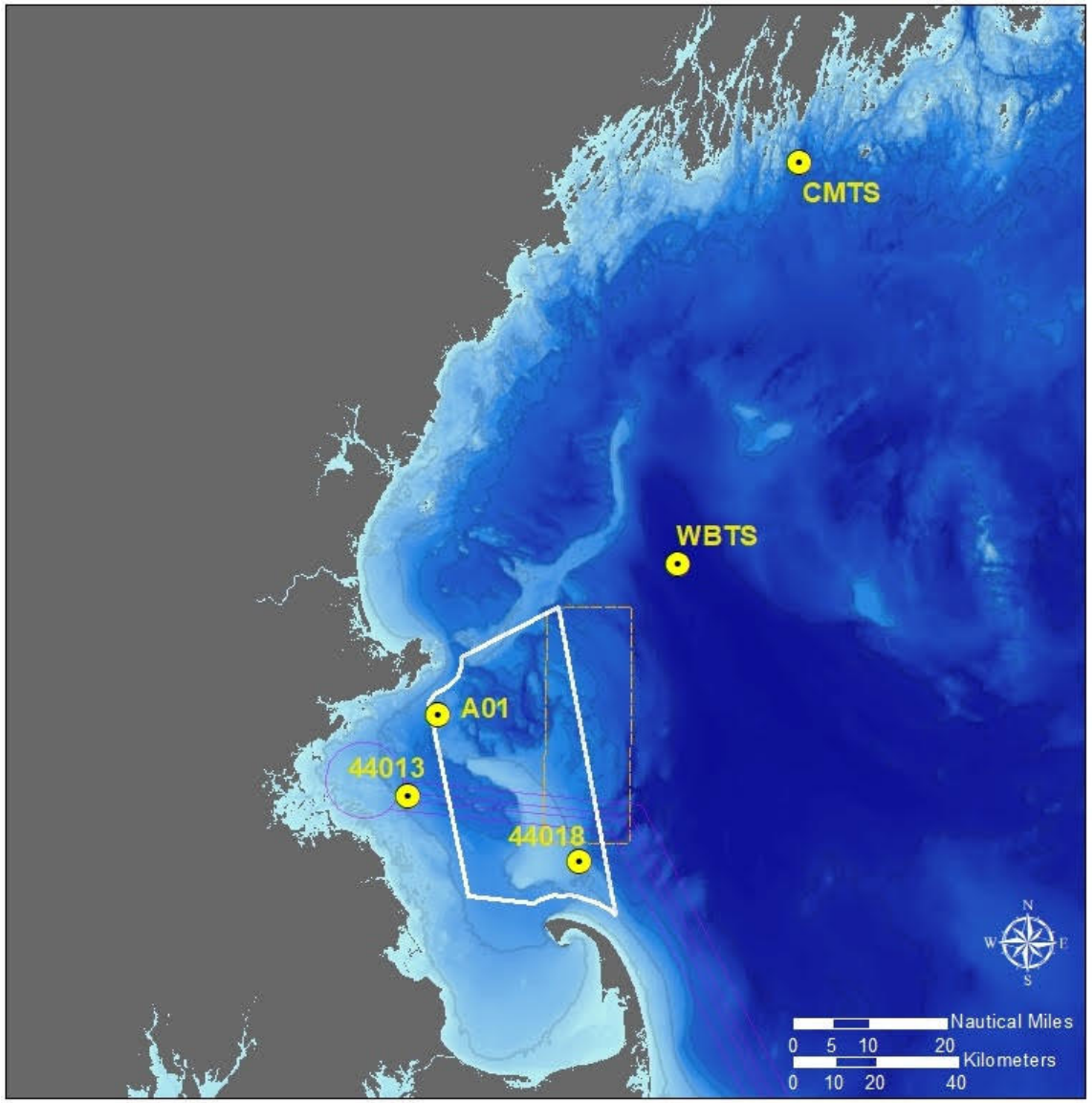


Suca et al. 2021



Ross et al. in prep.

