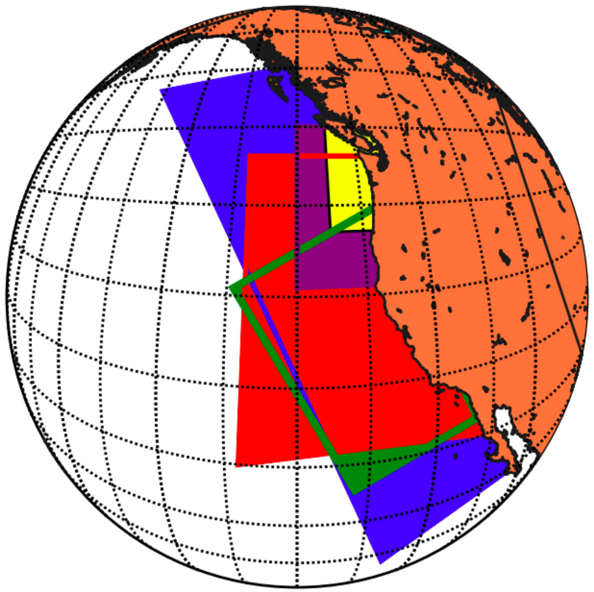
Toward a next-generation coastal observing network for ecosystem (and Marine Life) monitoring and prediction

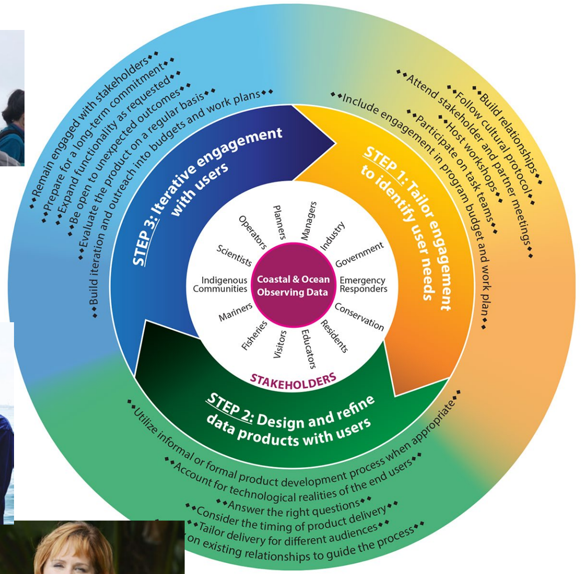
Clarissa Anderson, *Scripps Institution of Oceanography + SCCOOS + CIMEAS*

IOOS Advisory Committee Meeting, 6 December 2022, Washington, D.C.

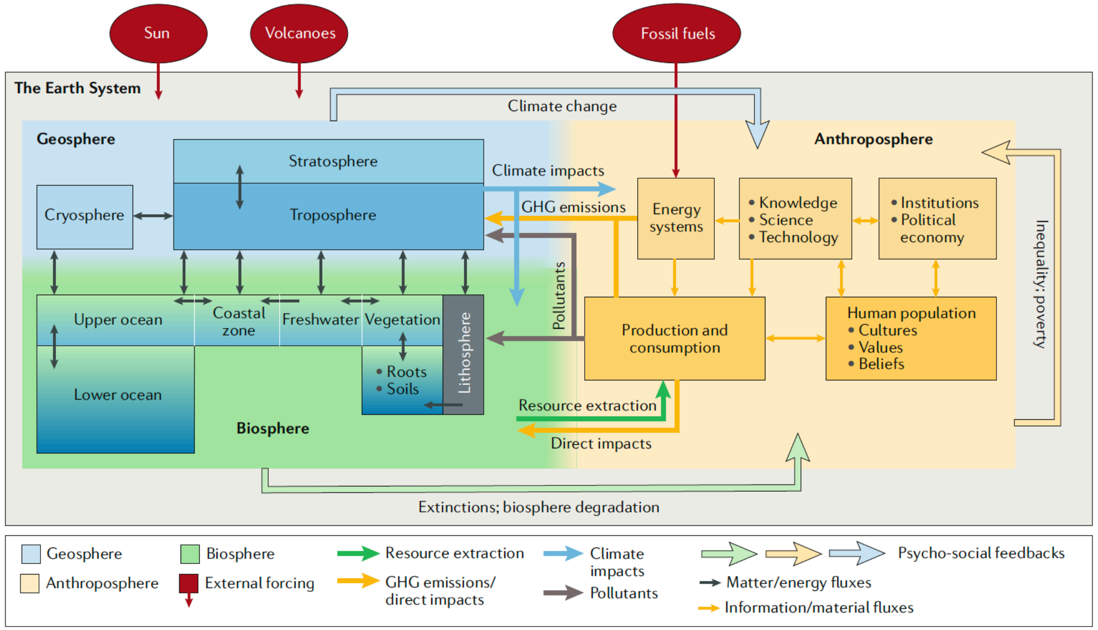


IOOS Coastal Ocean Modeling Testbed (COMT): evaluate impacts on regional models - UCSC, CA, OSU, LiveOcean (UW)

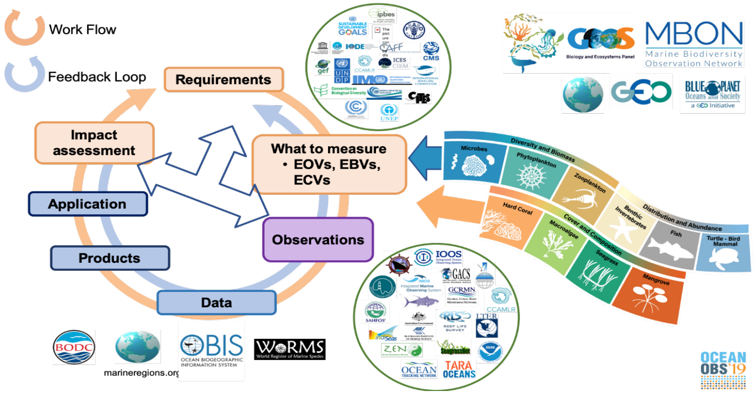
Stakeholder-driven Process to Develop Tailored Data Products



NASA Bretherton Diagram
Updated 2020 ES System



Steffen et al., 2020. The Emergence and Evolution of Earth System Science.
Nature Reviews Earth and Environment



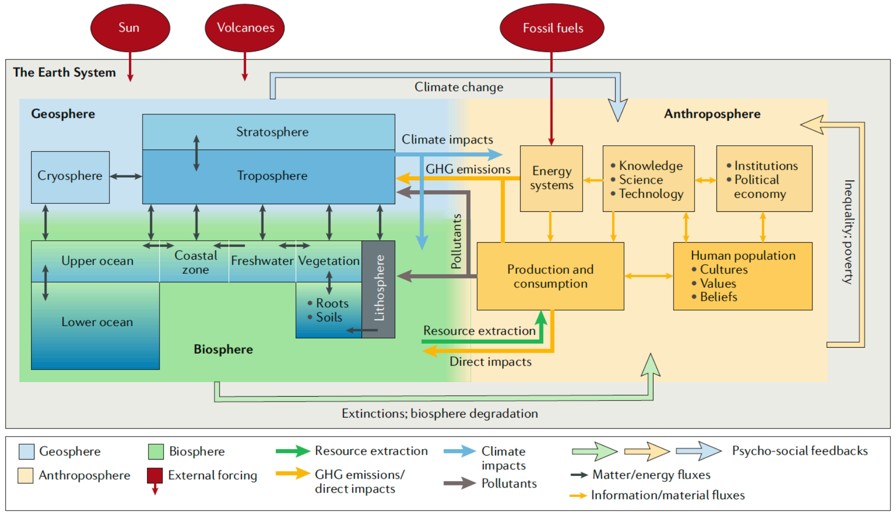
Expected Outcomes/Recommendations:

- Integrate biological observations into the global observing system as an integral and necessary component of ocean ecosystem science and understanding.
- Implement available technologies for biological observing now, maximizing access to biological data and information to quantify, explain, and forecast biodiversity changes.
- Advance decadal plans for a fully encompassing global ocean observing system that integrates biology, biodiversity, physical and biogeochemical observations.

