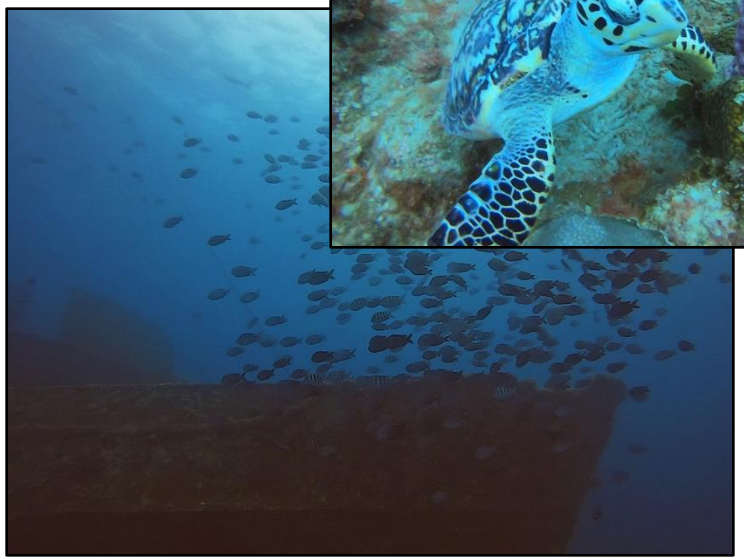
Carbon cycling on the Oregon-Washington Shelf: What we can learn from a decade of the Ocean Observatories Initiative's Coastal Endurance Array

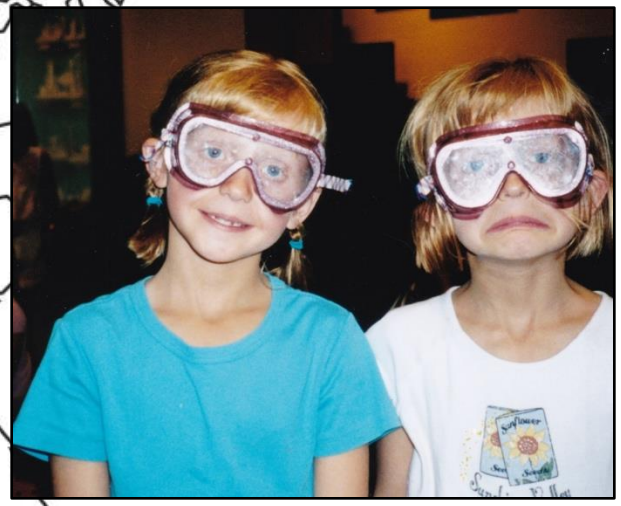
Anna Hughes, PhD student, Oregon State University

MBARI Earth Workshop 2025

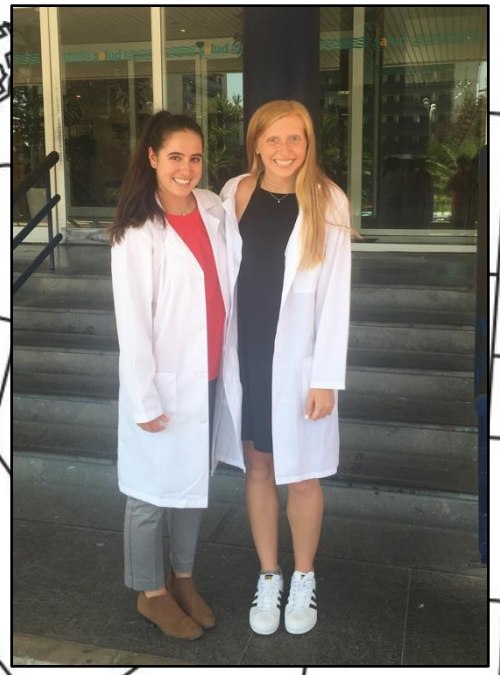
July 30th, 2025, Newport, OR

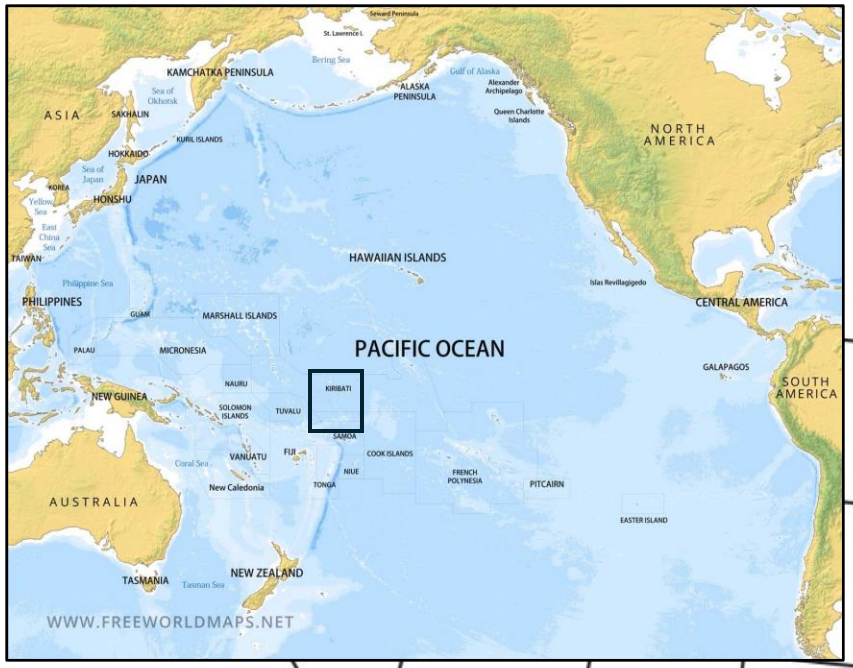
2004: Demonstrating how tectonic plates generate tsunamis