SBNMS as Sentinel Site



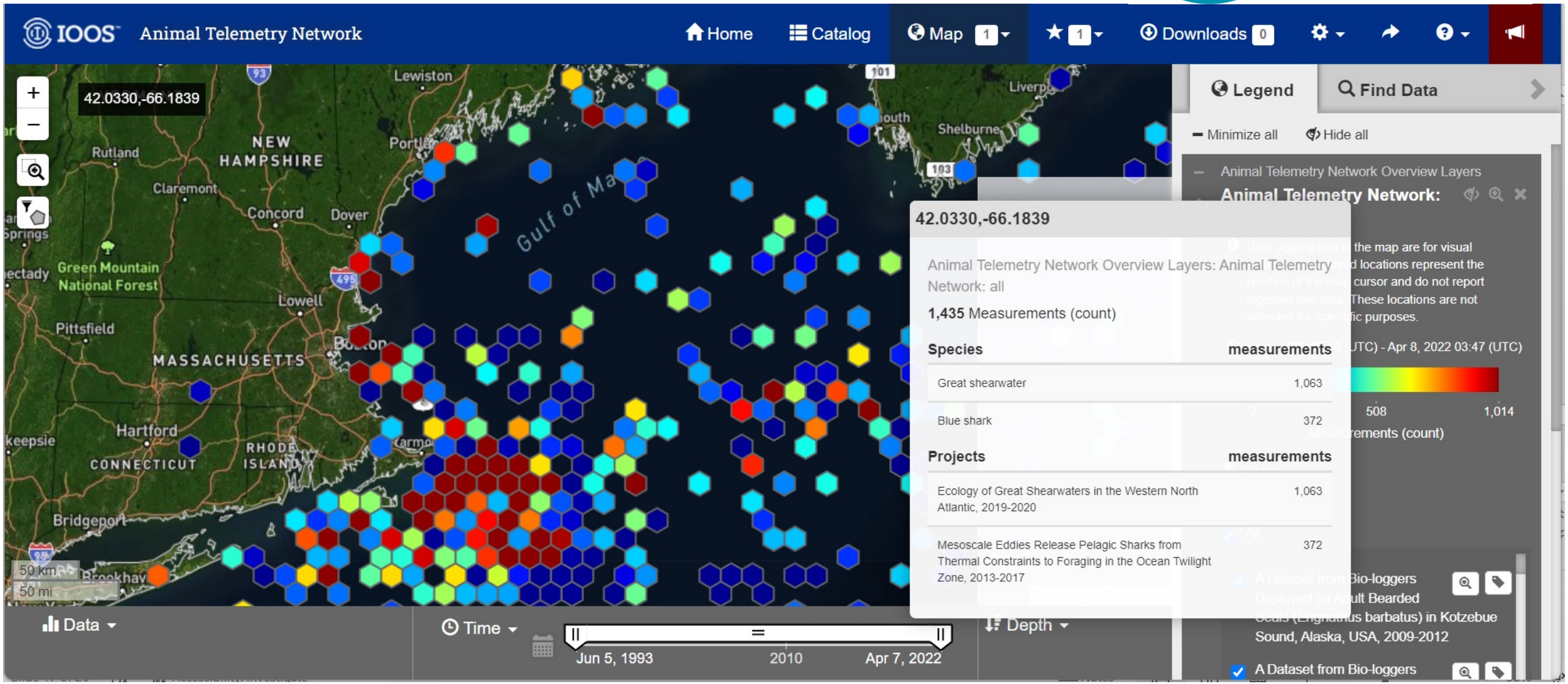
- Model *Calanus* abundance in SBNMS as a function of abundance at upstream (CMTS) and overwintering (WBTS) sites, mediated by ocean currents.
- Model sand lance abundance as a function of *Calanus*, herring, and oceanographic conditions.

