OA and HABs in coastal ecosystems: a multi-stressor perspective from the Northern California Current

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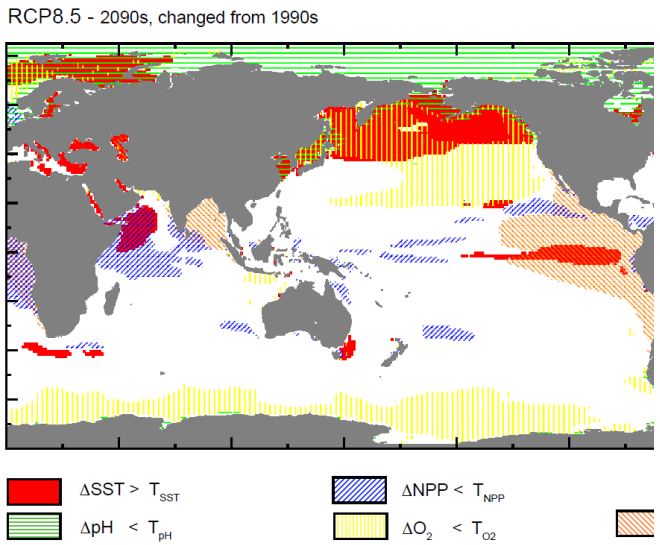
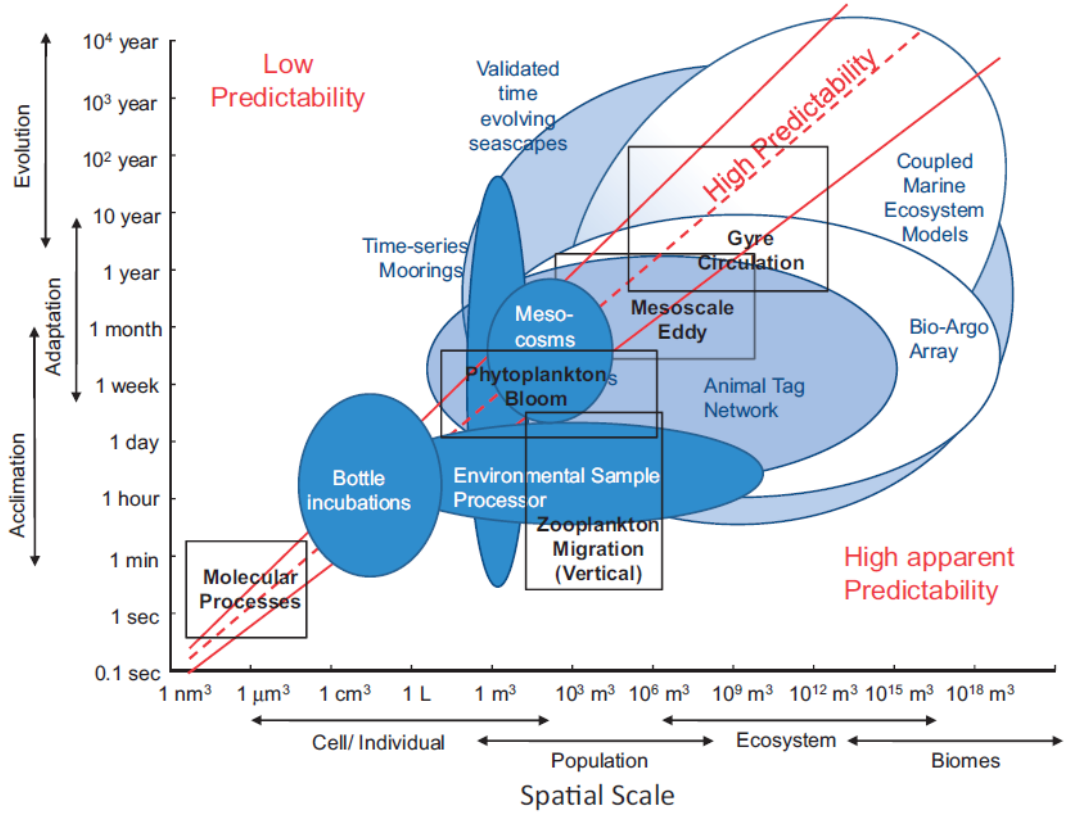
S. Siedlecki (U.Conn), V. Trainer (UW), S. Moore (NOAA)

- How systems and communities will respond/reorganize to multiple, overlapping stressors is unknown.
- Organisms respond on multiple time-space scales and levels of biological organization. But baselines are sparse.
- The ocean moves and species responses are non-constant.
- Coastal physics/chemistry exacerbate these challenges… community partnerships*a*

One view of the problem



Bopp et al., 2013



Kavanaugh et al., 2016

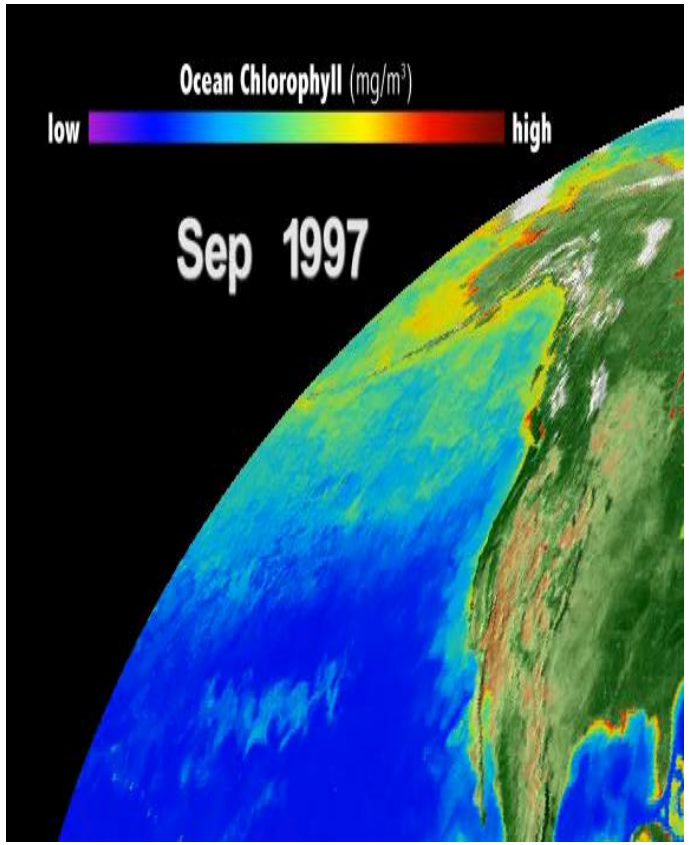
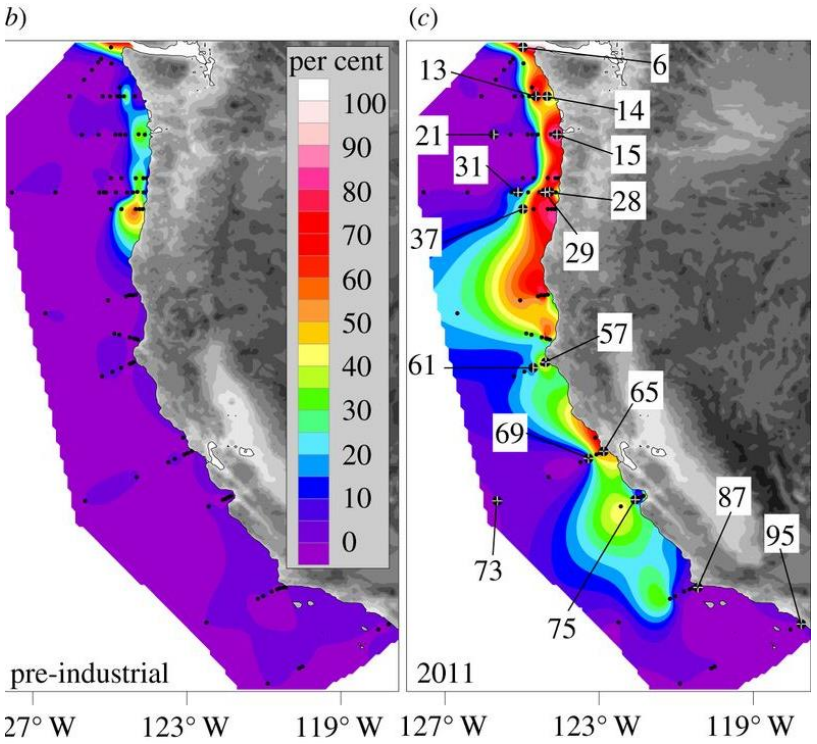
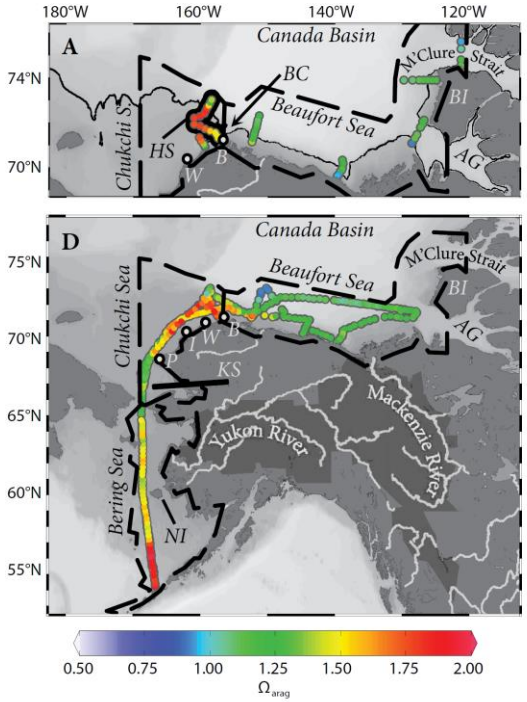
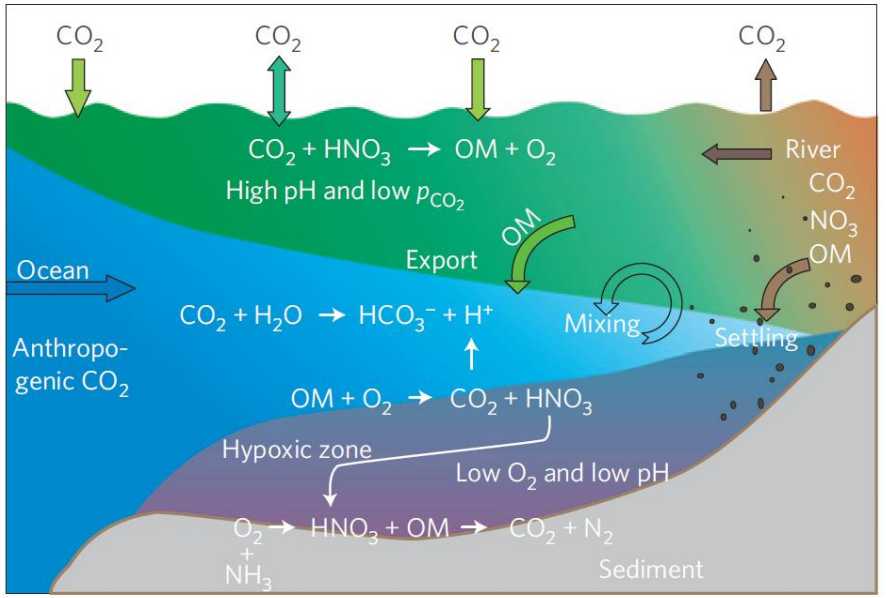