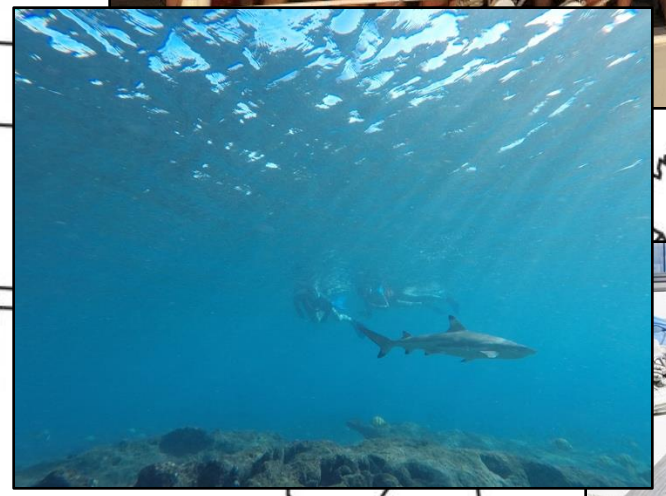


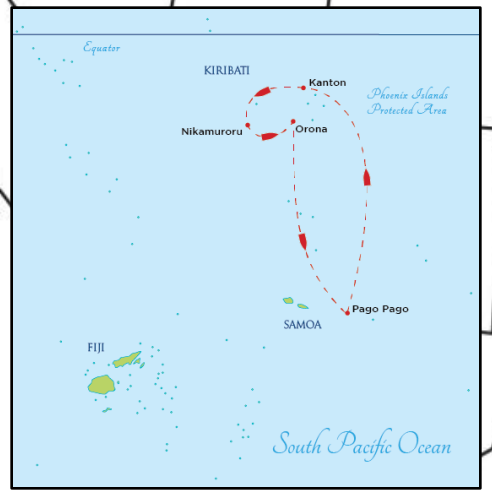


2017: Started pre-med at Carleton College







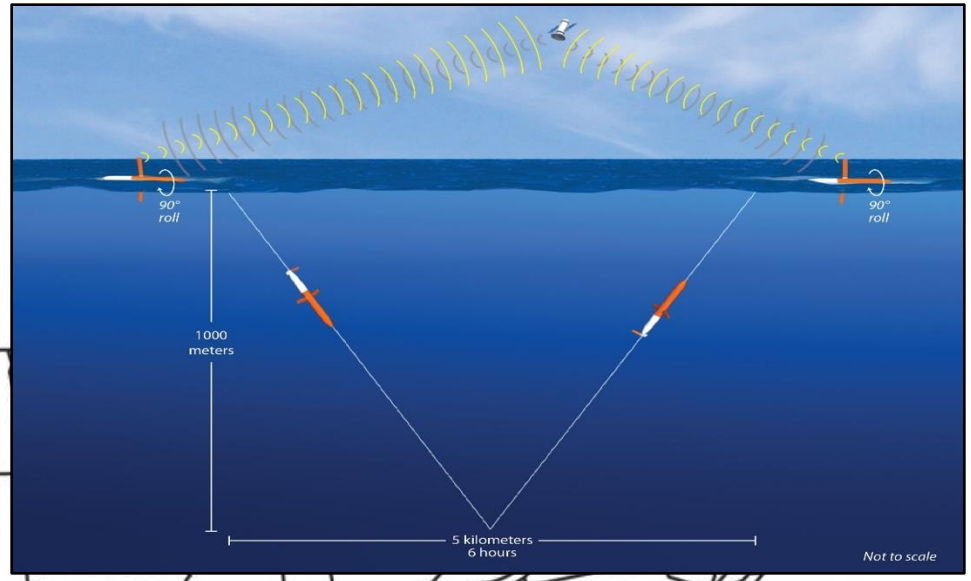


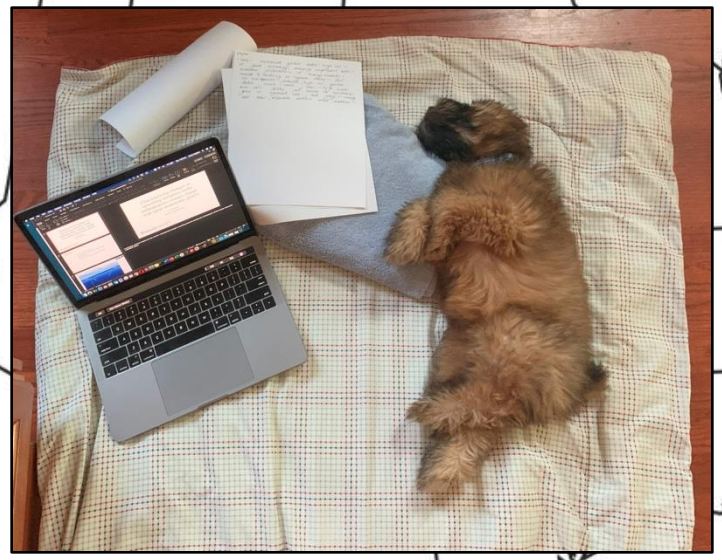
2019: Study abroad through Sea Education Association to the South Pacific

Characterizing changes in upwelling dynamics under anthropogenic climate change with spray underwater gliders

Anna Hughes
Mentor: Yui Takeshita

MBARI Monterey Bay Aquarium Research Institute

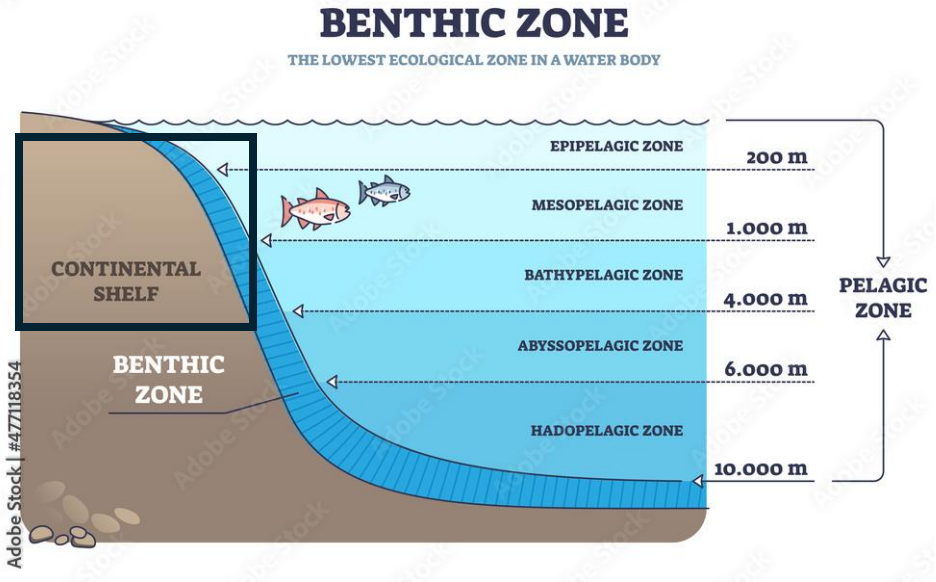


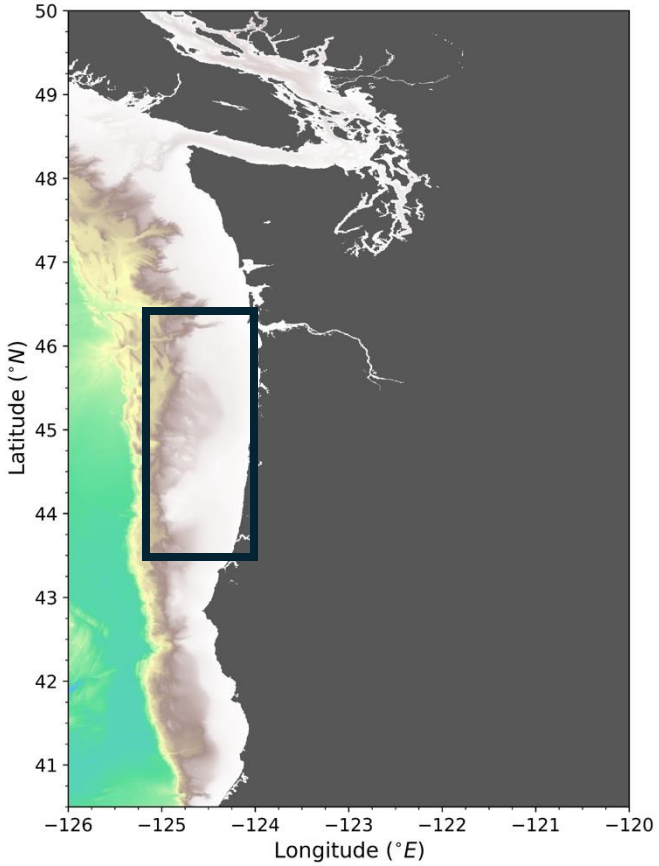


2020: (virtual) Research Experience for Undergraduates (REU) at the Monterey Bay Aquarium Research Institute

Fall 2021: Moved to Oregon, and embarked on a week-long camping trip with my graduate school cohort

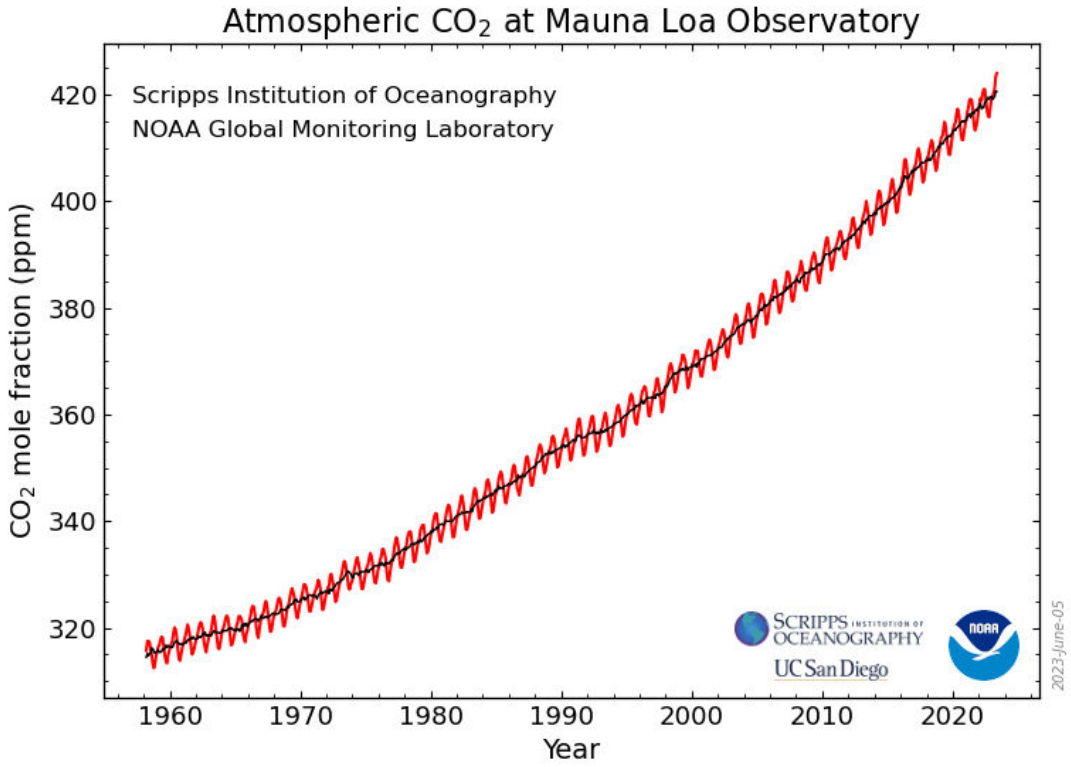
The Oregon State University
Benthic (below or bottom)
Biogeochemistry (study of the biological, geological, and chemical processes and reactions that govern the natural environment)
Lab