Ecosystem Health and Biodiversity Task Team at OceanObs-19

Bridging Earth System Science and Ocean Observing

Time to bridge the gap between global ocean and coastal ocean science to fully address societal challenges



How predictable is nature? …while questions about predictability cross all disciplines of ecology, there has been comparatively little discussion on the nature of prediction in ecology, from either a theoretical or practical perspective (Evans et al. 2013, Mouquet et al. 2015, Petchey et al. 2015, Houlahan et al. 2017). The importance of ecological predictability for practical applications is clear: **to make ecology more relevant to policy, management, and decision making, we need a better understanding of what we can forecast and how those forecasts can be improved** (Clark et al. 2001, Dietze 2017, Dietze et al. 2017).

M.C. Dietze. 2017. Prediction in Ecology: A First Principles Framework. *Ecological Applications*

NOAA Model for Service Delivery

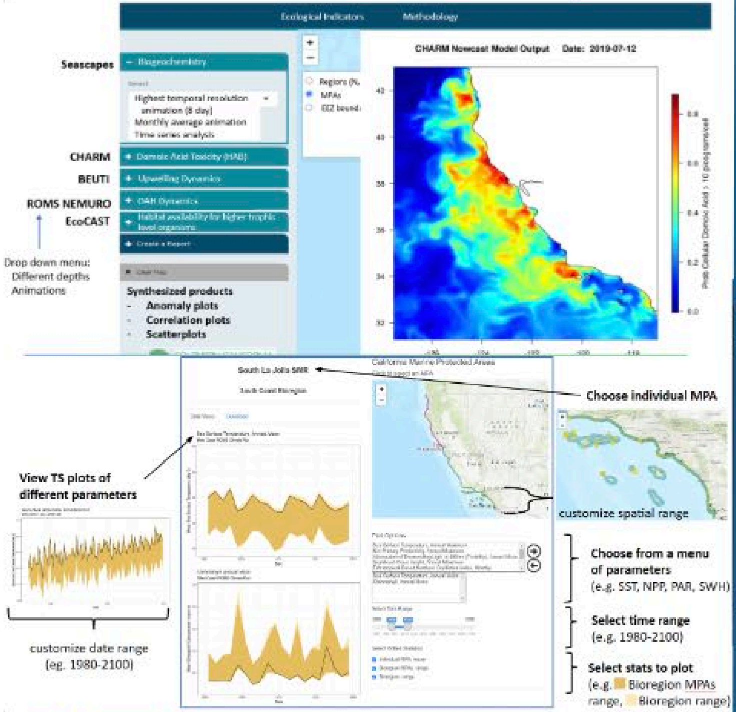
NOAA, 2020. A Model of Service Delivery for the NOAA Water Initiative: *A proven framework for integrating service delivery and decision support*. Authored by the NOAA Water Team

Are Earth System Science and Service Delivery compatible?

NOAA Vision of Service Delivery is entirely reliant on the solutions provided by the ESS Community

MPA Dashboard

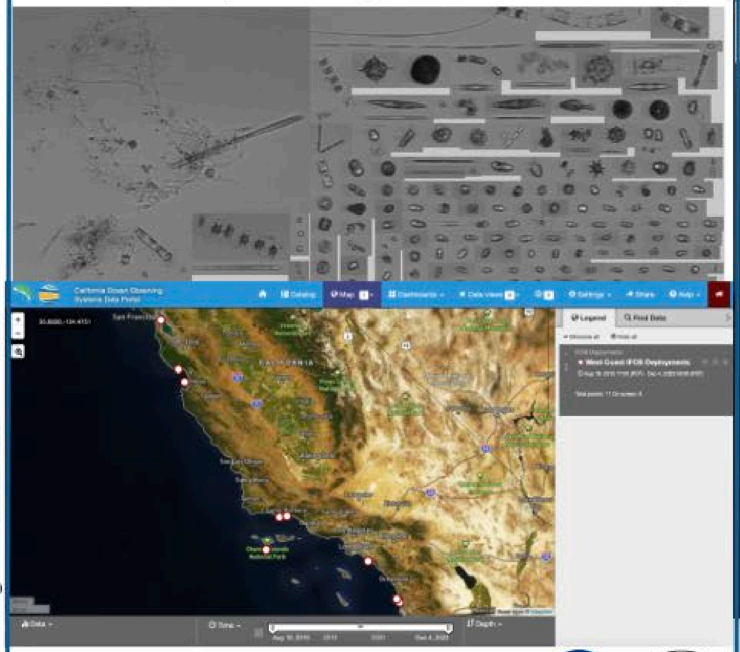
(PI: Ruhl H., Anderson C., Edwards C., Kahru M., Hazen E., Jacox M., Feichter J.)



mpa-dashboard.caloos.org/

IFCB Dashboard

(PI: Anderson C., Abell J., Barton A., Bowman J. Brzezinski M., Caron D., Carter M… & Smith J.,