Image: NASA

Coastal processes affect OA signatures







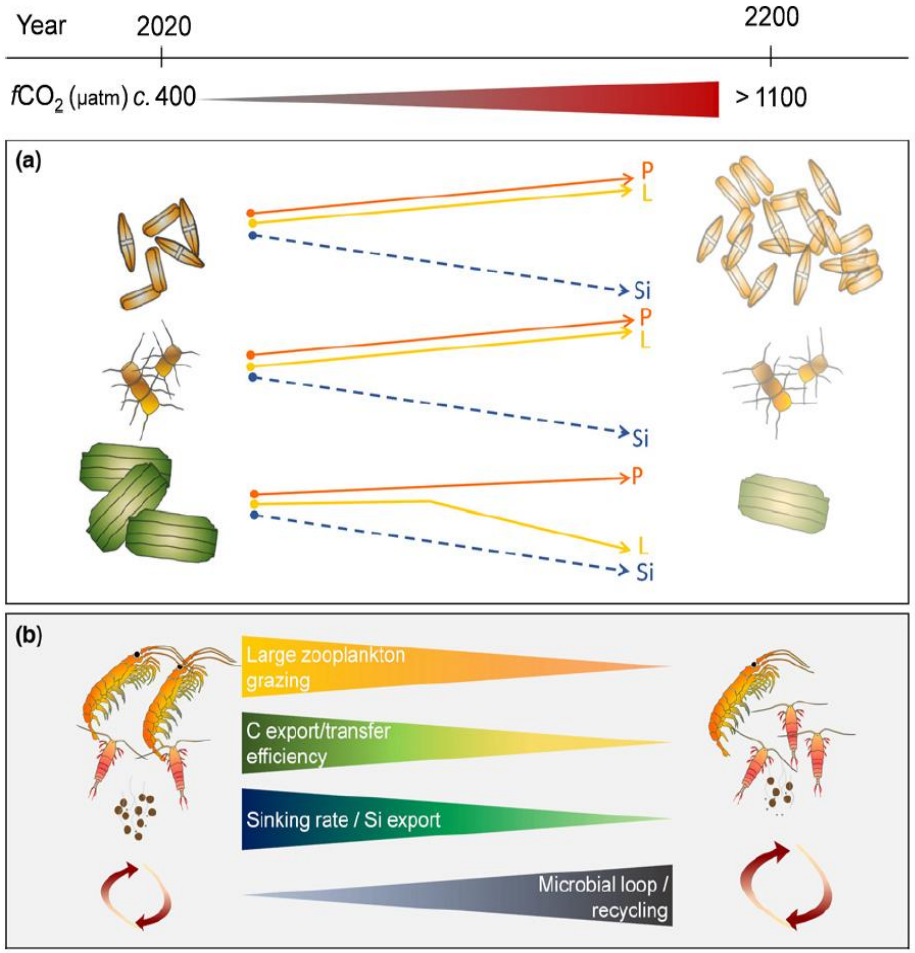
[Doney et al.. 2020; Bednarsek et al., 2014; Evans et al.,2015; Cai et al., 2011]

Doney SC, et al. 2020.
Annu. Rev. Environ. Resour. 45:83–112

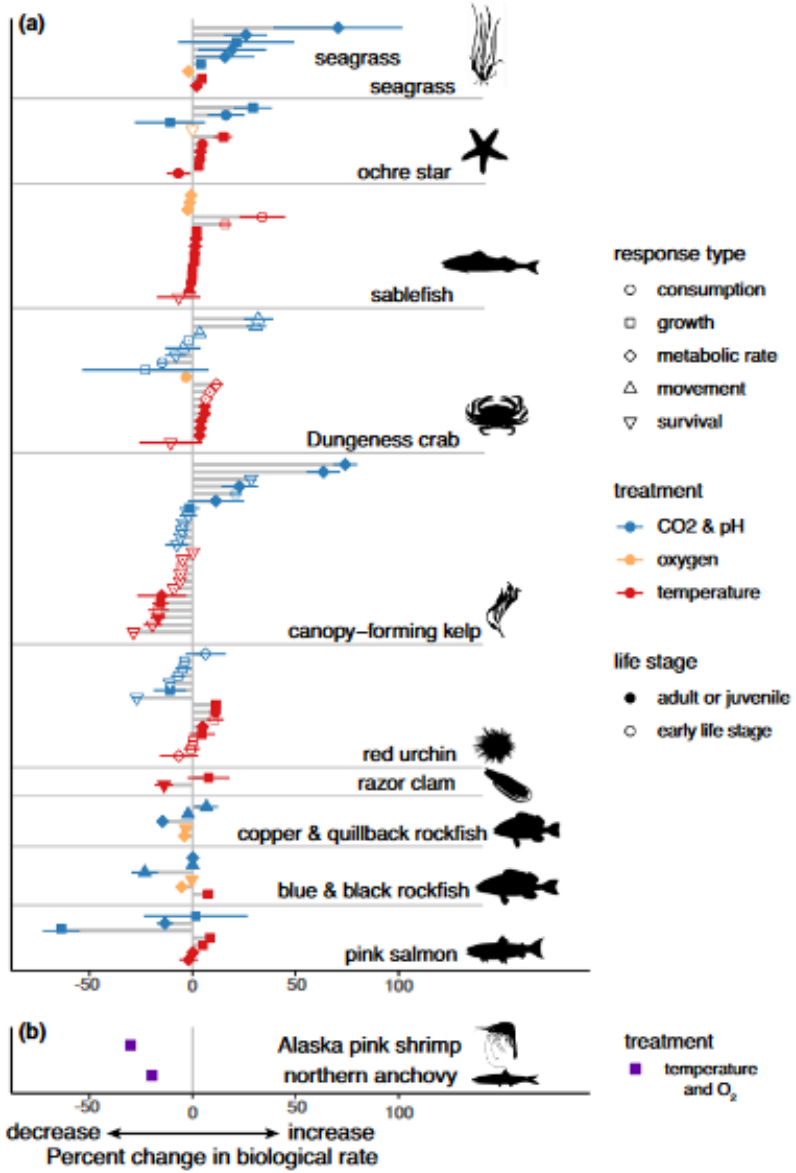
Beyond calcifiers: foundations and food webs