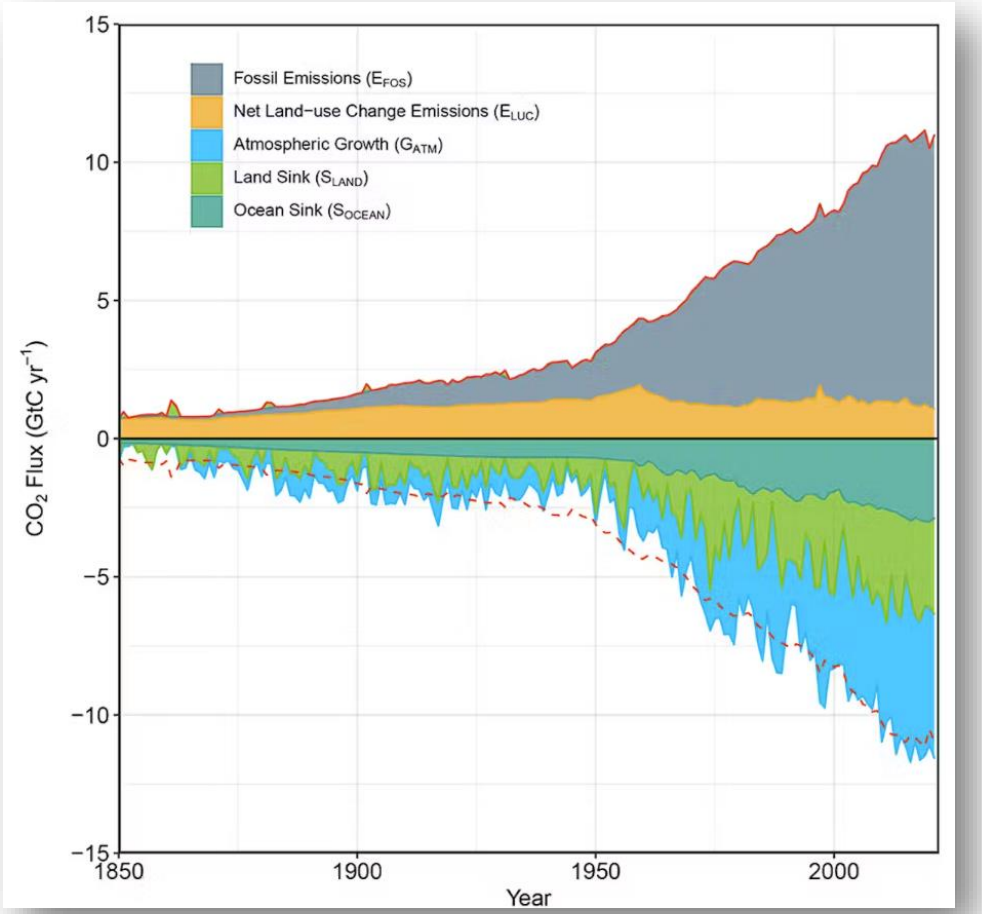
Why do we study sediments?

- Let's start with the atmosphere…
- Anthropogenic fossil fuel emissions have increased atmospheric CO_2 concentrations since the industrial era
- Oceans are a net sink for atmospheric CO_2



Why do we study sediments?

- Oceans have taken up ~25% of human-induced CO_2 emissions
- Sediments are the largest reservoir of organic carbon on earth
- Sediments are linked to the regulation of Earth's climate
- We need to understand the processes that influence carbon burial in sediments



Friedlingstein et al., 2022

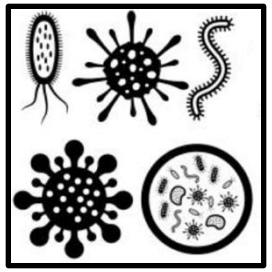
The Biological Carbon Pump

(Surface ocean)
Photic zone

NO_3^- PO_4^{3-} DIC

Nutrients

Photosynthesis by phytoplankton



Zooplankton grazing & excretion

Organic matter (zooplankton poop)

Water column

Physical mixing

Particle sinking (~50% of what is produced)

(Benthos)
Sediment

NO_3^- PO_4^{3-} DIC

Nutrients

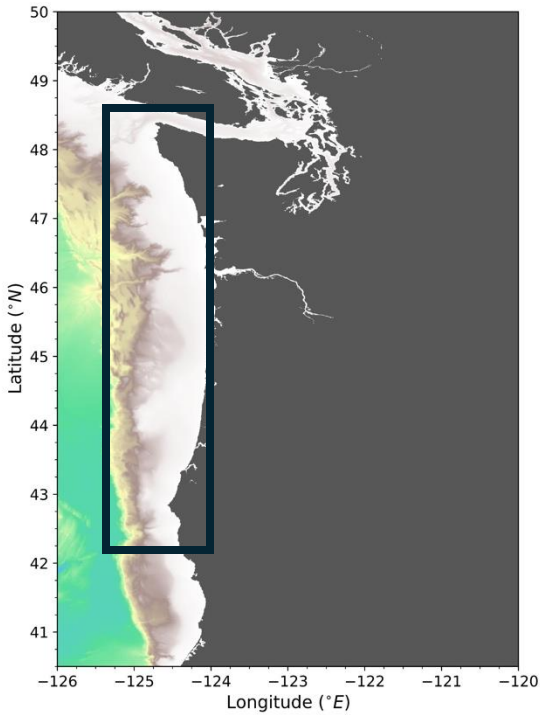
Organic matter respiration by microbes

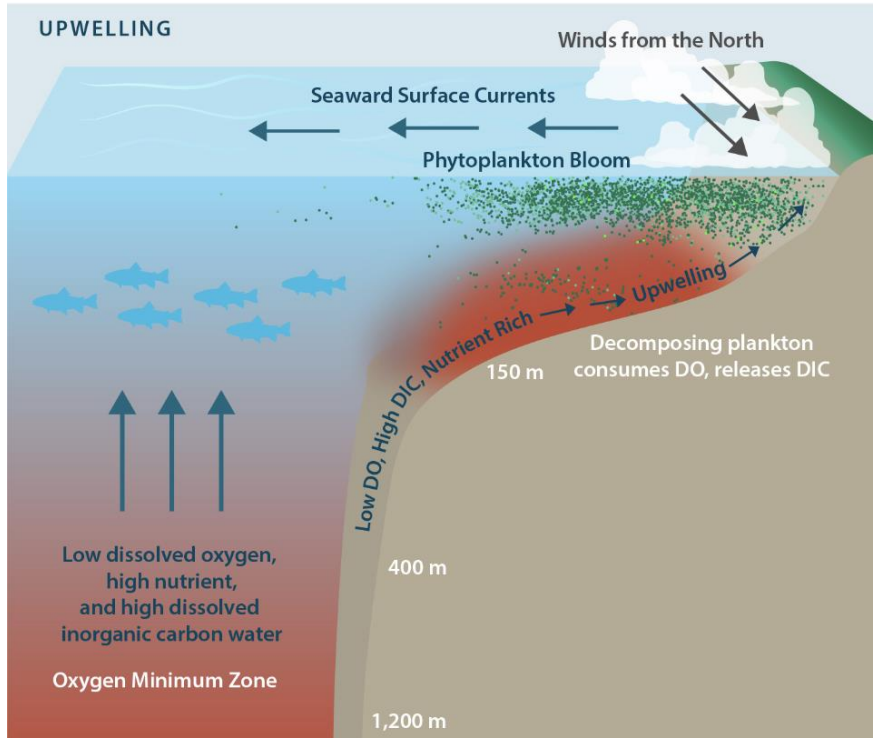
Organic matter

Burial in sediments (< 1% of organic matter produced)

The Oregon-Washington shelf

- The OR-WA shelf is part of the California Current System (CCS)
- The CCS is an upwelling system
- Upwelling systems have increased primary production and cycling of carbon and nutrients (lots of cool biogeochemistry!)