ifcb.caloos.org/dashboard

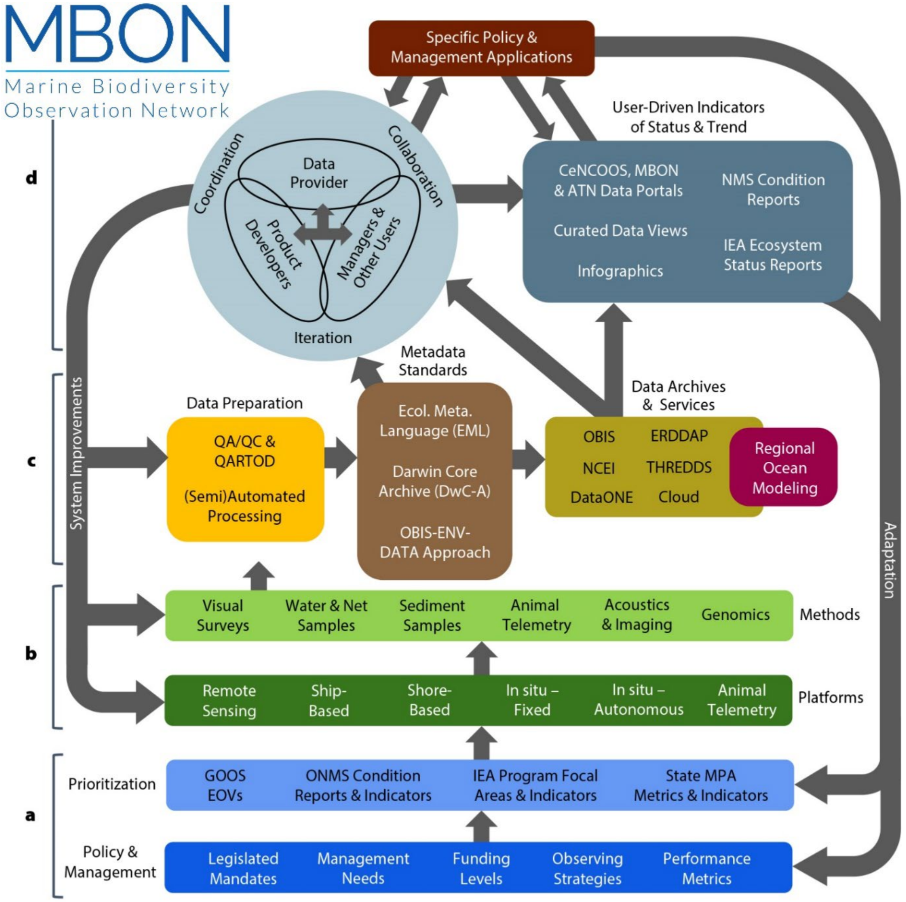
OAH Dashboard

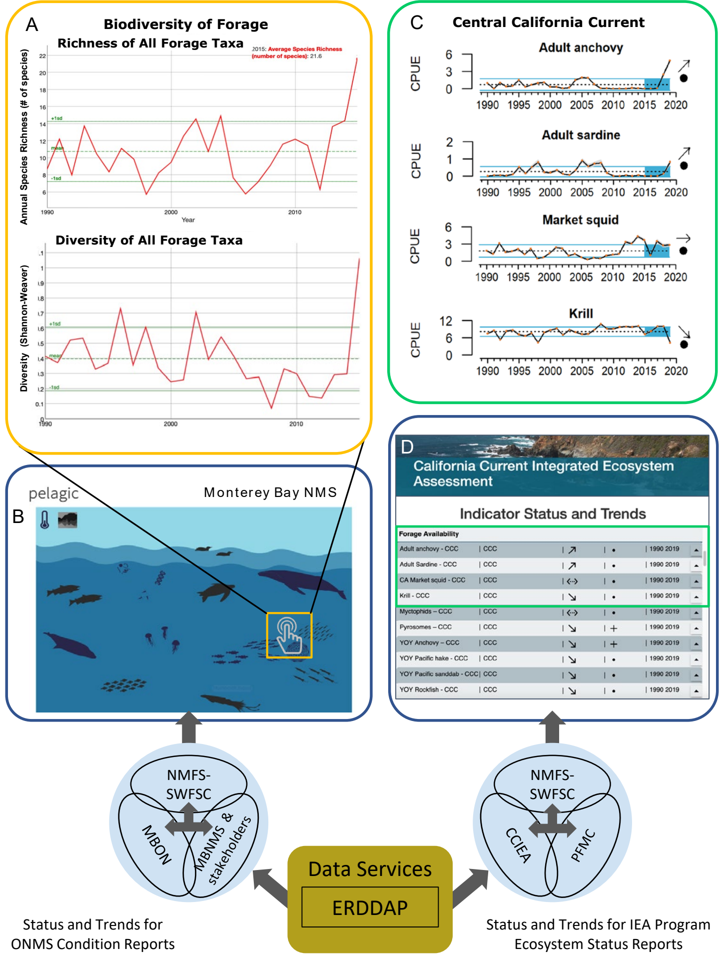
(PI: Harper A., Ruhl H., Anderson C., Newton J., Carini R., Satterwaite E., Bochenek R., Kessouri F.)

oah.caloos.org (beta)

Pan-Regional Products – Climate Change + Marine Life

Goal for 21st c. ocean observing is to facilitate science-based estimates of current & future ecosystem conditions for a range of coastal questions and activities





Slide Credit: Henry Ruhl

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

Ecosystem Science as seen through the lens of Ocean Observing Systems

U.S. Marine Biodiversity Observation Network offers a systems approach + interagency partnership

....but are we missing opportunities within the RA network?

REGIONAL INFORMATION COORDINATION ENTITY
CERTIFIED
INTEGRATED OCEAN OBSERVING SYSTEM
est. 2015

IOOS
Integrated Ocean Observing System

Observations

Data Management

Forecasts/Modeling

User Products

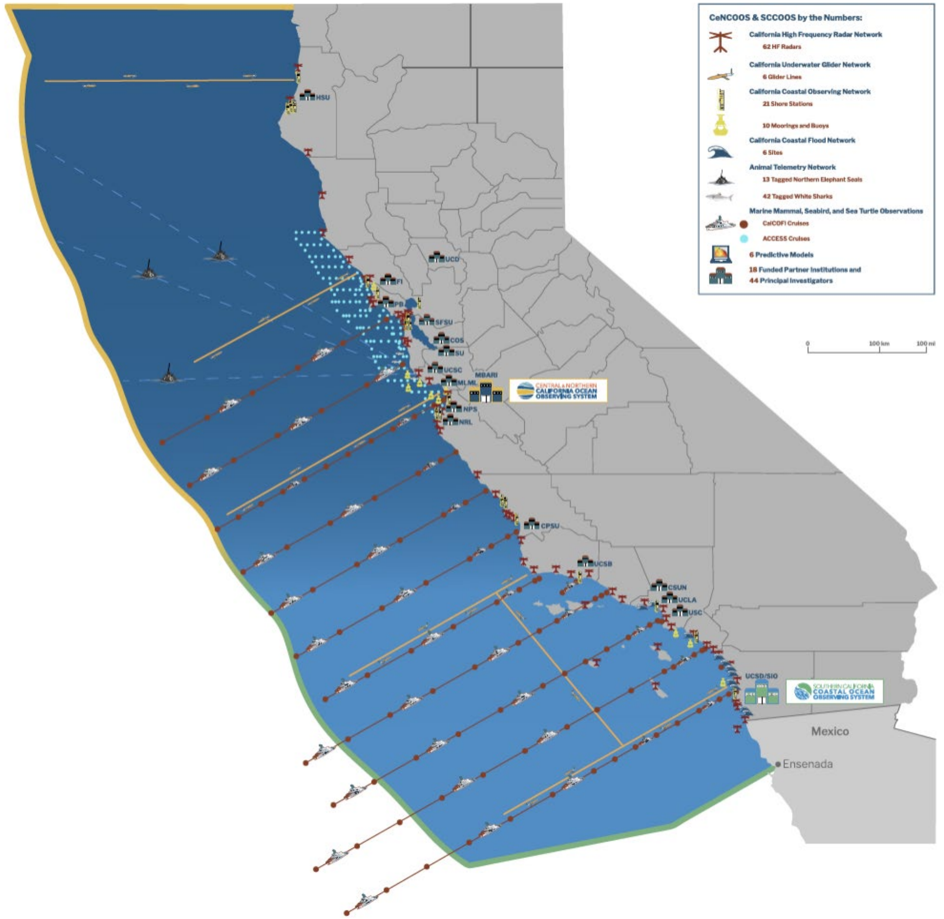
Outreach and Education

Leverage and Link

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM
CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM
NANOOS

CONSISTENT NATIONAL CAPABILITY

DIVERSE LOCAL STAKEHOLDERS



Our Ocean Vision:

A healthy and prosperous California coastal ocean powered by information solutions

Total 30 Projects at $6M/Year, included 45 Principal Investigators from 20 institutions

- Tier 1 - 12 Projects ($3M/yr)
- **Tier 2 - 18 Projects ($6M/yr)**

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

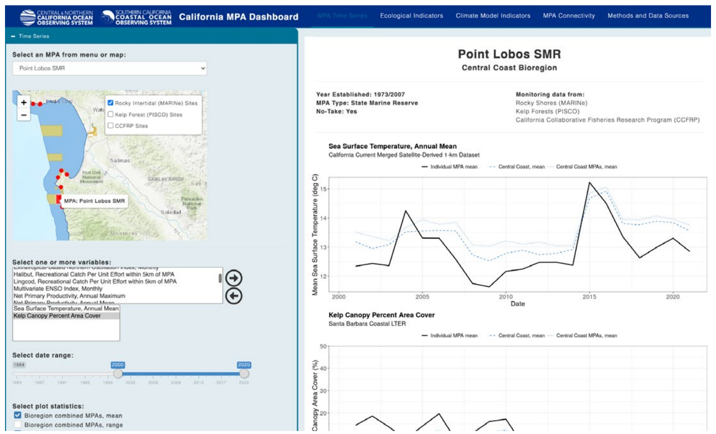
California Ocean Observing Systems – Regional Collaboration

Mission: *To produce, integrate and communicate sustained high-quality, science-based information to promote coastal ocean safety, resilience, and sustainability for all members of society*