Image: ODFW

Image: INaturalist.com



Duncan et al., 2021; Petrou et al., 2019

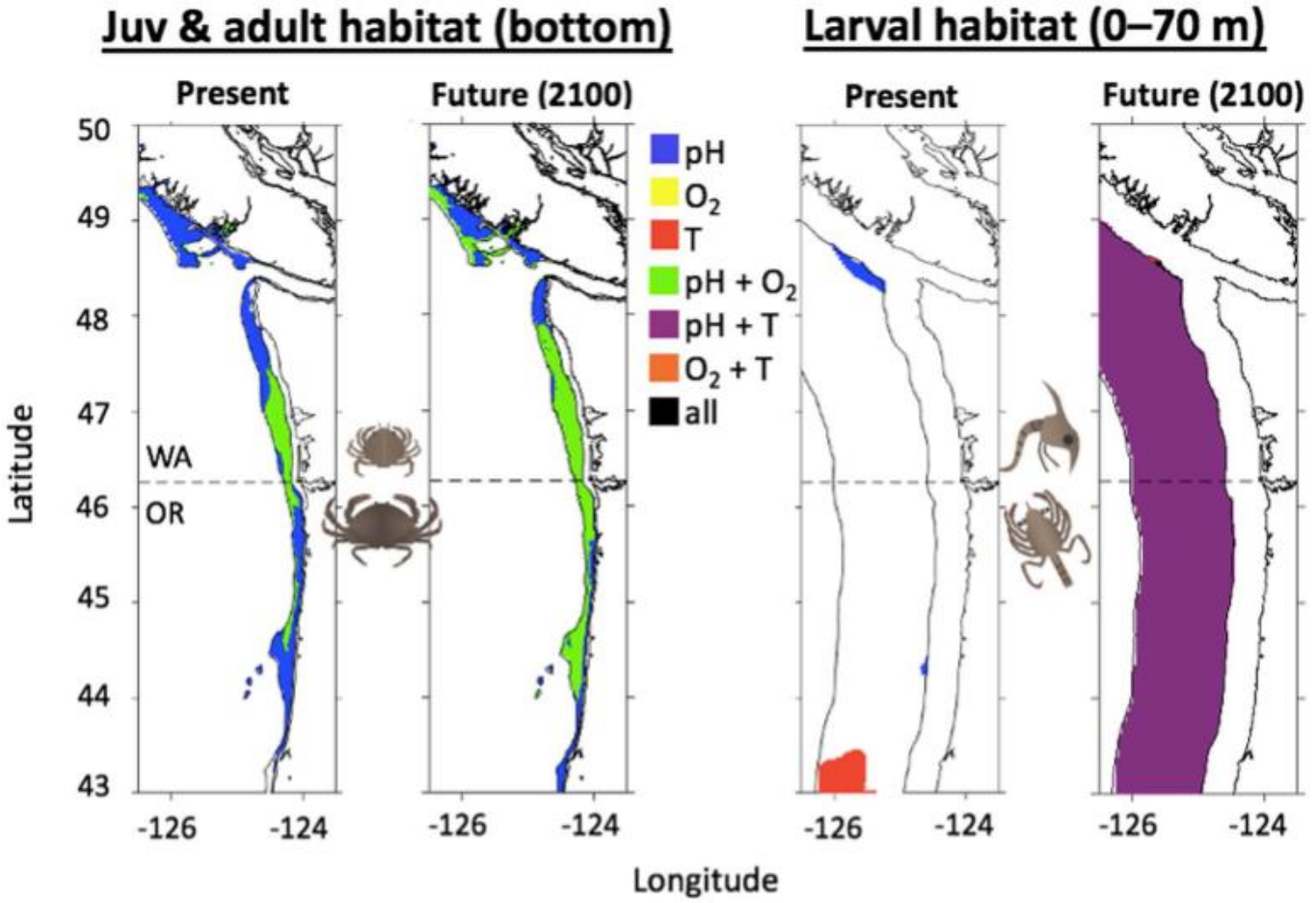


Sunday et al., 2022

But we still have a lot to learn about multiple stressors: non-stationary responses and interactions

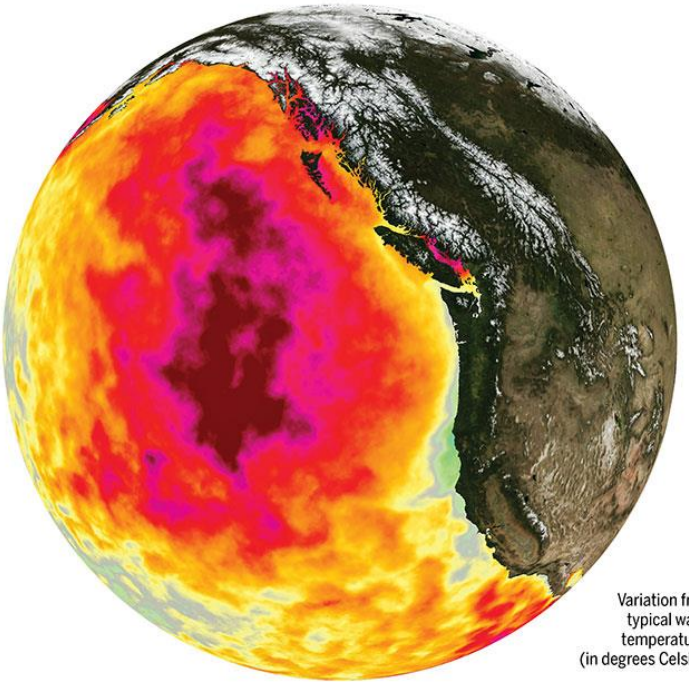
Research priorities:

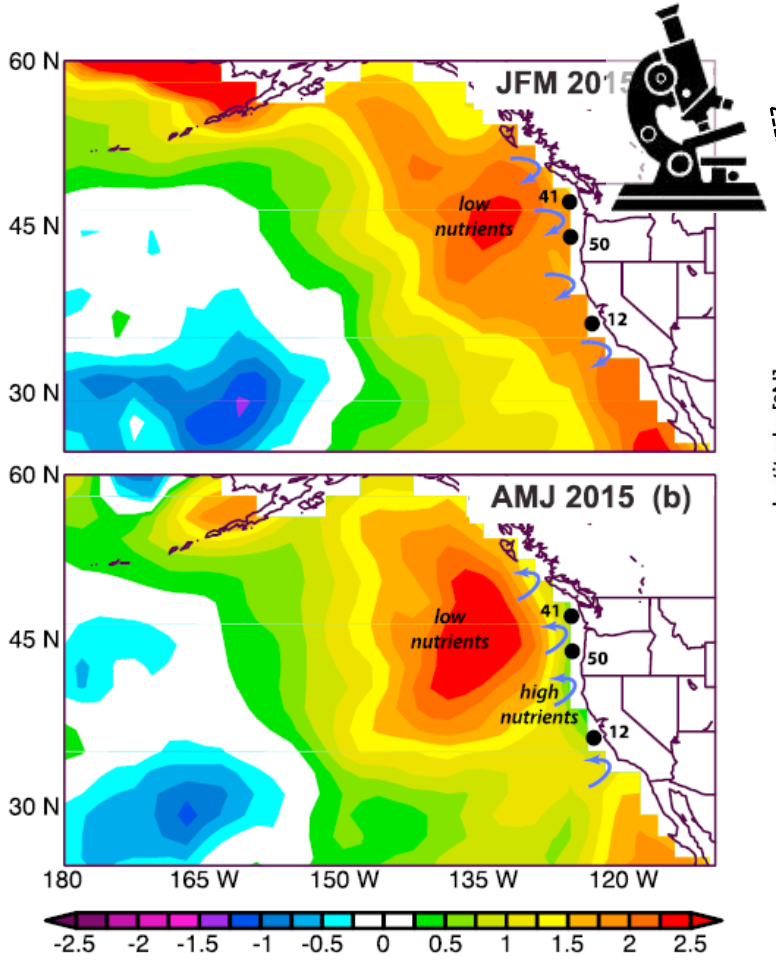
- Thresholds, tipping points, and interactions,
- Carbonate system as multiple stressor (e.g. separate effects of pCO2, aragonite, pH) and as part of multistressor (w/SST, HABS, hypoxia)
- Life history and trophic models; carryover effects;
- Regional modeling, attribution, and access to HPC