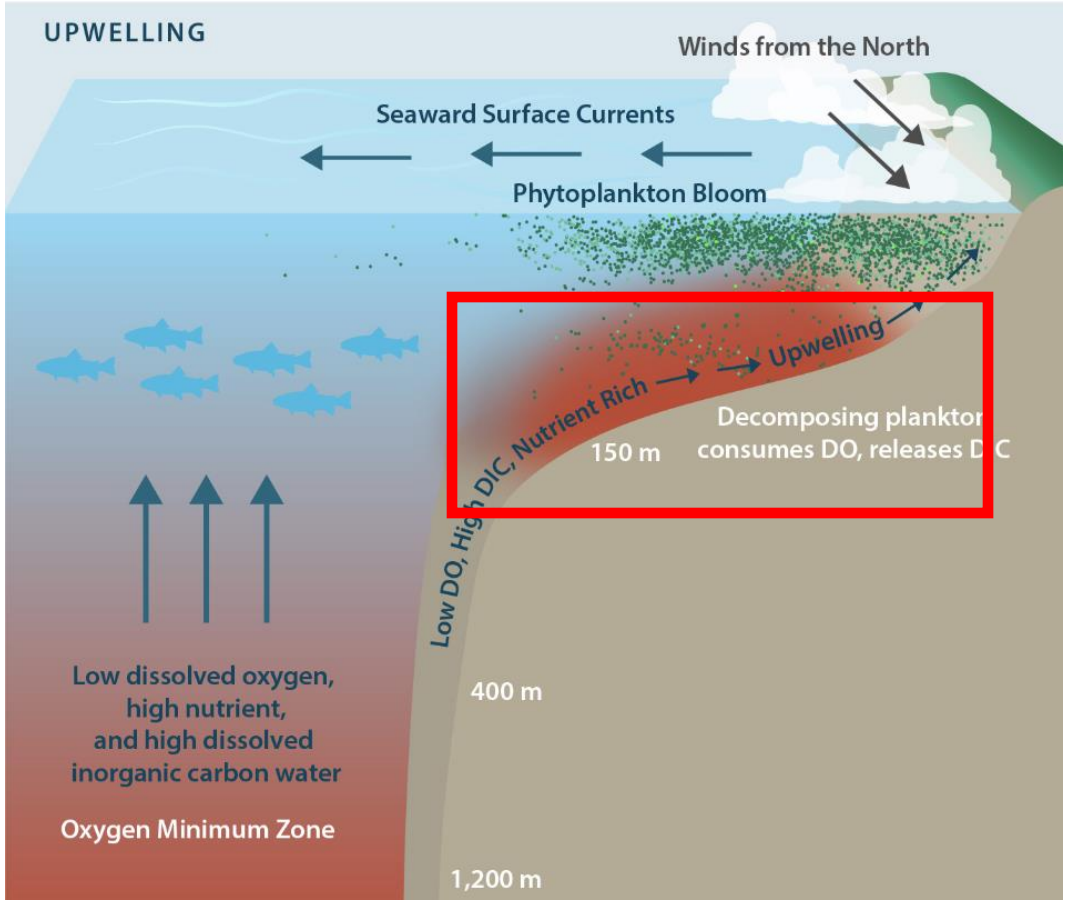


Chan, F., Barth, J. A., Kroeker, K. J., Lubchenco, J., & Menge, B. A. (2019). THE DYNAMICS AND IMPACT OF OCEAN ACIDIFICATION AND HYPOXIA

[Upwelling lesson plan from OR Seagrant: Oregon Marine Scientist and Educator Alliance]

The Oregon-Washington shelf

- Low bottom water dissolved oxygen, paired with organic matter remineralization (which consumes oxygen) can lead to hypoxia and anoxia (low-no oxygen) in shelf bottom waters
- Significant consequences for marine benthic ecosystems and Oregon fisheries



Chan, F., Barth, J. A., Kroeker, K. J., Lubchenco, J., & Menge, B. A. (2019). THE DYNAMICS AND IMPACT OF OCEAN ACIDIFICATION AND HYPOXIA

The Oregon-Washington shelf

- Upwelled waters also have a lower, more acidic pH
- Significant consequences for marine benthic ecosystems and Oregon fisheries

Chemical and biological impacts of ocean acidification along the west coast of North America

Richard A. Feely [a,*], Simone R. Alin [a], Brendan Carter [b], Nina Bednaršek [c,1], Burke Hales [d], Francis Chan [e], Tessa M. Hill [f,g], Brian Gaylord [f], Eric Sanford [f], Robert H. Byrne [h], Christopher L. Sabine [a], Dana Greeley [a], Lauren Juranek [d]

Primary Research Article

Risks of ocean acidification in the California Current food web and fisheries: ecosystem model projections

Kristin N. Marshall, Isaac C. Kaplan, Emma E. Hodgson, Albert Hermann, D. Shallin Busch, Paul McElhany, Timothy E. Essington, Chris J. Harvey, Elizabeth A. Fulton

First published: 12 January 2017 | https://doi.org/10.1111/gcb.13594 | Citations: 104

JGR Oceans

Research Article | Open Access

The Combined Effects of Ocean Acidification and Respiration on Habitat Suitability for Marine Calcifiers Along the West Coast of North America

Richard A. Feely, Brendan R. Carter, Simone R. Alin, Dana Greeley, Nina Bednaršek

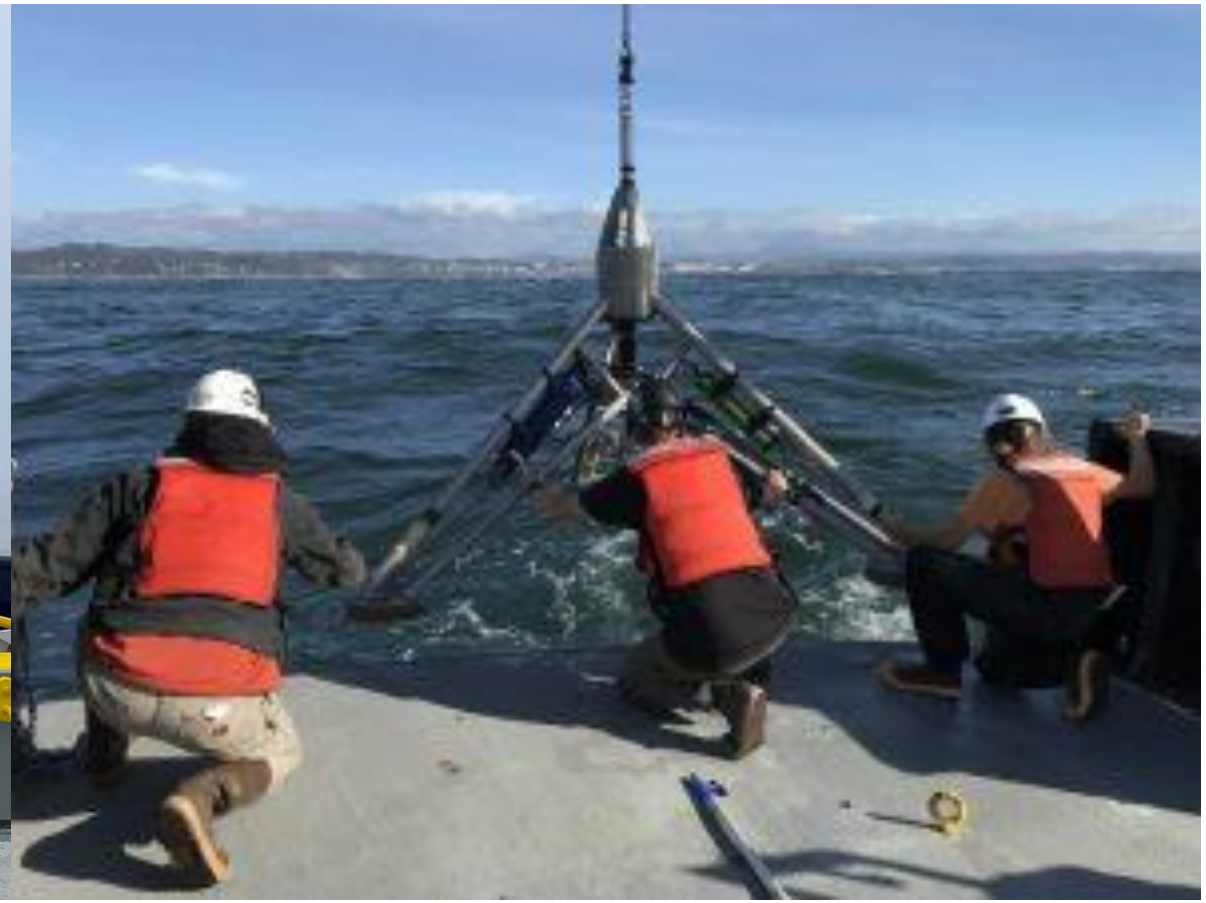
First published: 12 April 2024 | https://doi.org/10.1029/2023JC019892 | Citations: 12

How do we observe these systems?