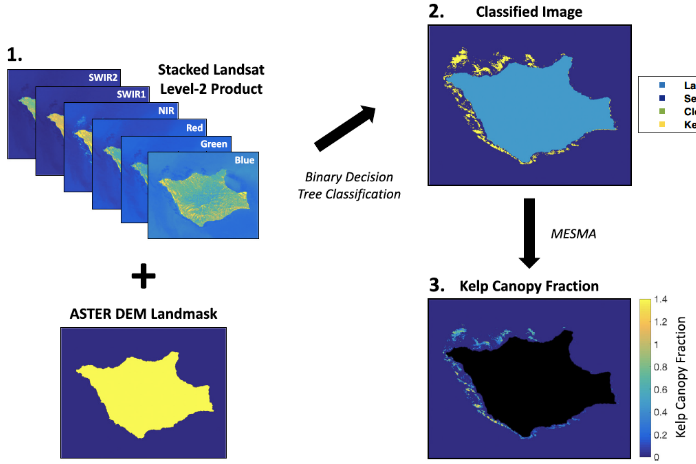
1. Cal OOS Data Portal
2. **CA HAB Bulletin**
3. **Cal HABMAP Dashboard**
4. **California IFCB Network Dashboard**
5. **Marine Protected Area Dashboard**
6. **CalCOFI + Infographics for IEA Assessment/Sanctuaries**
7. HF Radar Hourly Surface Currents Map
8. Automated Shore Station Dashboard
9. California Underwater Glider Network Dashboard
10. **Statewide Kelp Canopy Area/Biomass Dynamics**
11. Multivariate Ocean Climate Indicator
12. California operational 4DVAR ROMS 3km + Drop-a-Drifter
13. West Coast Ocean Forecast System, searchable nowcasts and forecasts
14. **Seabirds on the CalCOFI/CCE-LTER Survey (PI: Sydeman, FI)**
15. SoCal Index (PI Rudnick, SIO)
16. **La Jolla Cove Area of Special Biological Significance Dashboard**
17. Ports and Harbor Dashboard
18. NAVAIR Dashboard (SCCOOS & ADS)
19. Imperial Beach and Cardiff Beach Flood Forecasts (PI Merrifield, SIO)
20. Tijuana Plume Tracker (PI Terrill, SIO)

- SCCOOS/CeNCOOS Co-funded Product
- SCCOOS product only

MPA Dashboard (PIs Ruhl, Anderson, Edwards)



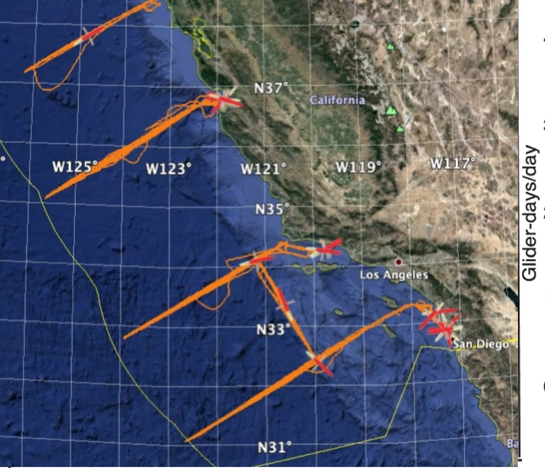
Kelp Biomass
PI T. Bell

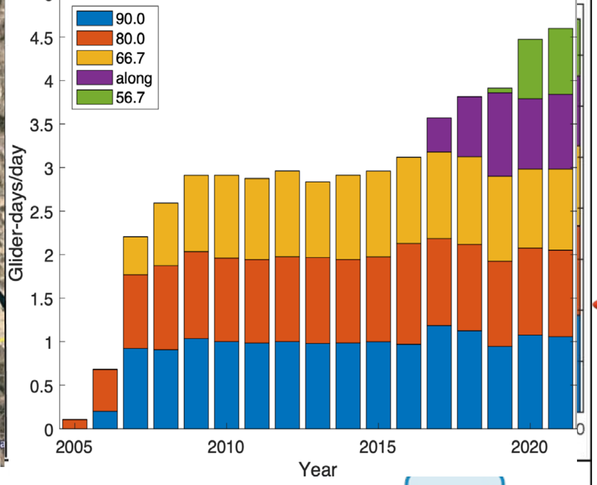


SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM
CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

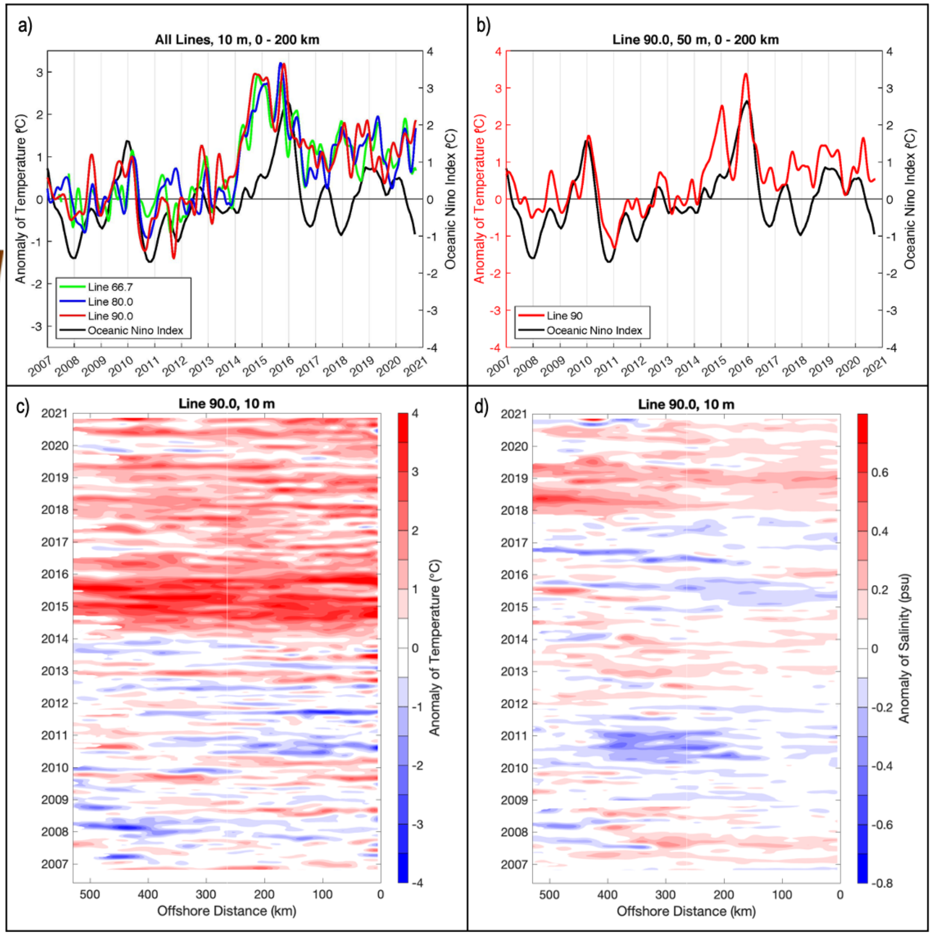
Ecosystem State Products for Stakeholders – at least 13 shared products

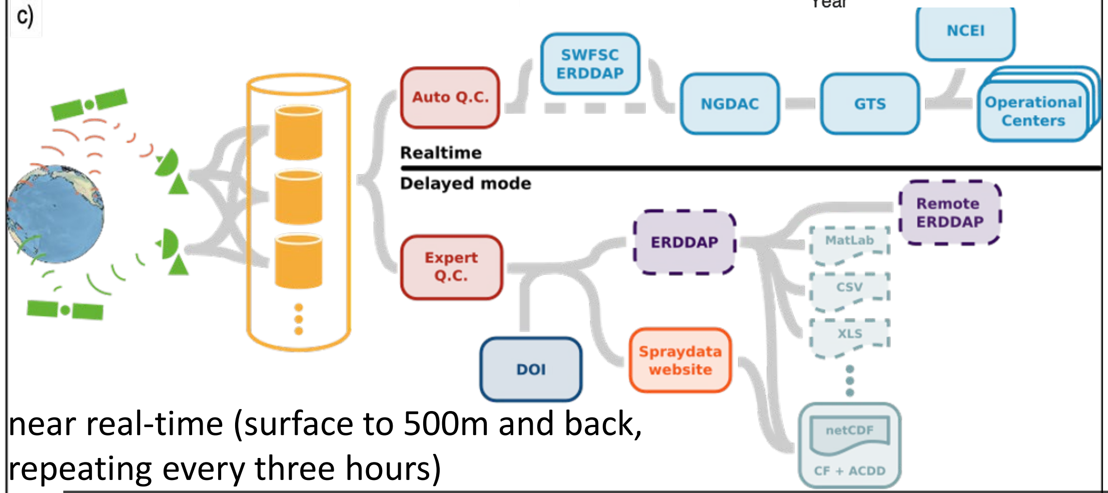
- *Bringing in new PIs with each funding round or via collaborative, extramural proposals to NOAA, NASA, NSF etc.*
- *Ensuring that the best science is transitioned to operations to build a fully end-to-end system*