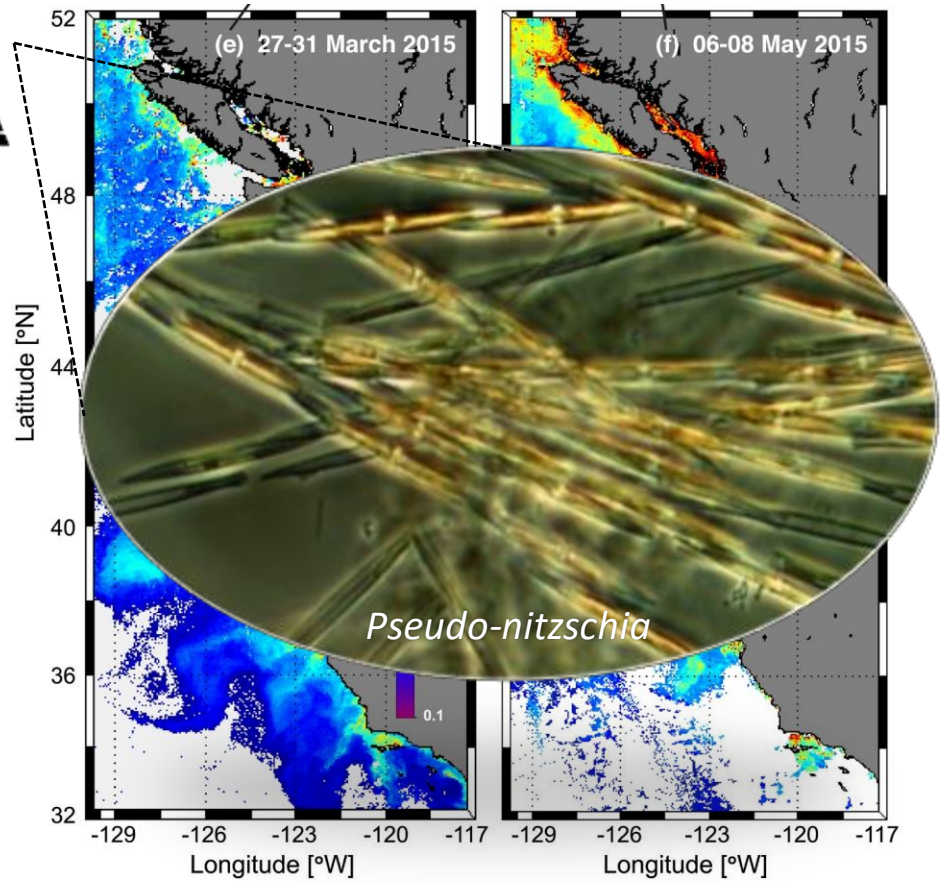


Berger et al., 2021; AGU Advances

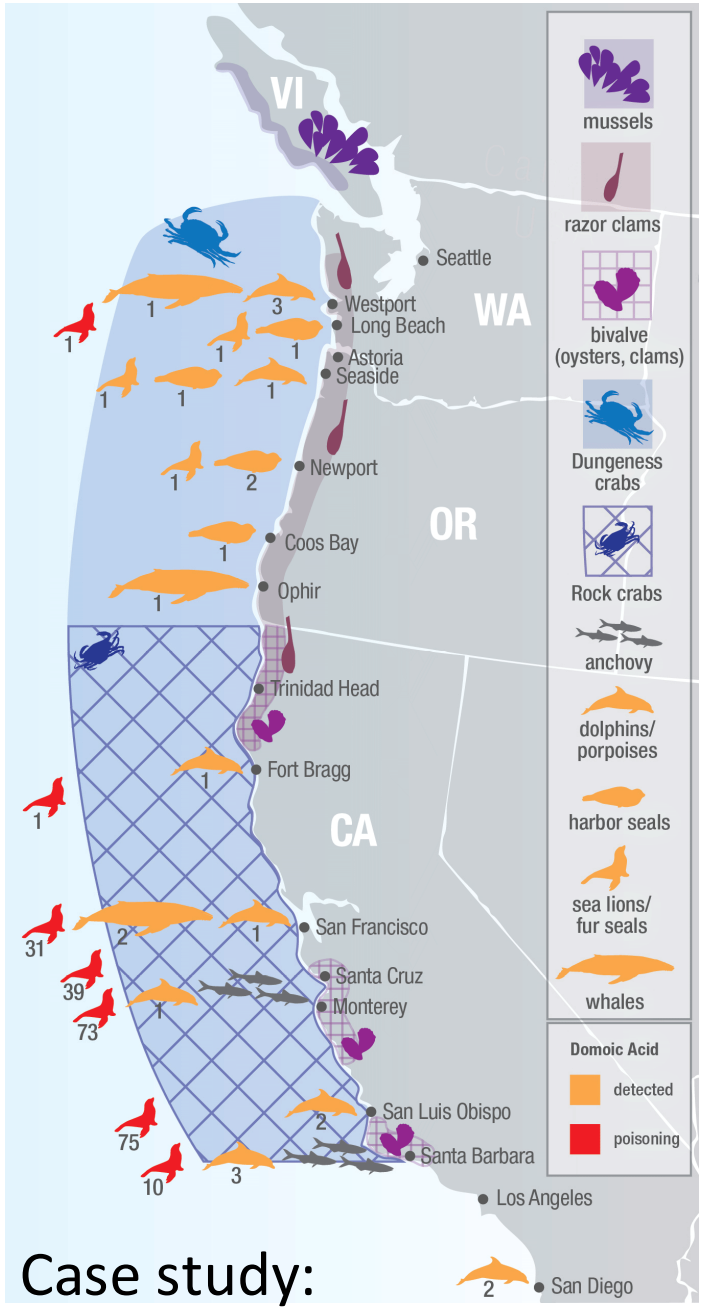
Harmful Algal Blooms: Adaptive Solutions are hard-earned, growing, but still reactionary and need mechanistic insight







[McCabe et al. 2016: Geophysical Research Letters, McKibben et al., 2017 PNAS]



Biggest-ever toxic algal bloom hits West Coast, shutting down shellfish industries

Posted Jun 16, 2015

By Tom Hallman Jr. | The Oregonian/OregonLive

Dungeness Crabbers Hit Hard By Algae Bloom On Washington Coast

By ASHLEY AHEARN • 18 HOURS AGO

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Crabber Tom Petersen would rather have his crab pots on the floor of the Pacific, but a toxic algae blo prompted health officials to close the south Washington coast to commercial and recreational crabbin

California's commercial Dungeness crab season postponed indefinitely over toxin risk

Kory Cropper, left, loads crab traps into the Amber Lynn before the start of the dungeness crab season in Bodega Bay on Wednesday, November 13, 2013. (Conner Jay/The Press Democrat)

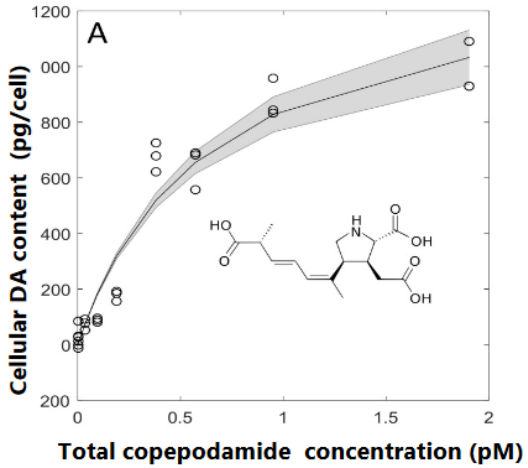
..also a surge in foodbank usage

Case study: Stephanie Moore, NOAA NWFSC

[McCabe et al. 2016: Geophysical Research Letters]

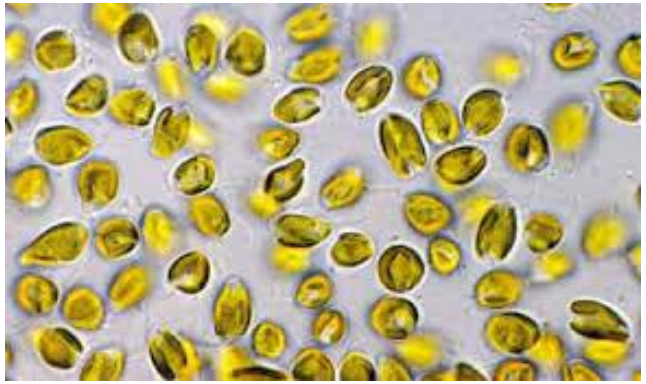
HAB Research priorities

- Prediction of blooms and toxicity: nutrient stress, grazing response, and context dependency
- Ecosystem effects: direct and indirect
- HABs as part of multistressor (w/SST, OA)
- Effects of cumulative low level exposure–ecosystem and humans.
- Development of accessible monitoring tools: Imaging, spectral/satellite, eDNA
- Training Next Gen: taxonomy, instruments, omics



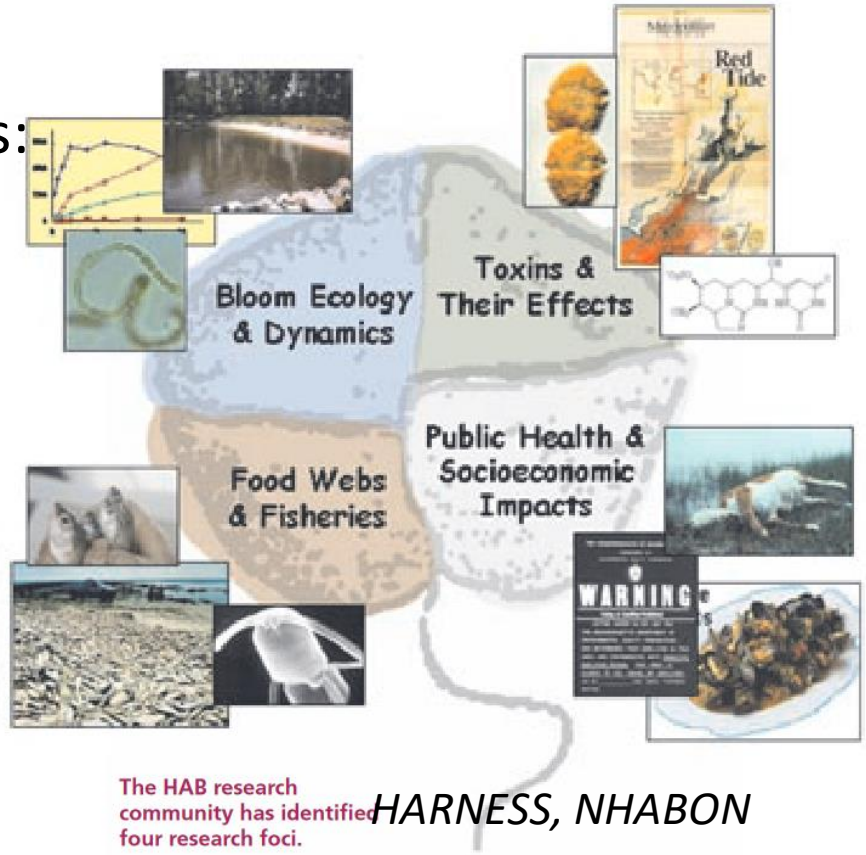
Selander et al., 2019

IFCB, McLane

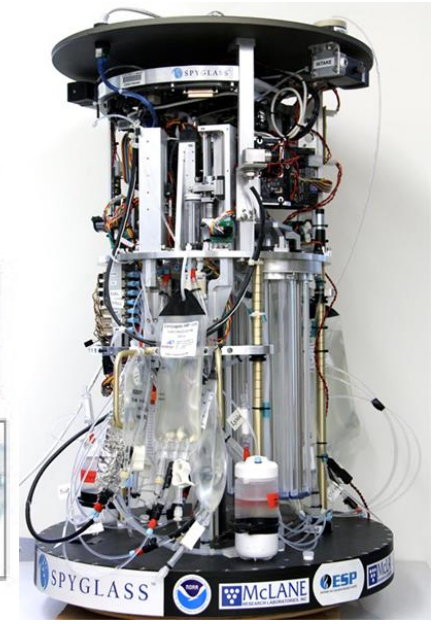


http://cfb.unh.edu/phycokey/

Menge et al., in prep



HARNESS, NHABON



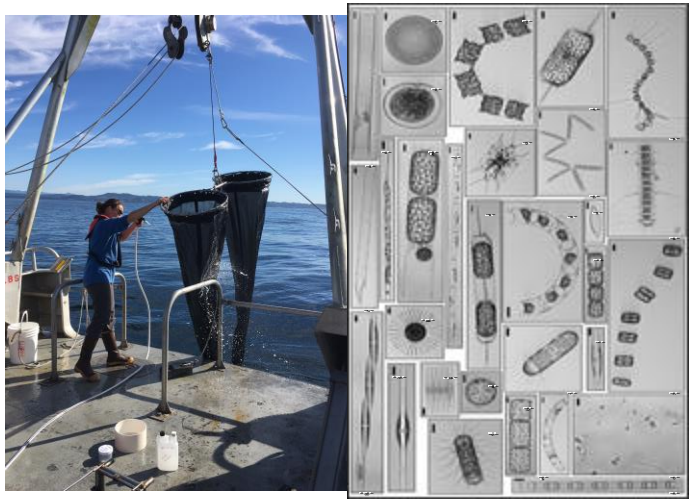
ESP, McLane

Challenge of context dependency, non-stationarity…What is our strategy?