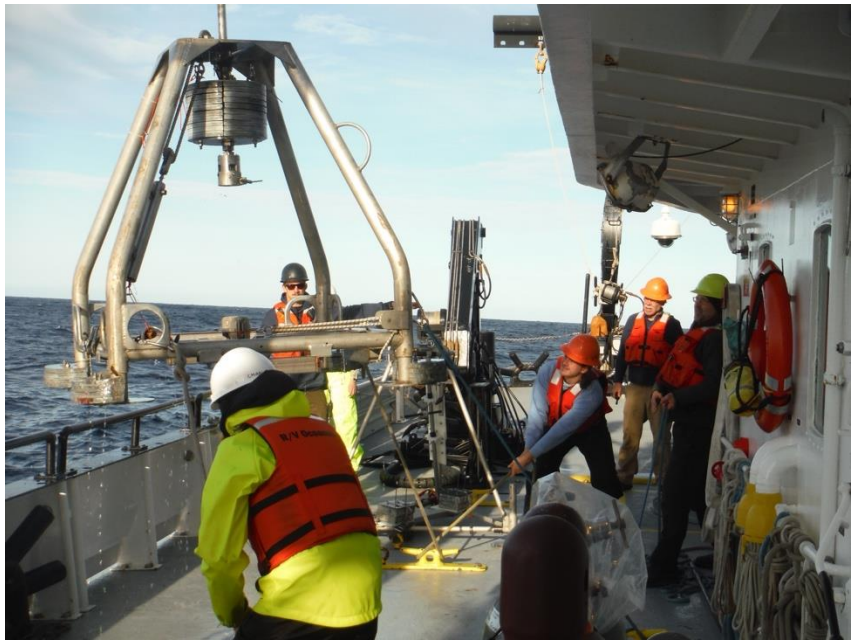
1. *In situ*: We take measurements in the water column and at the seafloor

2. *Ex situ*: We collect samples to be measured in the lab

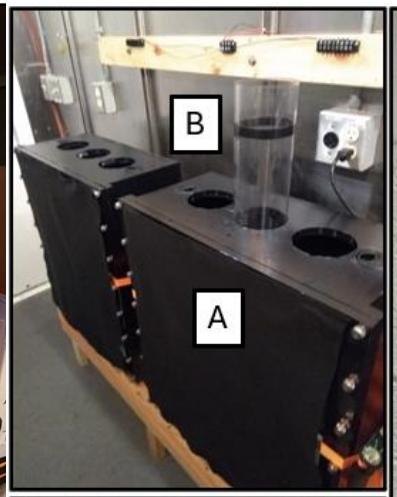
1. Lander used to measure oxygen fluxes with eddy covariance

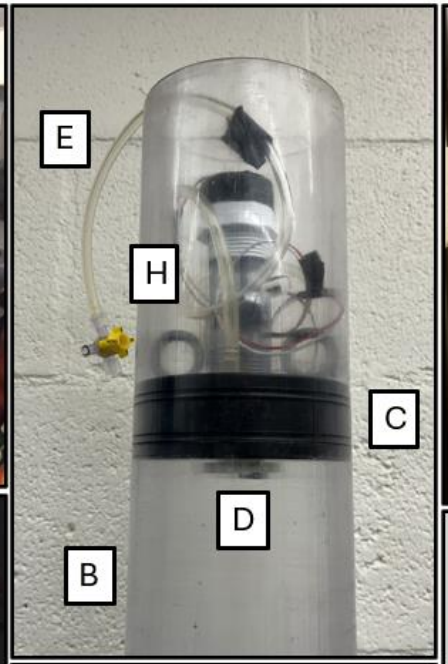


2. Sediment cores: measure benthic fluxes

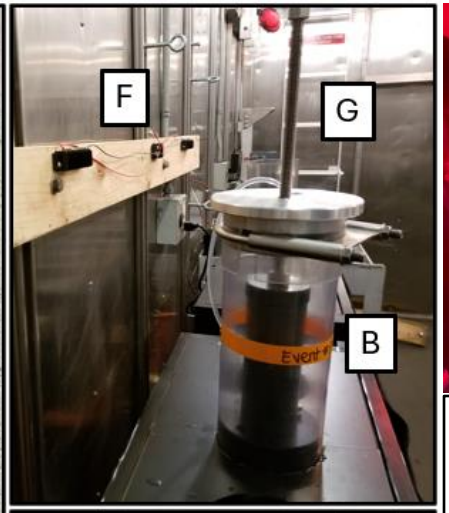


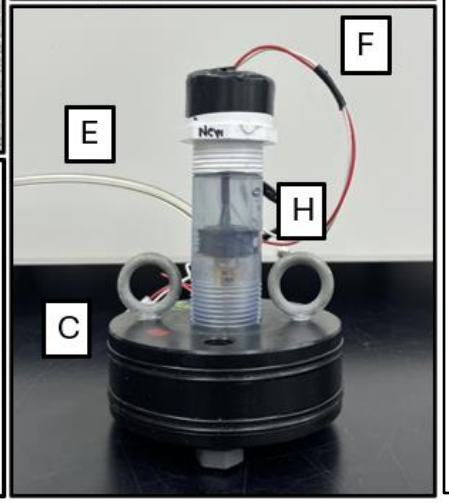
How sediment fluxes are measured in sediment cores:





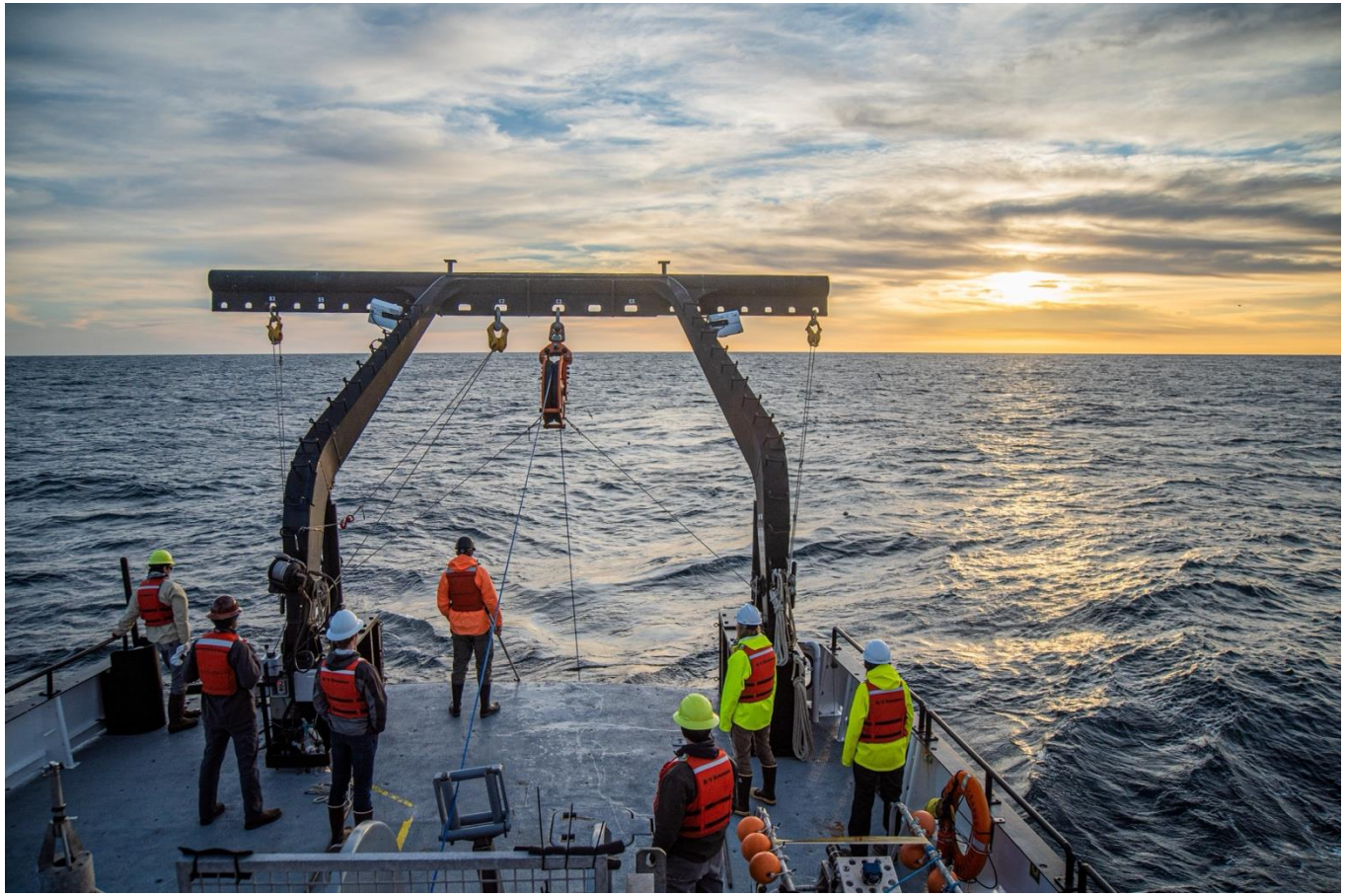
A. Core incubation boxes
B. Sediment core tube
C. Black Delrin puck with X-rings
D. Magnetic stir bar
E. Tygon sampling tube with 3-way valve
F. Motor wiring
G. Stainless steel sampling apparatus and core tube clamp
H. Motor housing