PI: D. Rudnick
(UCSD)





near real-time (surface to 500m and back, repeating every three hours)

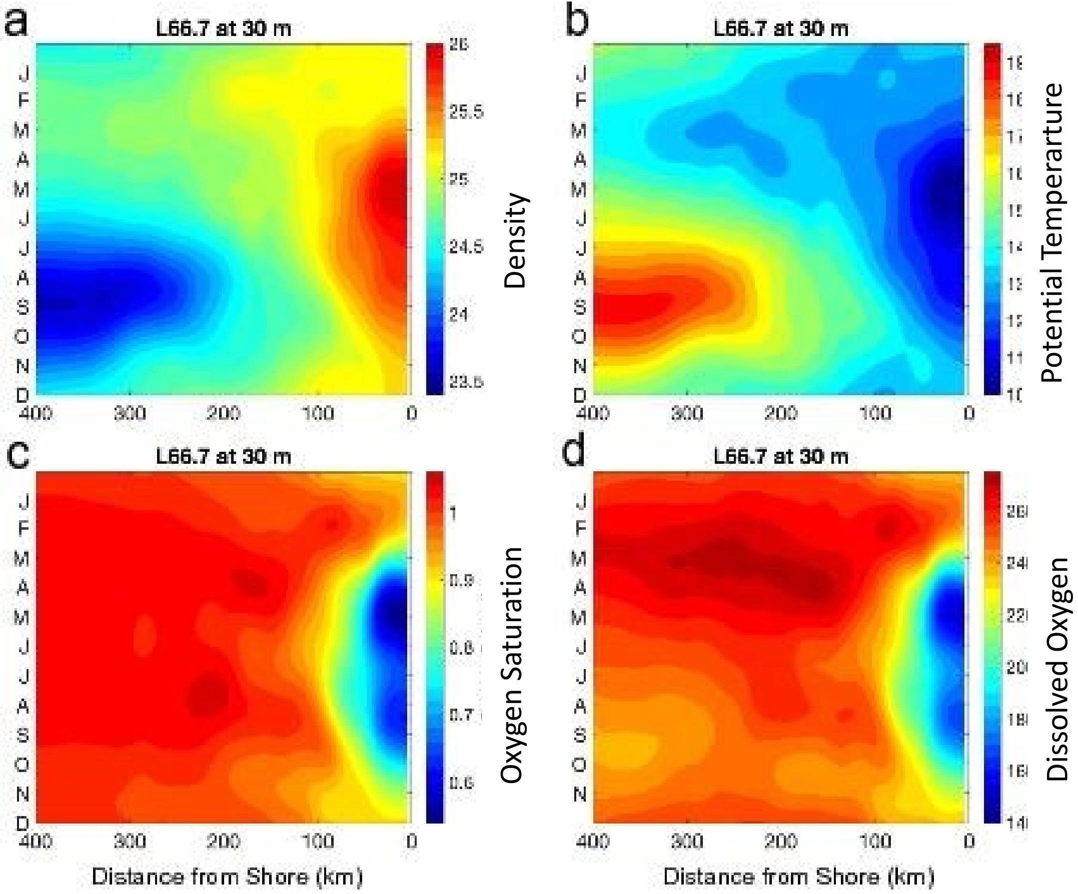
SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

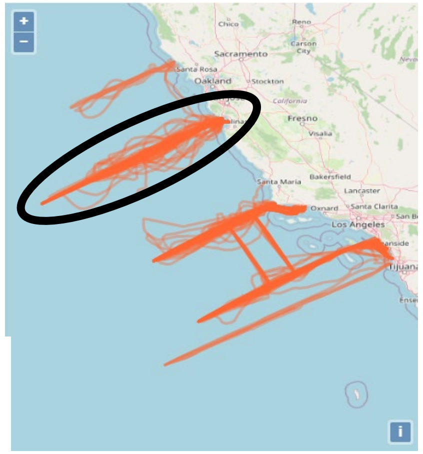
NANOOS

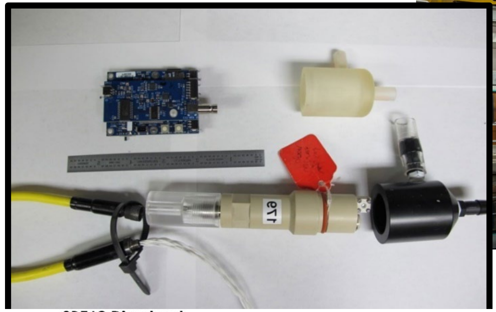
California Underwater Glider Network

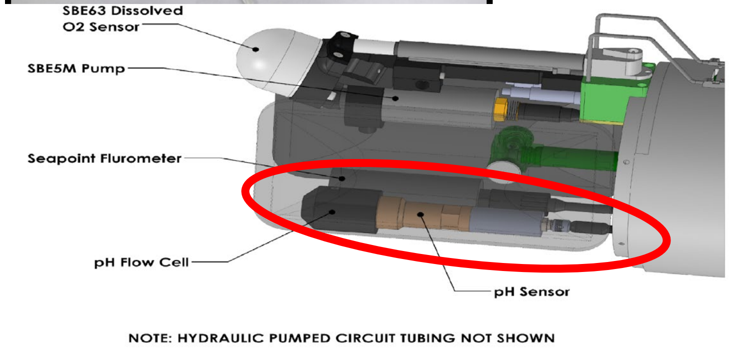
SIO Spray Glider program provides essential information on subsurface heat content and ocean state of coastal California in relation to the Pacific Basin, especially the equatorial Pacific

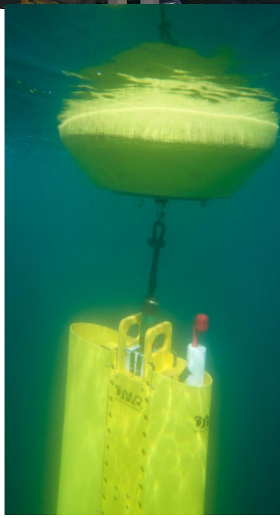


Annual O_2 Cycle









Yui Takeshita, MBARI
Alice Ren, SIO

- Deep-Sea-Durafet pH Sensor
- Seabird 63 w/ DO sensor
- ISUSv2
- Planktivore Camera

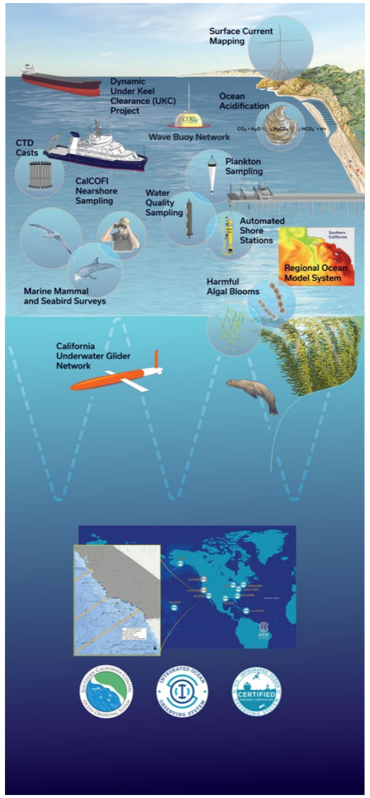
T
Takeshita et al. 2021

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM
CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