Modified from F. Chan

Multifactor mechanistic experiments?

Modularize earth system models ?
Physics-based + machine learning pathways?

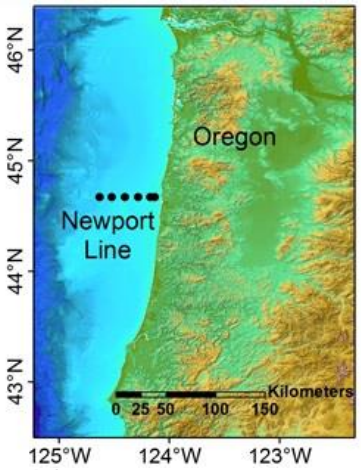


Bolster and advance ocean ecology observations?

Yes, investment in infrastructure will help, and access to mesocosms/field stations, HPC, and next-gen instrumentation should focus on equity and inclusion

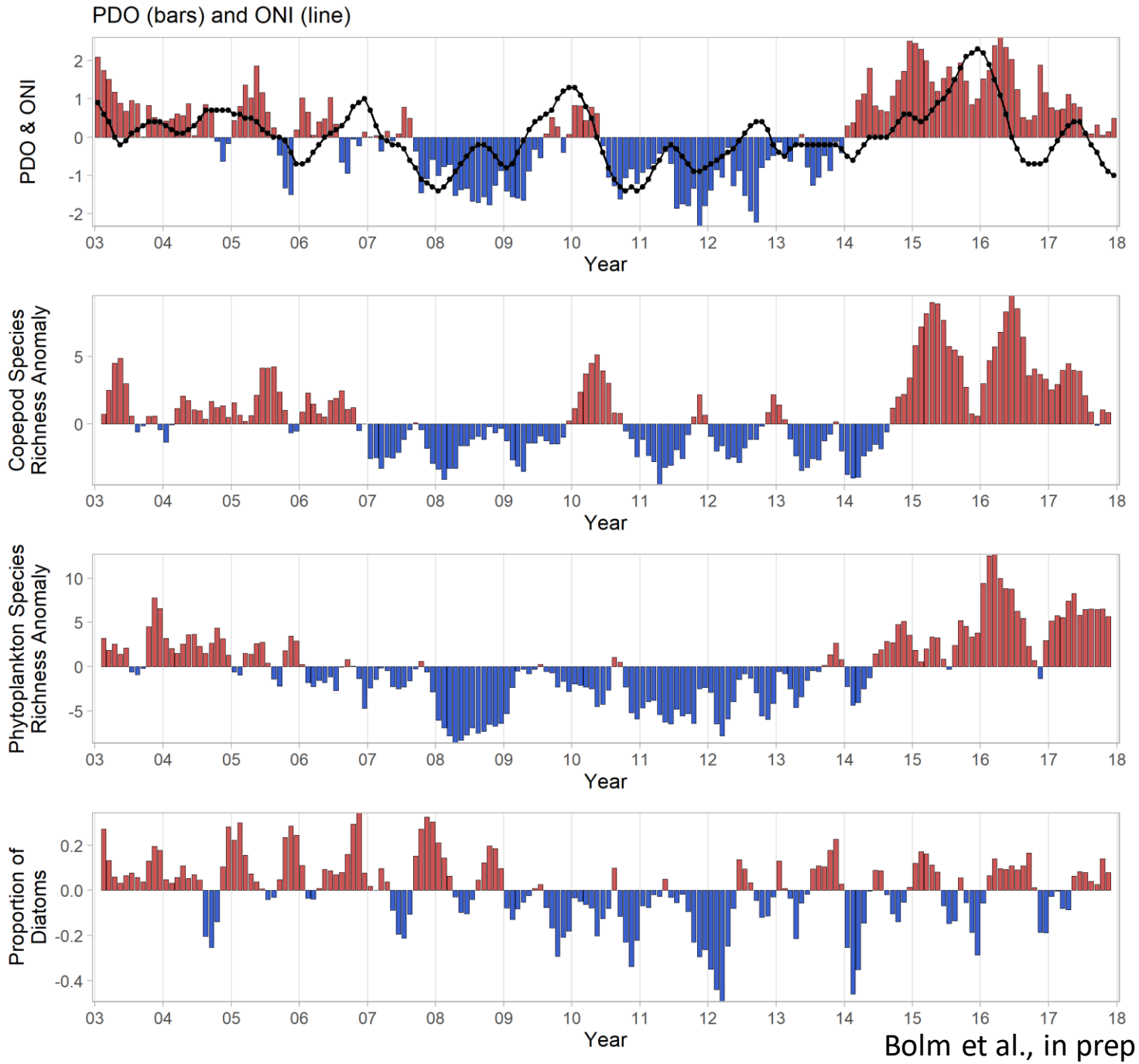
Climate-ecosystem linkages through sustained ocean observations: Support, intercalibrate, add capacity and complexity

https://www.fisheries.noaa.gov/west-coast/science-data/newportal-blog-northwest-fisheries-science-center



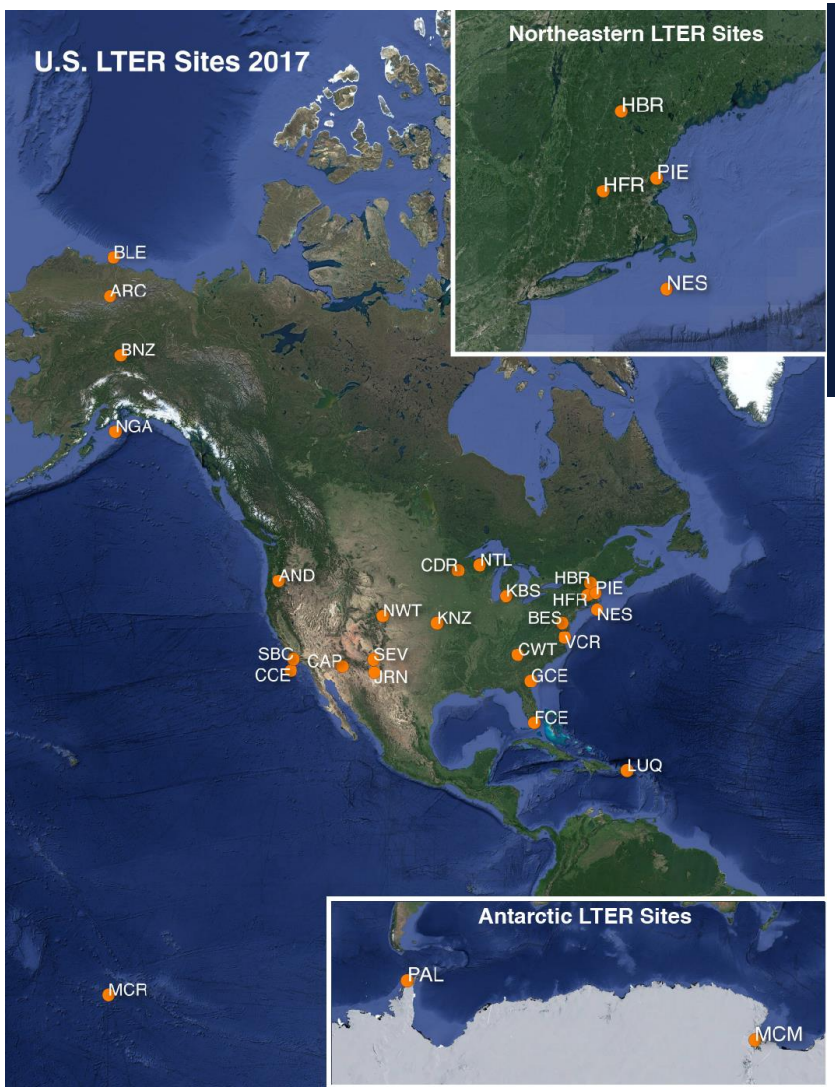
Newport Hydrographic Line

Bill Peterson (NOAA)
1942-2017

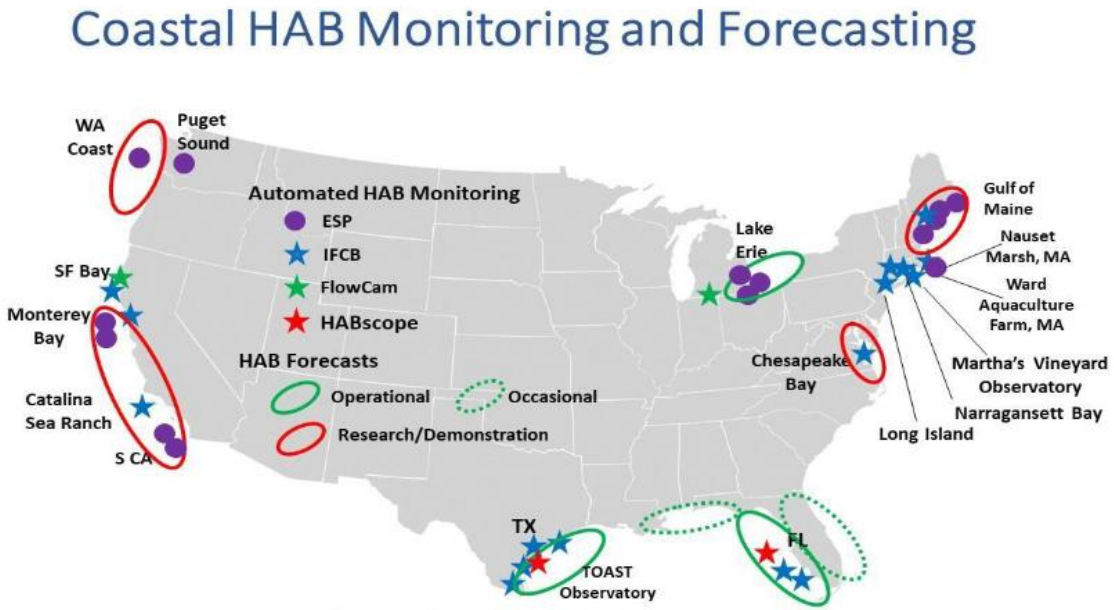


Bolm et al., in prep

Synthesize lessons learned and conduct ecosystem comparisons through cross-network collaboration/integration