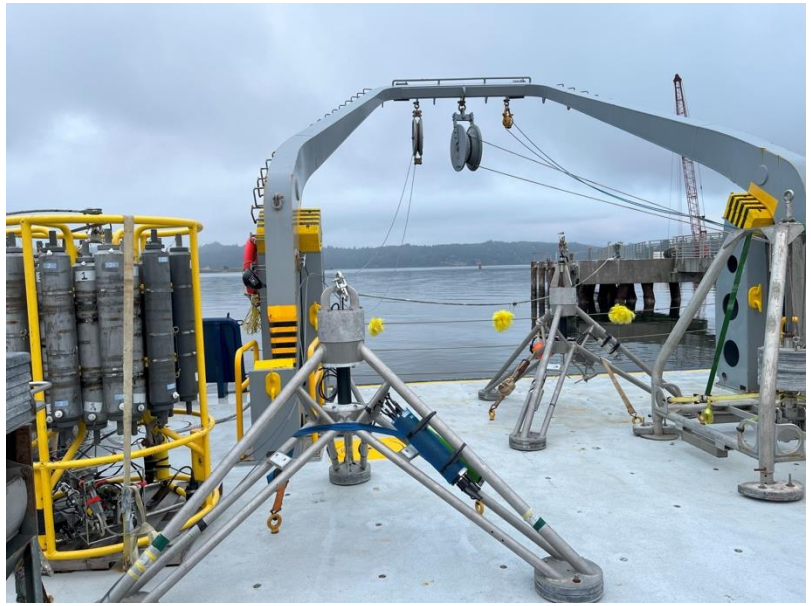


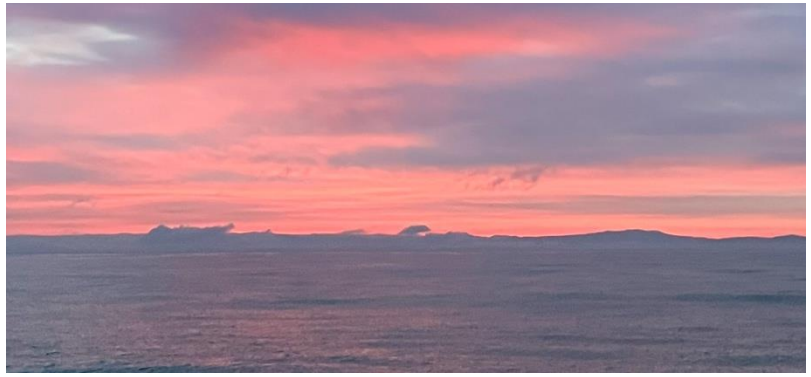
- Incubate cores in a cruise lab
- Set lab temp to bottom water temp (40-45 C)
- Collect water samples every 4-6 hours for 24-48 hours

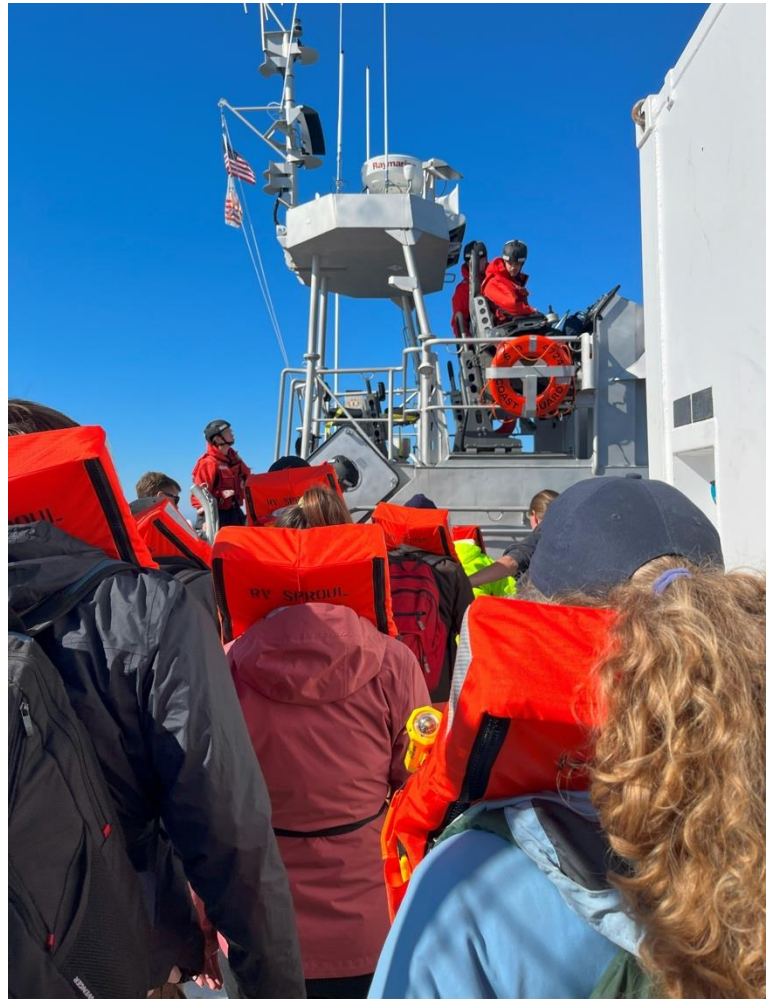
My lab collects much of our data on research vessels



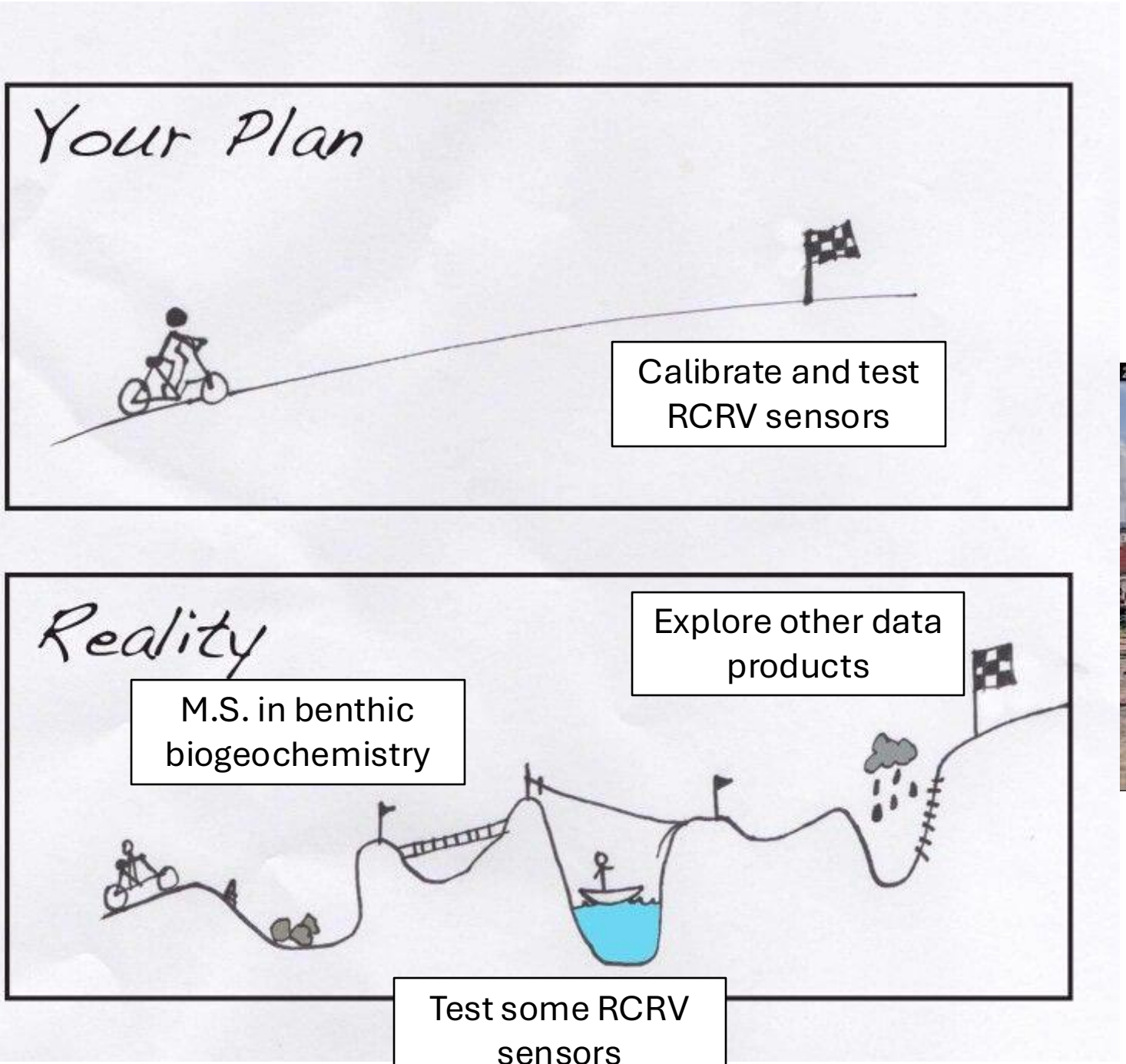
Research cruises don’t always go to plan…