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

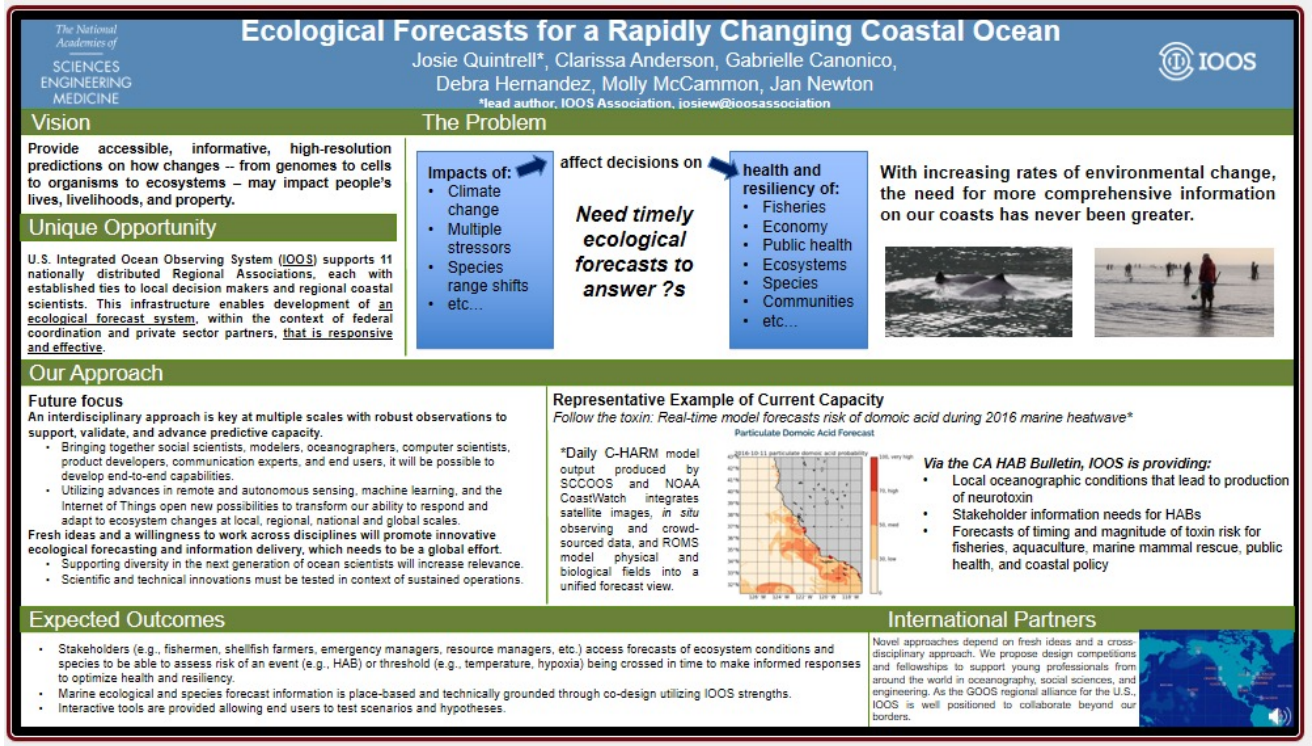


What are limitations we are struggling with for collecting sufficient physical-ecological-BGC data that if overcome would significantly increase our ability to assess and predict the ecological states at IOOS sites?

- 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



Ecological Forecasts for a Rapidly Changing Coastal Ocean

The National Academies of SCIENCES ENGINEERING MEDICINE

Josie Quintrell*, Clarissa Anderson, Gabrielle Canonico, Debra Hernandez, Molly McCammon, Jan Newton

*lead author, IOOS Association, josiew@ioosassociation

IOOS

Vision

Provide accessible, informative, high-resolution predictions on how changes -- from genomes to cells to organisms to ecosystems -- may impact people's lives, livelihoods, and property.

Unique Opportunity

U.S. Integrated Ocean Observing System (IOOS) supports 11 nationally distributed Regional Associations, each with established ties to local decision makers and regional coastal scientists. This infrastructure enables development of an ecological forecast system, within the context of federal coordination and private sector partners, that is responsive and effective.

The Problem

Impacts of:
- Climate change
- Multiple stressors
- Species range shifts
- etc...

affect decisions on

Need timely ecological forecasts to answer ?s

health and resiliency of:
- Fisheries
- Economy
- Public health
- Ecosystems
- Species
- Communities
- etc...

With increasing rates of environmental change, the need for more comprehensive information on our coasts has never been greater.