MBON
Marine Biodiversity Observation Network



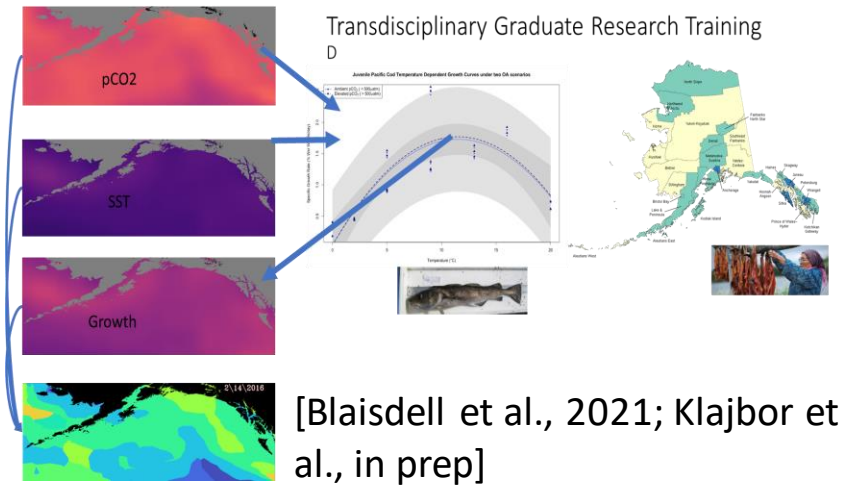
Transdisciplinary, trans-sector research: takes time; requires reframing traditional structures.

Climate-ready, inclusive workforce

USDA National Institute of Food and Agriculture
UNITED STATES DEPARTMENT OF AGRICULTURE

From Learning to Leading: Cultivating the Next Generation of Diverse Food and Agriculture Professionals (NextGen)

Transdisciplinary Research



[Blaisdell et al., 2021; Klajbor et al., in prep]

National Science Foundation Research Traineeship Program

Community Collaboration

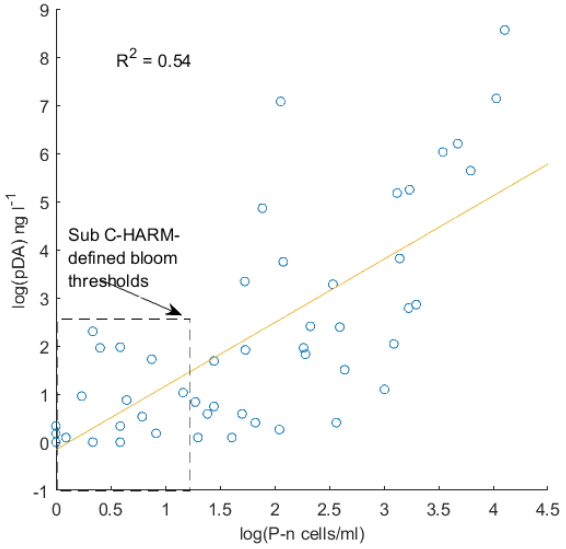
Collaborative/Cooperative Fisheries HABOA Research

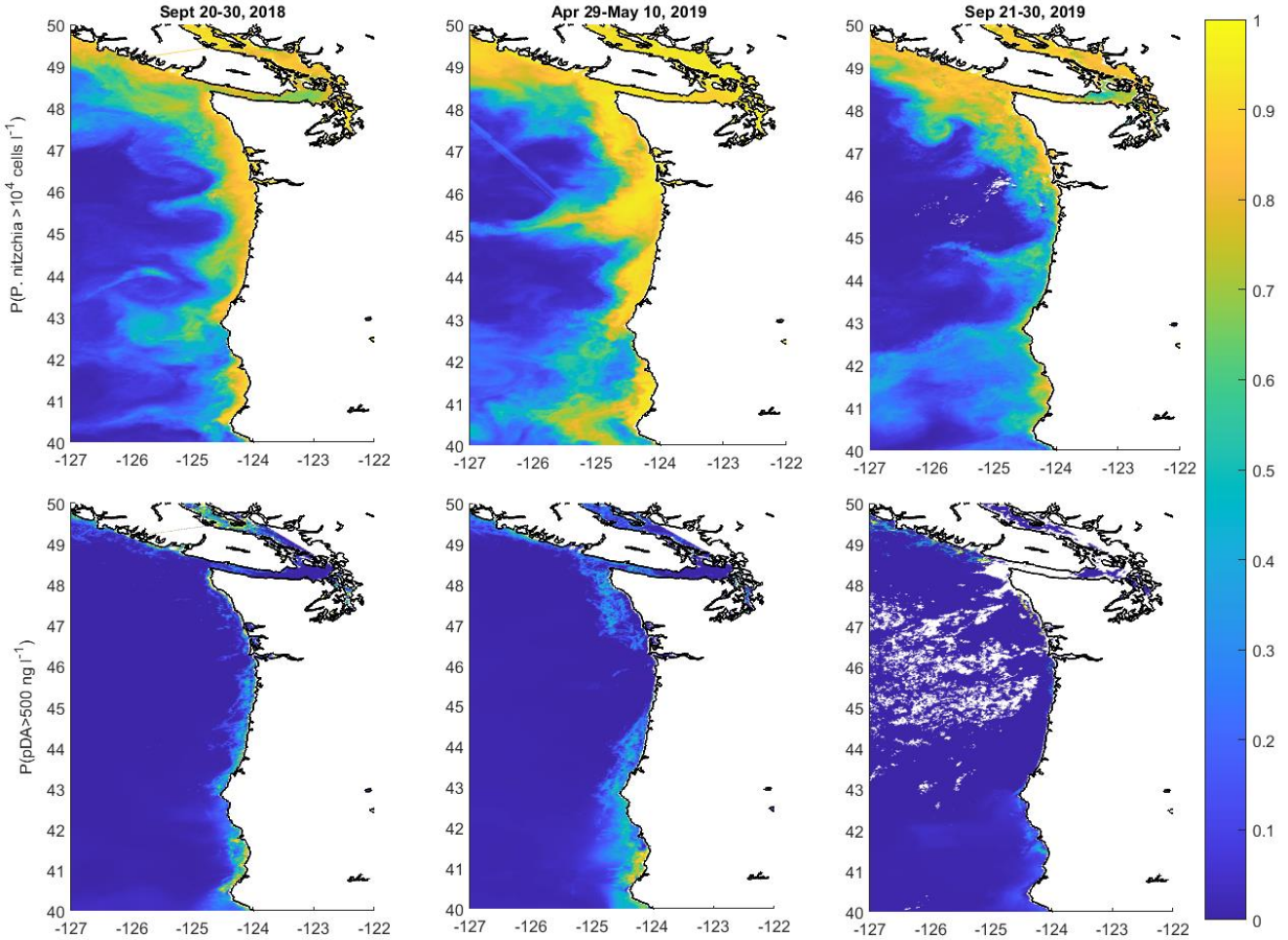
Thank You

maria.kavanaugh@oregonstate.edu

C-HARM: evaluated for NCC

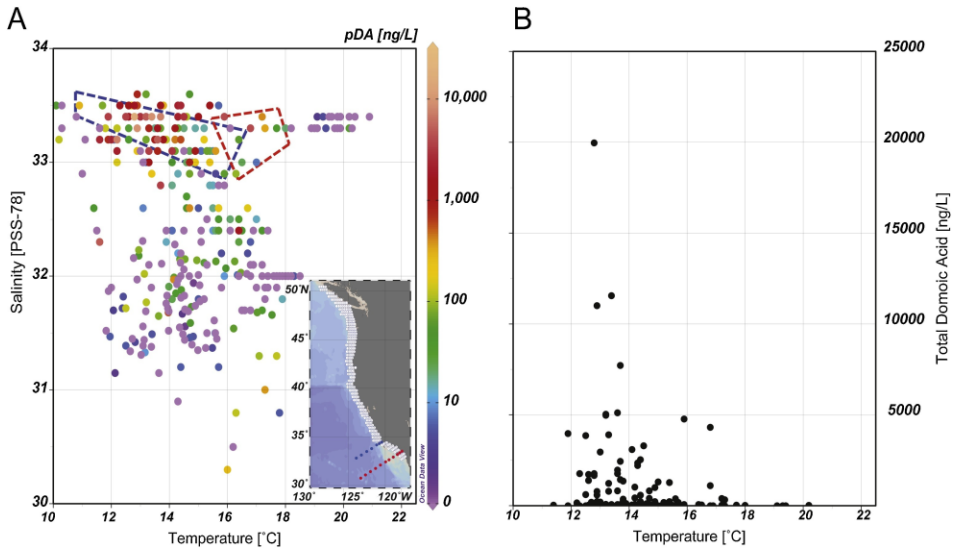
- Satellite SST, Rrs, chl-a
- Modeled salinity
- CA thresholds/tolerances