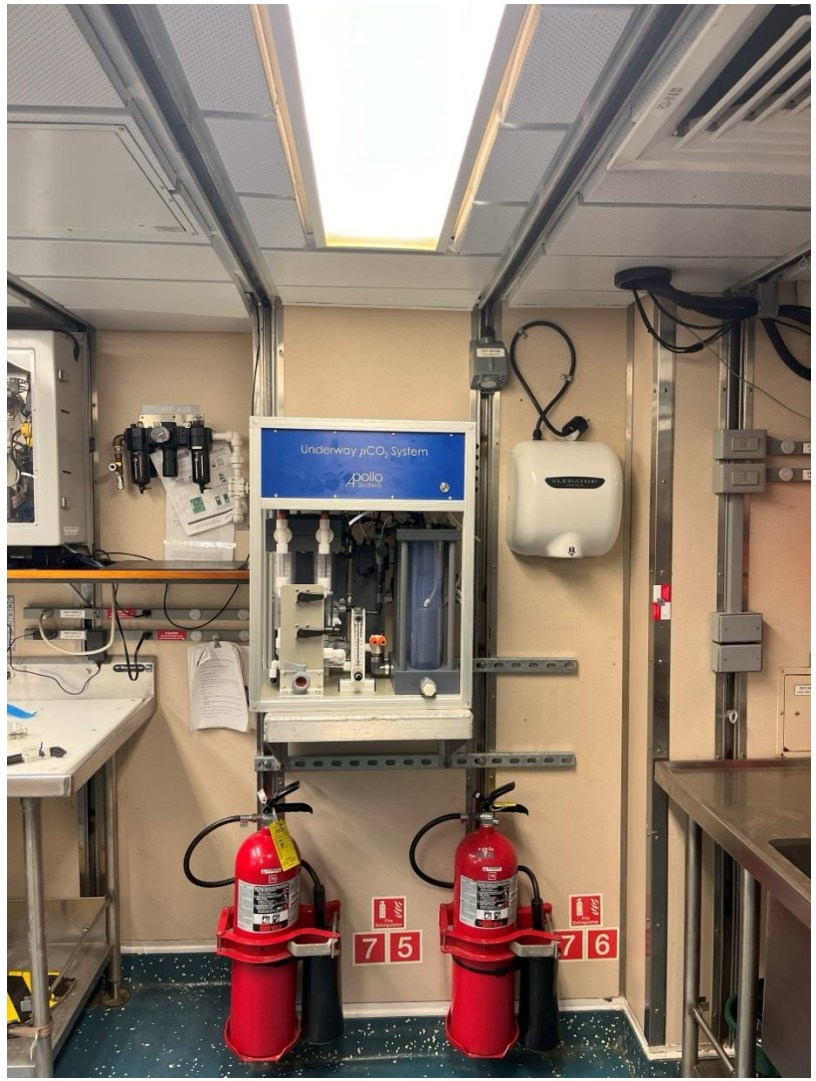
Neither do PhD plans…



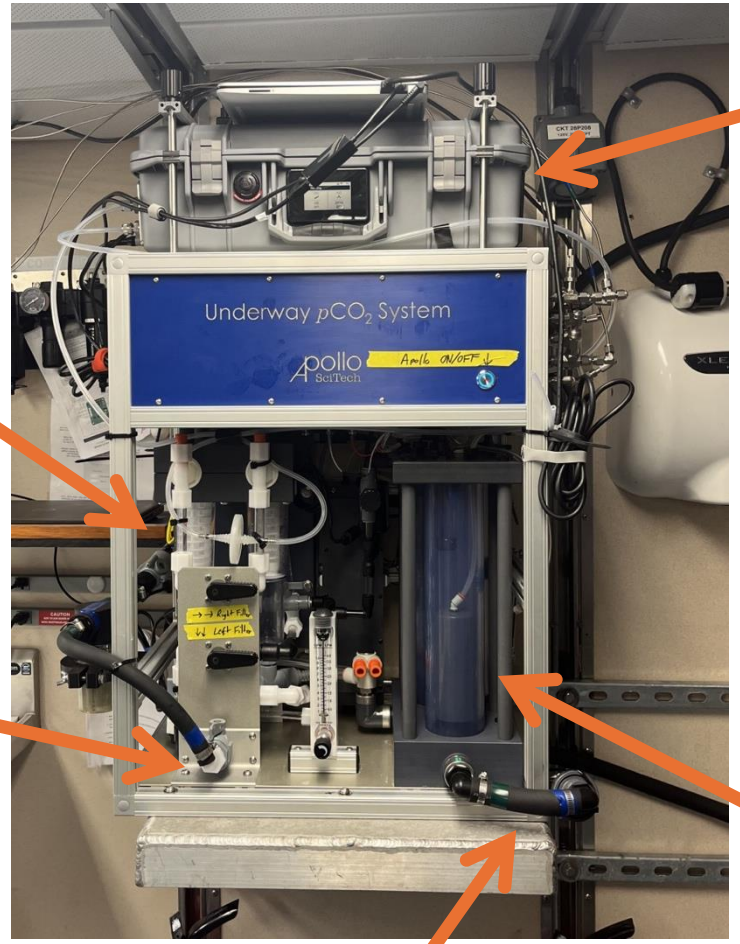
Current state of the RV Taani:

coriolix.sikuliaq.alaska.edu

Test RCRV sensor on the R/V Sikuliaq



Conduct intercomparison of RCRV and R/V Sikuliaq underway pCO_2 sensors



Air sample is measured for amount of CO_2

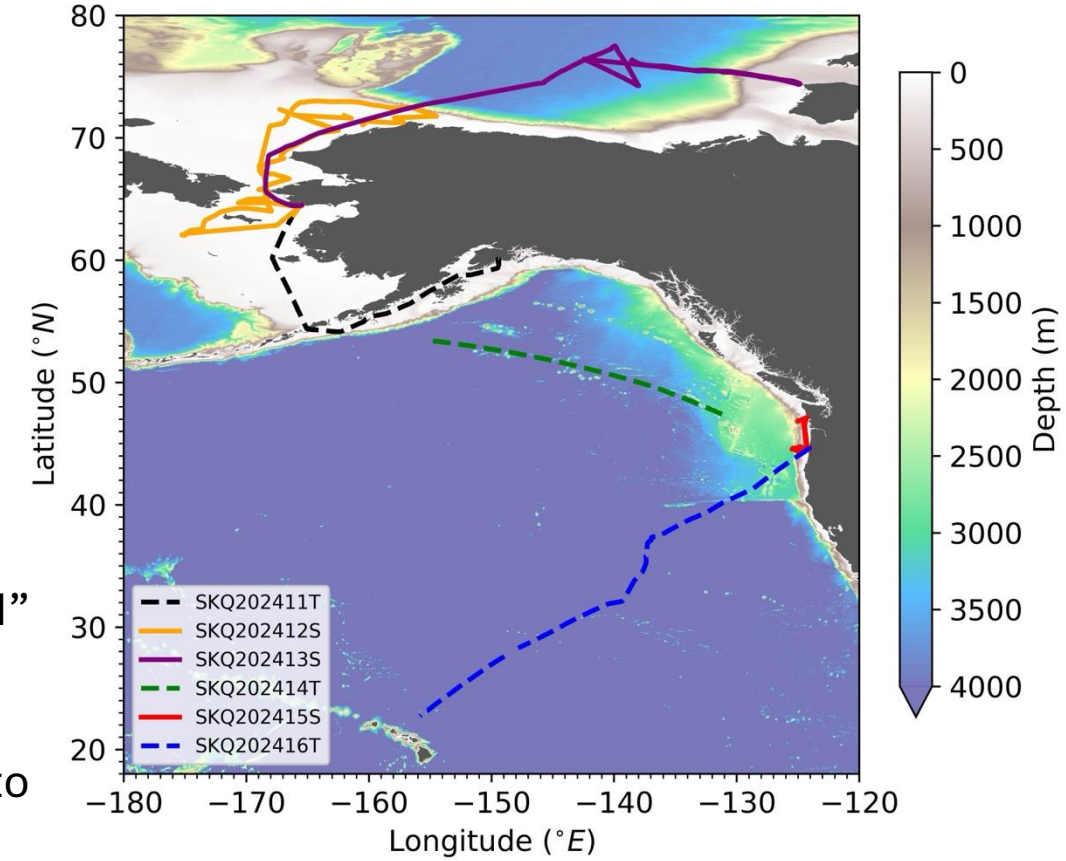
Water is filtered, and temperature and salinity are measured

Water intake, water is pumped from the ship's bow

Water is "equilibrated" with air, air sample is transported to analyzer

Water drains back to sea

Underway pCO_2 sensors: measures the CO_2 content (partial pressure) in the surface ocean, help us understand ocean CO_2 uptake!