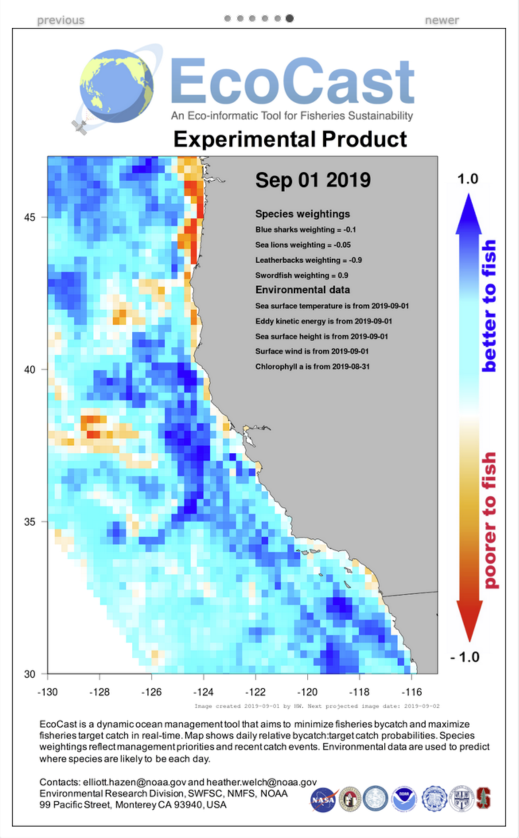
Biogeochemical-Eco Gliders – moving towards Spray 2 glider recap

Need collocated measurements on sustained glider lines to capture the coastal climate signal, establish baselines for change, and provide the raw material to improve ecological forecasts

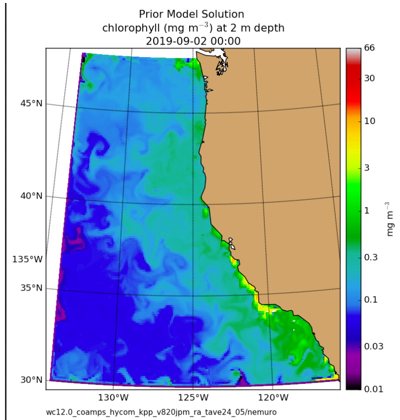
Observational Impacts in Data Assimilation

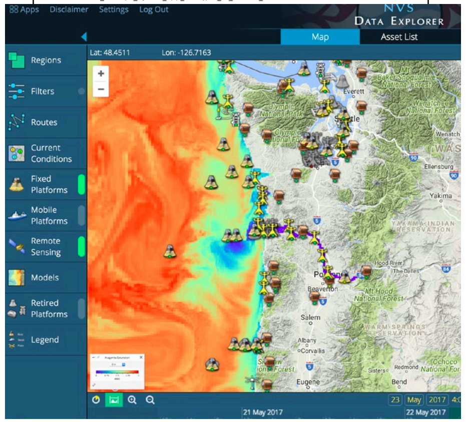


Fisheries Habitat



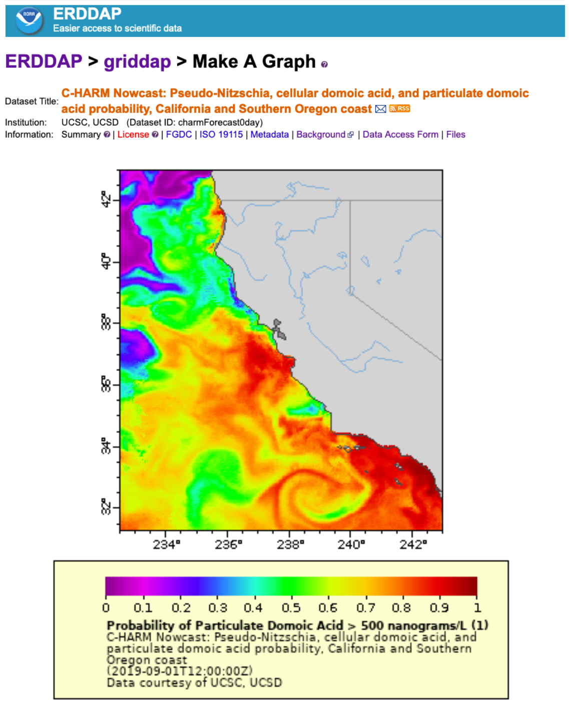
Ocean Acidification & Hypoxia





Harmful Algal Blooms

C-HARM Model (California-Harmful Algae Risk Mapping)



SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM
CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM
NANOOS

IOOS West Coast Coastal Ocean Modeling Testbed

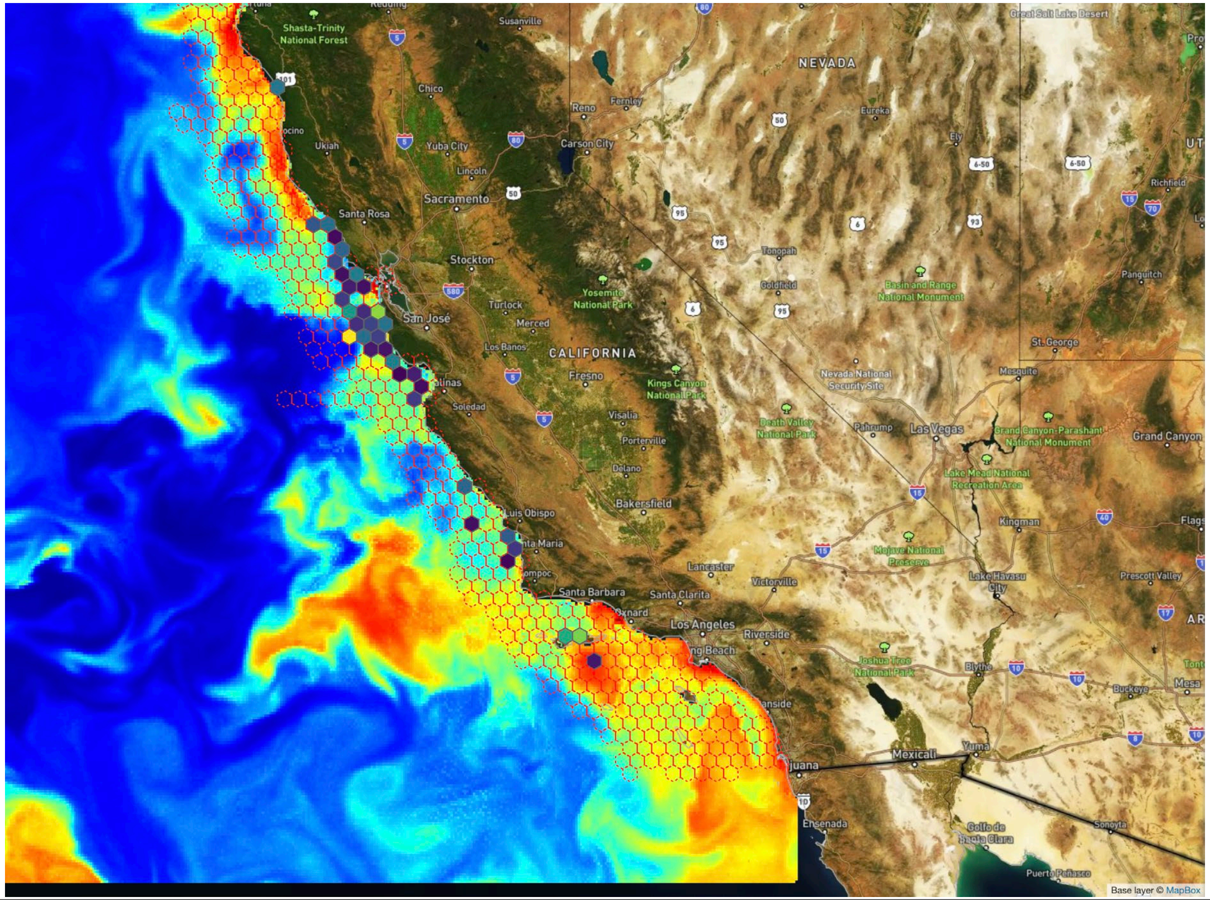
Evaluating impacts of operational NOAA West Coast Ocean Forecast System on existing /planned Ecological Forecasts