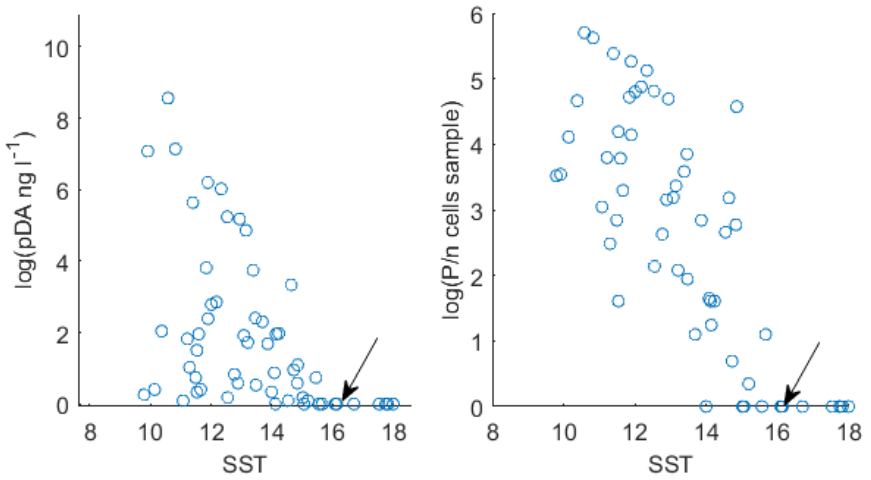




Challenge:

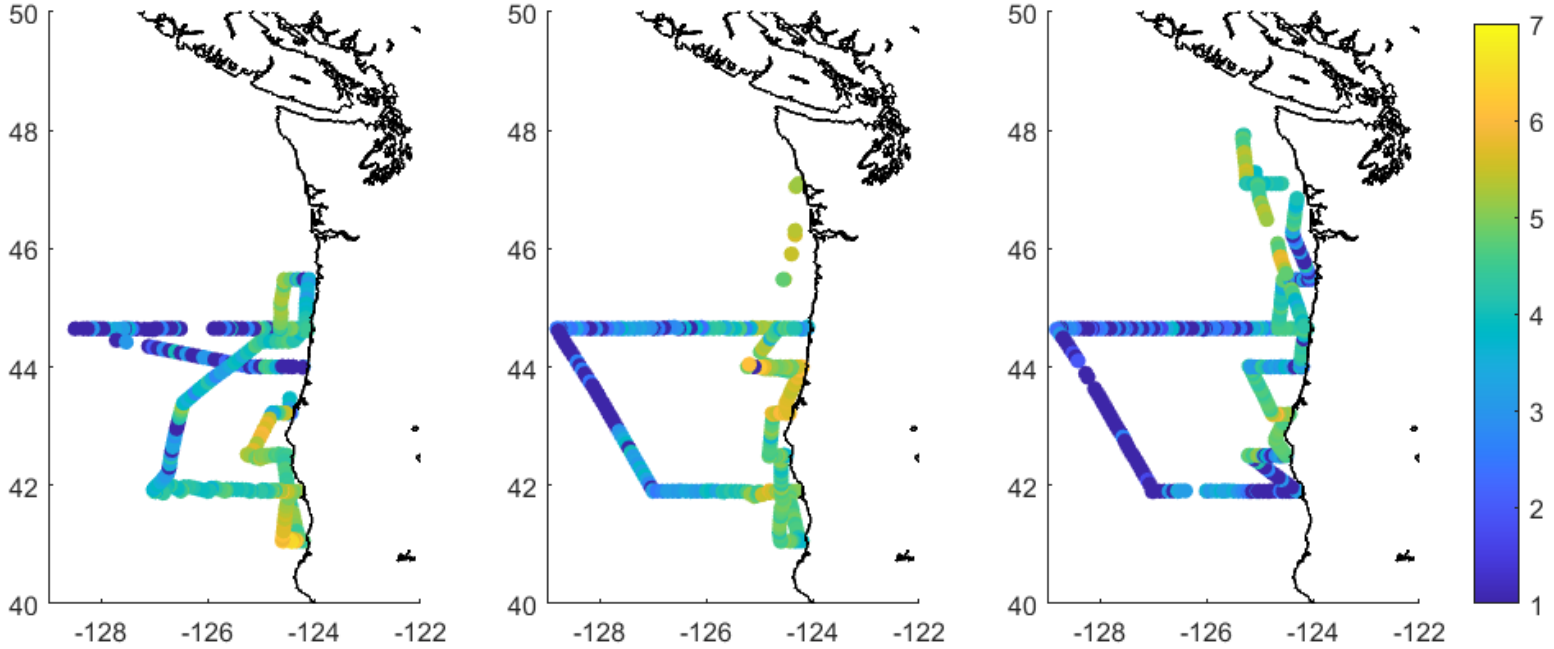
- Predicting P/N toxicity
- Different strains
- Different populations
- Different seasonal induction: nutrient stress (Si, Fe, P)? CO2? grazing or grazer types?

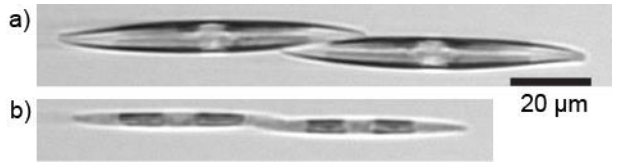




IFCB: Biovolume

- Maps of biovolume
- Need good classification
- Need a correction factor to create cell counts of thick verses thin
- Effects of community?
  - Grazers
  - Competition
  - Grazing and competition
    - Choanoflagellates!





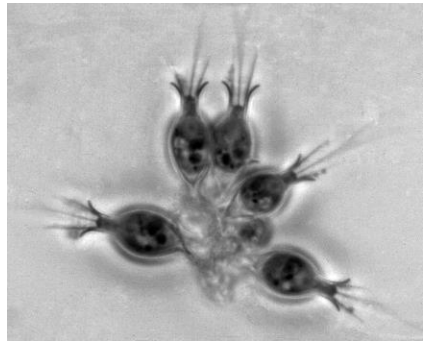
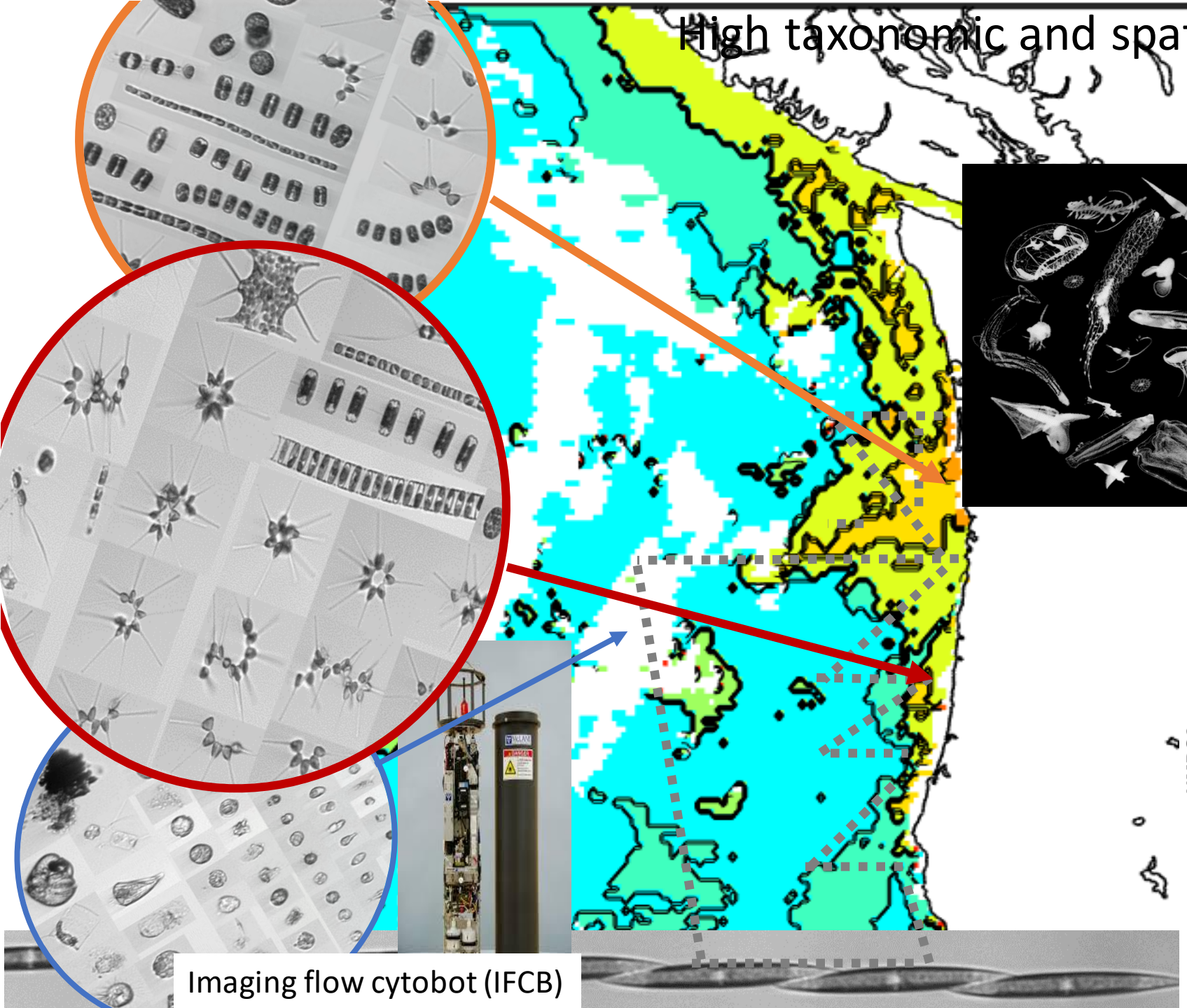