Our Approach

Future focus

An interdisciplinary approach is key at multiple scales with robust observations to support, validate, and advance predictive capacity.
- Bringing together social scientists, modelers, oceanographers, computer scientists, product developers, communication experts, and end users, it will be possible to develop end-to-end capabilities.
- Utilizing advances in remote and autonomous sensing, machine learning, and the Internet of Things open new possibilities to transform our ability to respond and adapt to ecosystem changes at local, regional, national and global scales.

Fresh ideas and a willingness to work across disciplines will promote innovative ecological forecasting and information delivery, which needs to be a global effort.
- Supporting diversity in the next generation of ocean scientists will increase relevance.
- Scientific and technical innovations must be tested in context of sustained operations.

Representative Example of Current Capacity

*Follow the toxin: Real-time model forecasts risk of domoic acid during 2016 marine heatwave**

Particulate Domoic Acid Forecast

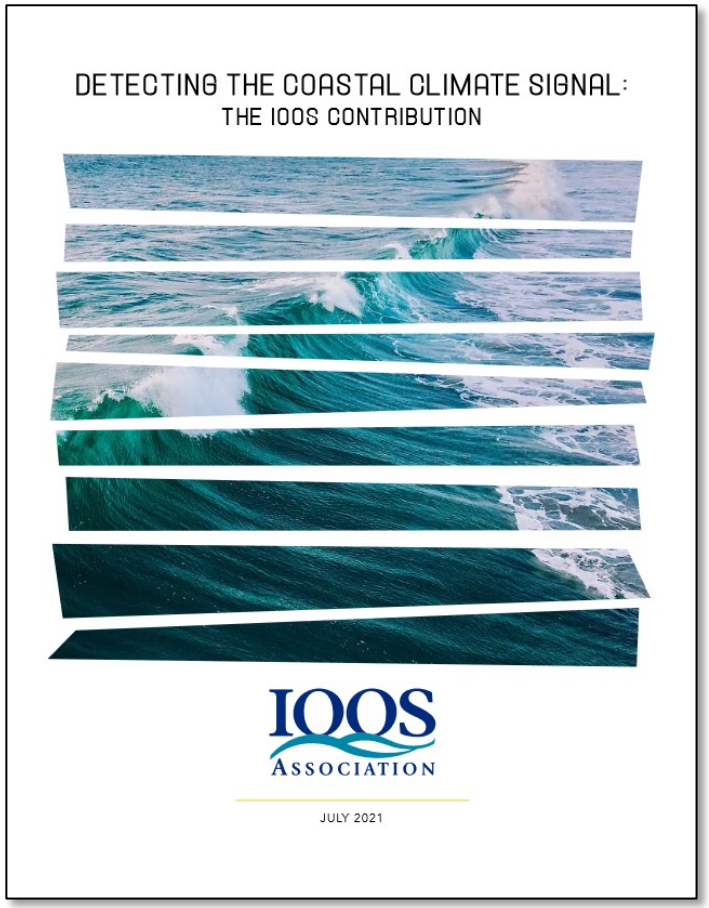
*Daily C-HARM model output produced by SCCOOS and NOAA CoastWatch integrates satellite images, *in situ* observing and crowd-sourced data, and ROMS model physical and biological fields into a unified forecast view.

Via the CA HAB Bulletin, IOOS is providing:
- Local oceanographic conditions that lead to production of neurotoxin
- Stakeholder information needs for HABs
- Forecasts of timing and magnitude of toxin risk for fisheries, aquaculture, marine mammal rescue, public health, and coastal policy

Expected Outcomes
- Stakeholders (e.g., fishermen, shellfish farmers, emergency managers, resource managers, etc.) access forecasts of ecosystem conditions and species to be able to assess risk of an event (e.g., HAB) or threshold (e.g., temperature, hypoxia) being crossed in time to make informed responses to optimize health and resiliency.
- Marine ecological and species forecast information is place-based and technically grounded through co-design utilizing IOOS strengths.
- Interactive tools are provided allowing end users to test scenarios and hypotheses.

International Partners

Novel approaches depend on fresh ideas and a cross-disciplinary approach. We propose design competitions and fellowships to support young professionals from around the world in oceanography, social sciences, and engineering. As the GOOS regional alliance for the U.S., IOOS is well positioned to collaborate beyond our borders.



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