NOAA

SIO/SCCOOS

Rick Stumpf
NOAA

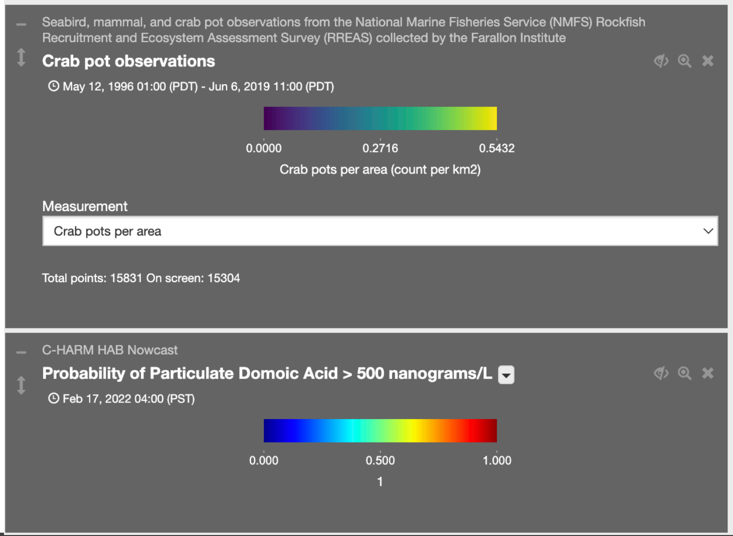
Dale
Robinson
NOAA



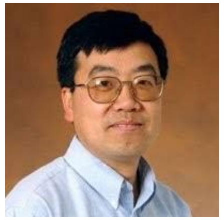
CalOOS Portal

Particulate Domoic Acid February 2022

Crab Pot Locations Overlayed



Raphe Kudela
UCSC



Yi Chao -
Seatrec

California Harmful Algae Risk Mapping (C-HARM) System

Operational model at NOAA Coast Watch provides spatially explicit nowcasts and 1-3 day forecasts of domoic acid risk in the California Current – synthesis in CA HAB Bulletin

Anderson et al., *Harmful Algae* (2009), *Geophysical Research Letters* (2011), *Harmful Algae* (2016)

Imaging Flow Cytobot Network

Leads: C. Anderson,
R. Kudela, A. Barton, K. Kenitz,
U. Send, F. Chavez, H. Ruhl

- **Largest IFCB array in the world**
- Close to having 9 IFCBs running in real-time, most at stations with full hydrological and nutrient sampling suites
- 12 IFCBs total in the network
- O&M now covered via IOOS/NCCOS support to SCCOOS and CeNCOOS (NHABON Pilot Projects)

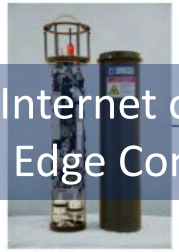
CA IFCB Network – HAB alerts + ecosystem science

We are using extramural funds and state support to build a statewide ecological observatory

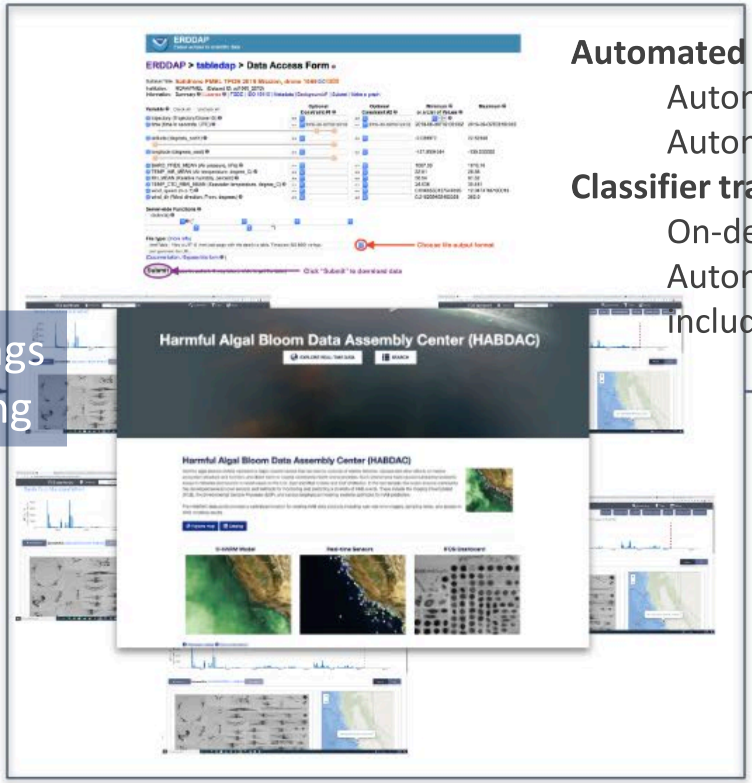
NOAA NCCOS PCMHAB Project to build a national repository & computational framework for IFCB data –

Central clearing house where Level 1 data are QCd, Level 2 and 3 products generated

HAB Data Assembly Center (DAC) Development



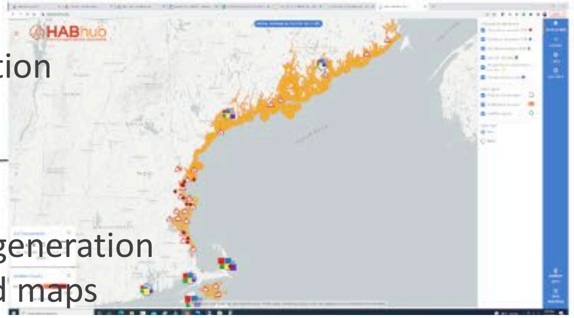
Internet of Things
Edge Computing



Automated data accession
- Automated image product generation
- Automated image product access

Classifier training and evaluation tools
- On-demand classifier application
- Automated **level 2 and 3** product generation including summary time series and maps