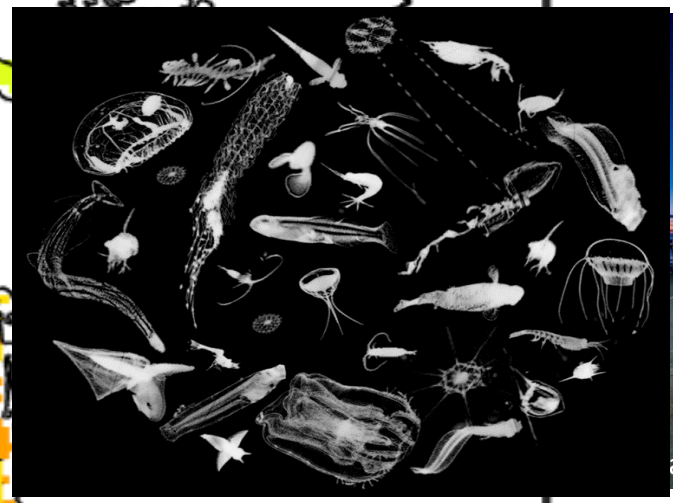
Figure X. Example IFCB images of toxic 'seriata' large size class (left) and nontoxic 'delicatissima' small size (right) class *Pseudo-nitzschia* species.

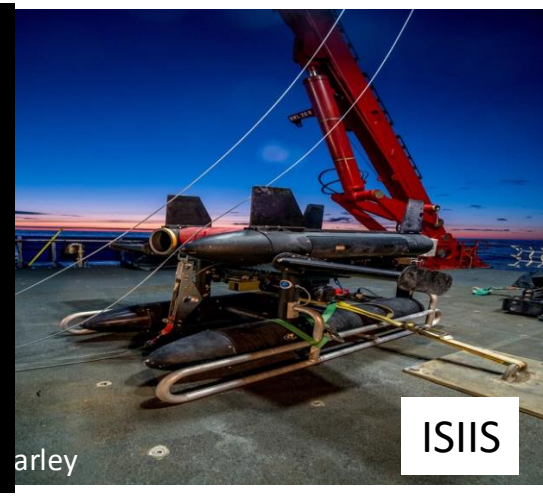
Some lessons

- The footprint of climate ocean connections appear to be changing
- “Biology” is responding to multiple physical factors, that may be decoupling, oscillating in phase, or anticorrelated at local scales
- Spatial footprint of predictive response is likely changing
- We definitely aren’t measuring/modeling enough biological complexity

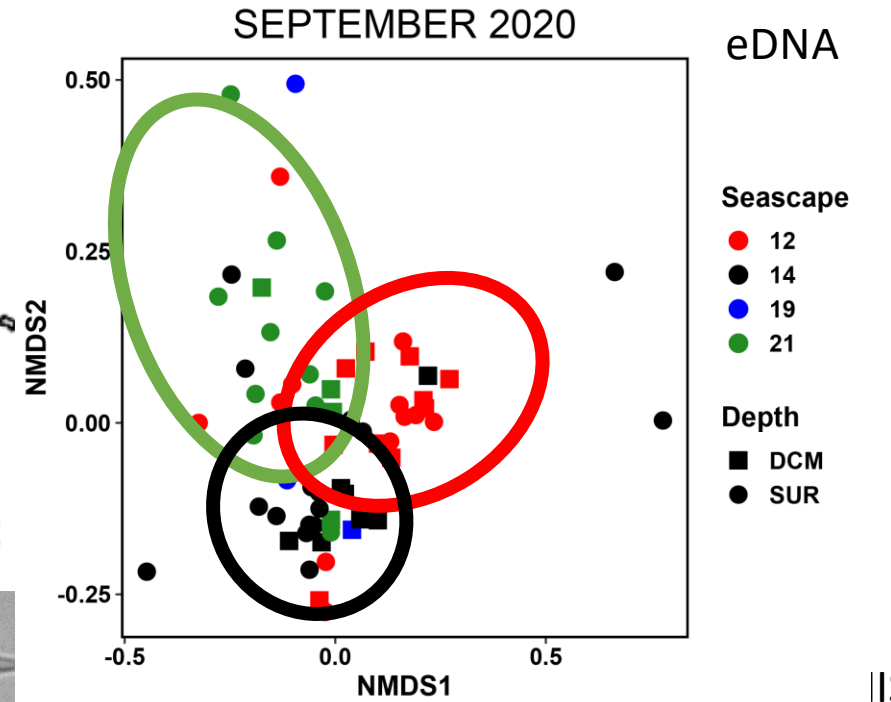
High taxonomic and spatial resolution that scales up: Imaging and eDNA





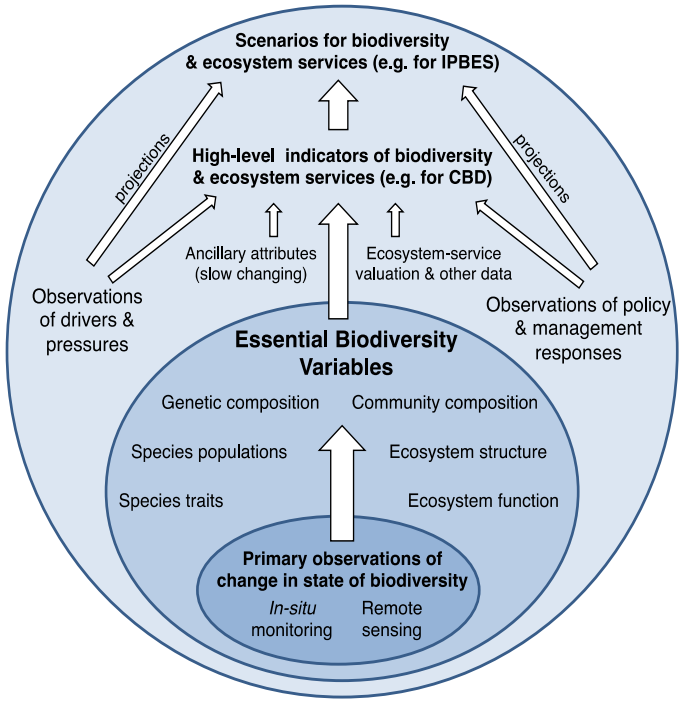


Imaging flow cytobot (IFCB)



Science-driven indicator co-development across multiple scales to inform diverse conservation/management goals.

Global: e.g Convention on Biodiversity, IPBES



Essential Biodiversity Variables
Pereira et al. (2013)

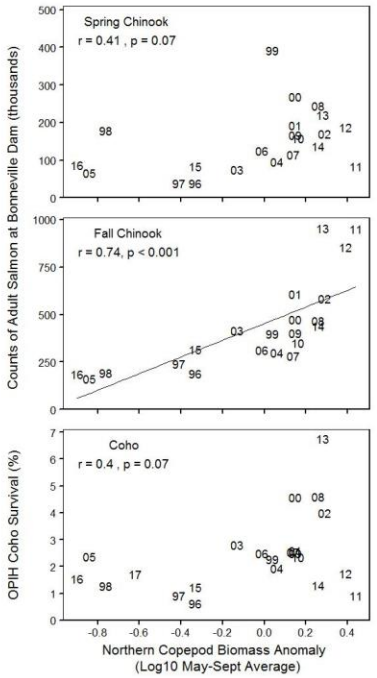
Regional:
e.g. NOAA Fisheries

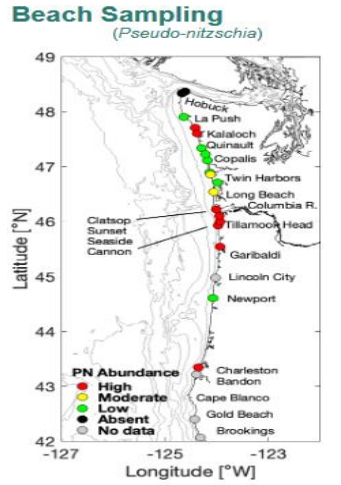
Table SF-01. Ocean ecosystem indicators of the Northern California Current. Colored squares indicate positive (green), neutral (yellow), or negative (red) conditions for salmon entering the ocean each year. In the two columns to the far right, colored dots indicate the outlooks for adult returns based on ocean conditions in 2018 (coho salmon) and 2017 (Chinook salmon).

	Juvenile Migration Year				Adult Return Outlook	
	2015	2016	2017	2018	coho 2019	Chinook 2019
Large– scale ocean and atmospheric indicators						
PDO (May - Sept)	■	■	■	■	●	●
ONI (Jan - Jun)	■	■	■	■	●	●
Local and regional physical indicators						
Sea surface temperature	■	■	■	■	●	●
Deep water temperature	■	■	■	■	●	●
Deep water salinity	■	■	■	■	●	●
Local biological indicators						
Copepod biodiversity	■	■	■	■	●	●
Northern copepod anomalies	■	■	■	■	●	●
Biological spring transition	■	■	■	■	●	●
Winter ichthyoplankton biomass	■	■	■	■	●	●
Winter ichthyoplankton community	■	■	■	■	●	●
Juvenile Chinook salmon catch – June	■	■	■	■	●	●
Juvenile coho salmon catch – June	■	■	■	■	●	●

Ocean Ecosystem Indicators
NOAA Integrated Ecosystem Assessment

Local:
Tribes, state, NGOs





Lower trophic level indicators used in tribe and state management decisions