WHOI, PI Brosnahan, MERHAB



Team Leads

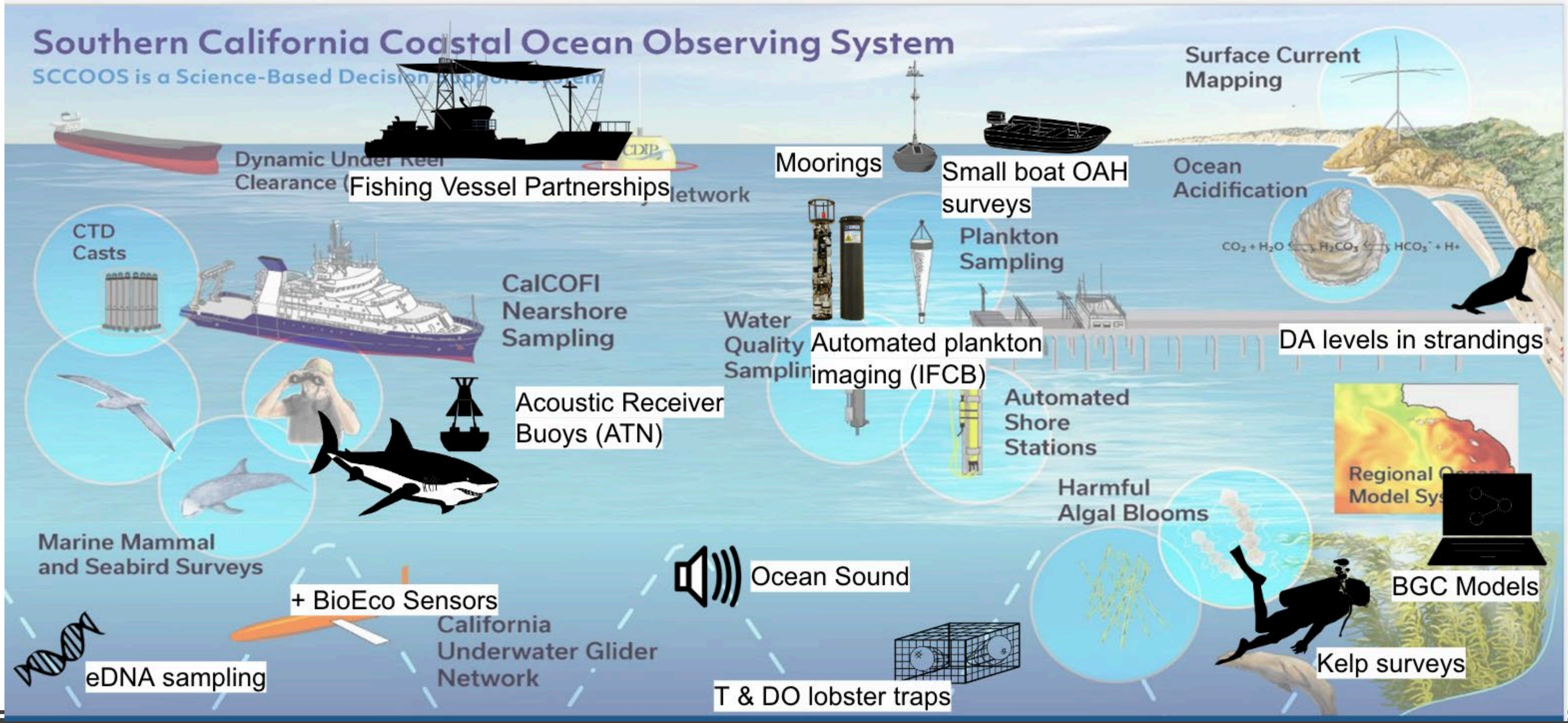
C. Anderson, SIO
R. Bochenek, ADS
H. Sosik, WHOI
S. Beaulieu, WHOI
H. Ruhl, MBARI
R. Kudela, UCSC

Regional Decision-Enhancing Products

NOAA NCCOS

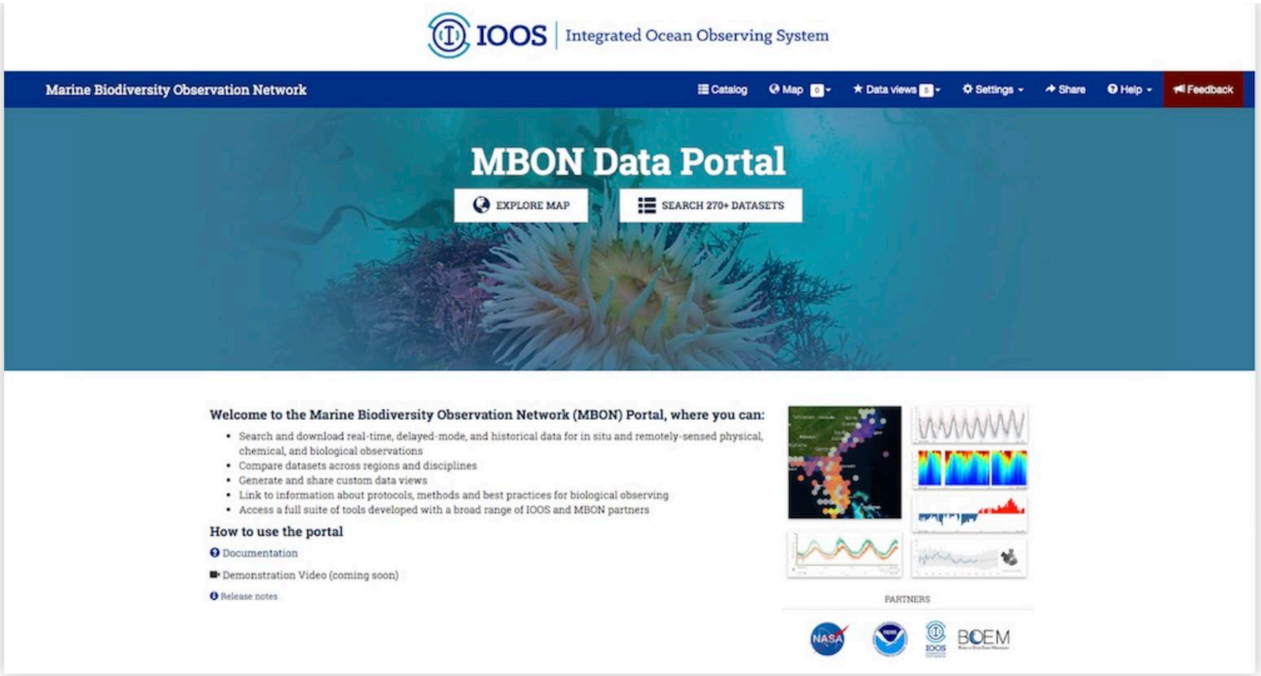
"Plankton/Microbial" Database scaled up to national programs

Ocean Observing systems driving creation of community analysis tools for facilitating downstream improvements in ecosystem science and prediction

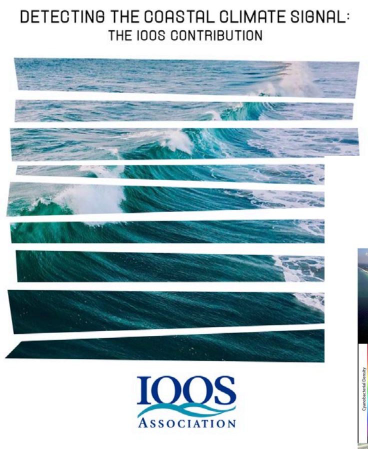


So… what does it take to build an end-to-end observing system from physics to marine life?

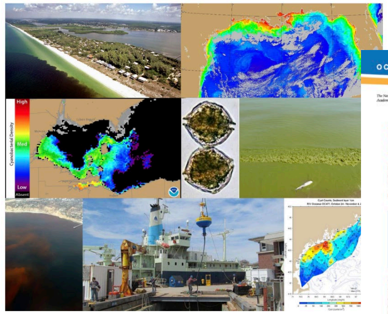
- *IOOS consistently underfunds the regional ocean observing systems – can't get to Tier 2!*
- *Requires at least double the investment to build out a true ecosystem monitoring and prediction system*



IOOS Association initiatives to consider from perspective of the MBON Framework:



Framework for the National Harmful Algal Bloom Observing Network: A Workshop Report



National Centers for Coastal Ocean Science and U.S. Integrated Ocean Observing System
National Oceanic and Atmospheric Administration

December 18, 2020

Revisit MBON – *how do we grow the vision within NOAA as a whole?*

Interagency mission with NASA, BOEM, IOOS support – what are the operational objectives?

- *Ocean Observing of Marine Life is not restricted to IOOS, which is a 17-agency program in theory*
- *Need to leverage all observing efforts and build on the rich legacy of investment across the IOOS Regions*

RECOMMENDATIONS

- Next-generation observing systems must take advantage of current RA investments from a variety of sources, i.e. honor legacy “backyard” time series but move forward deliberately and intentionally to include marine life observations

- Leverage interagency resources to meet global to coastal observing requirements – NEW PARTNERSHIPS

- Skillful ecosystem prediction will require robust sensor suites on fixed and Lagrangian platforms (cross and alongshore scales), complemented by successful and fully funded biological/ecological monitoring programs

NOTHING ELSES LIKE THIS EXISTS IN THE USA!

(or anywhere)

- HOW? 1. Fill critical gaps in marine life and biodiversity observing through top-down investment in R2O from MBON to all regions. 2. Encourage a grass-roots RA initiative around marine life with several flagship programs or motives (e.g. NHABON, Ecological Forecasting, centralized biological DMAC).

Need slide on WC Biology Workshop
And ESON