The Ocean Observatories Initiative (OOI)

NSF | OCEAN OBSERVATORIES INITIATIVE

OOI data exploration outline

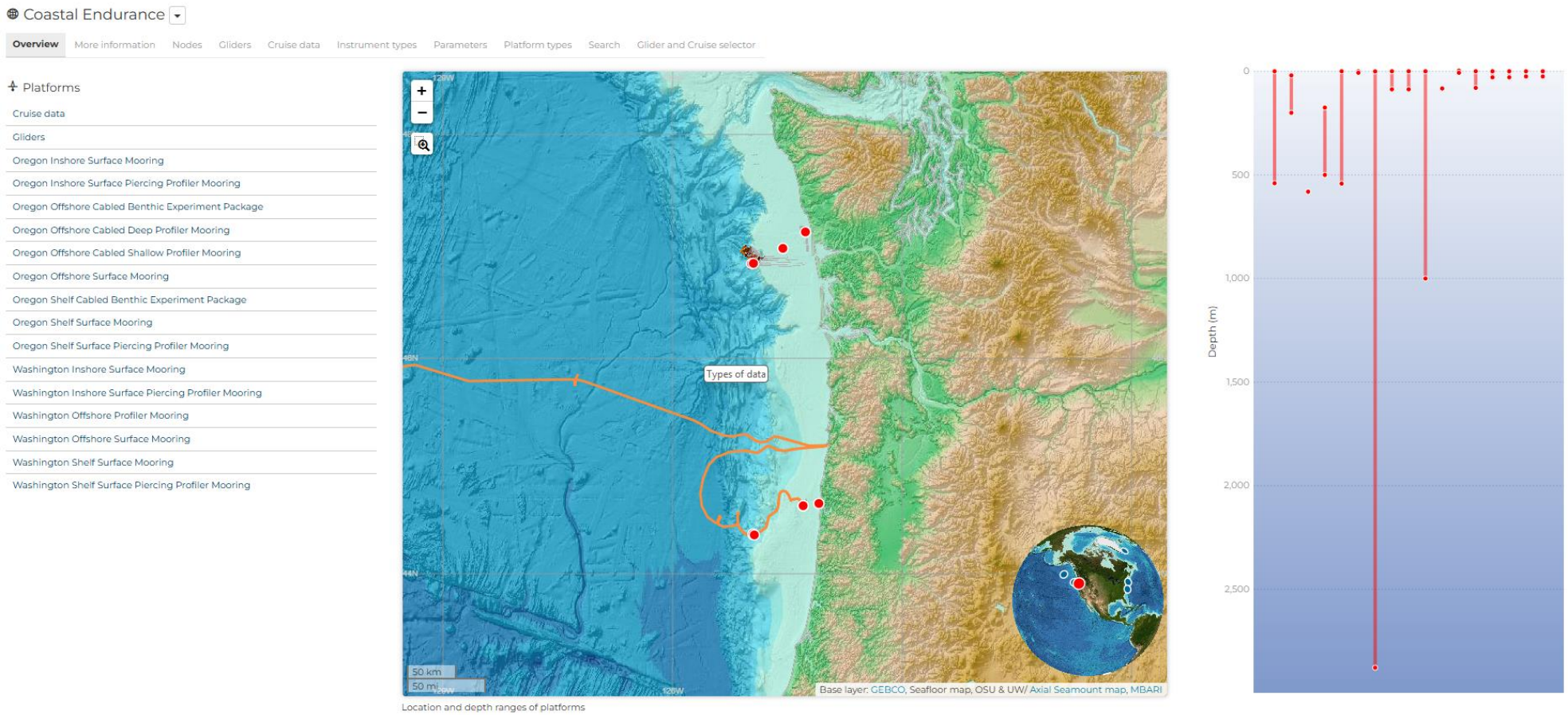
- OOI Data Arrays
- Types of OOI platforms for collecting data
- Types of sensors and data
- Ways to access and use data
- Data exploration

What is the Ocean Observatories Initiative?

The Ocean Observatories Initiative (OOI)

- Coastal Pioneer Array: (now) Coastal Pioneer Mid-Atlantic Bight
- Global Irminger Sea Array
- Global Station Papa Array
- Regional Cabled Array (OR-WA shelf)
  - Cabled Continental Margin Array
  - Cabled Axial Seamount Array
  - Cabled Endurance Array
- Global Argentine Basin (Mar 2015 – Jan 2018)
- Global Southern Ocean Array (Feb 2015 – Jan 2020)

The Coastal Endurance array (2014-2025)



Location and depth ranges of platforms

[Link to CE array webpage: OOI Data Explorer: Coastal Endurance]

[Link to video from Jon Fram at OOI about the CE array and accessing data]

The Coastal Endurance Array

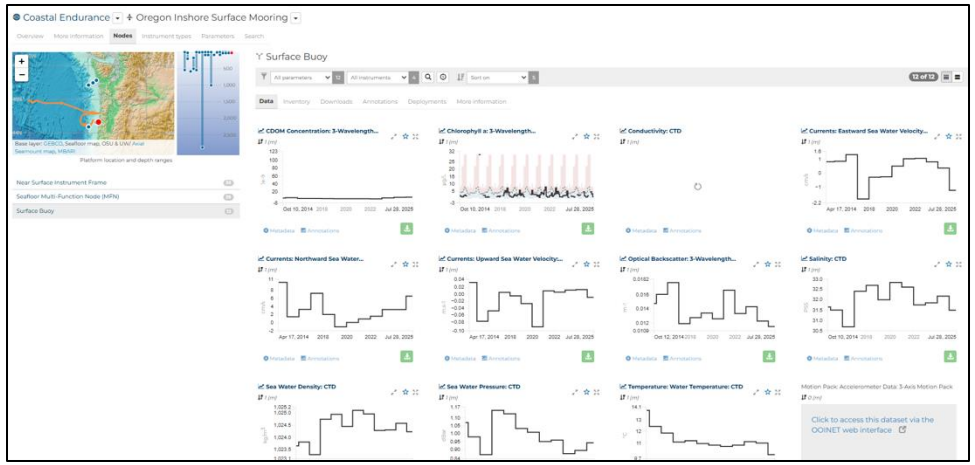
Types of data platforms (subset of all)

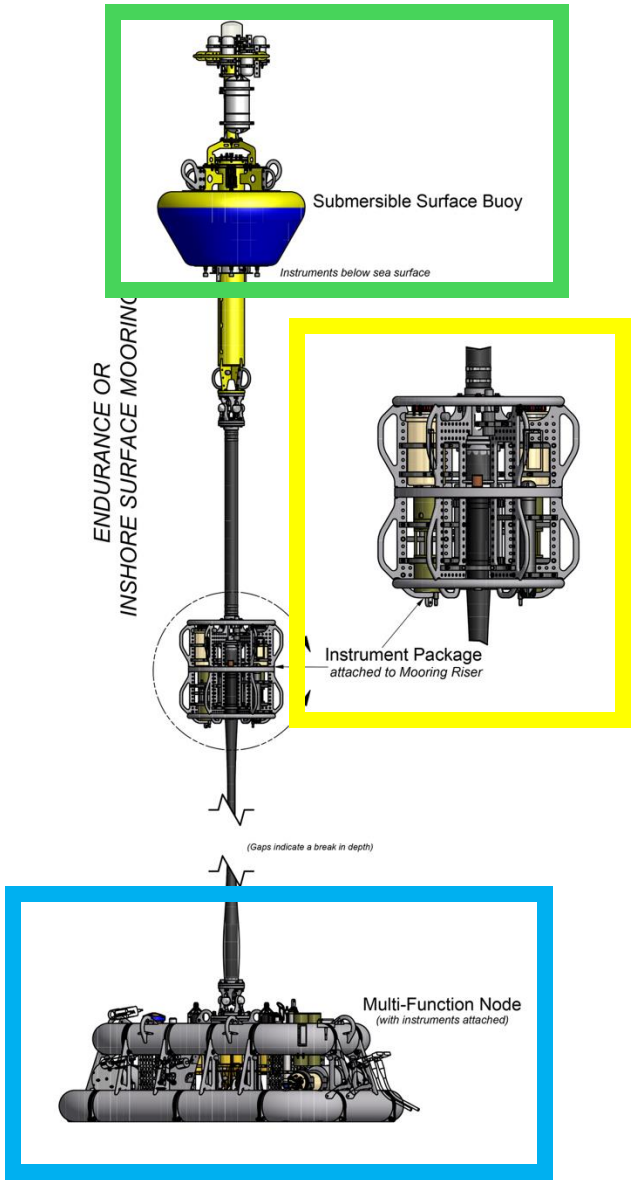
State (OR/WA)	Site (Inshore/Shelf/Offshore)	Instrument type*
Oregon	Inshore	Surface Mooring
Oregon	Inshore	Surface Piercing Profiler Mooring
Oregon	Offshore	Cabled Benthic Experiment Package
Oregon	Offshore	Cabled Deep Profiler Mooring
Oregon	Shelf	Surface Mooring
Washington	Inshore	Surface Piercing Profiler Mooring
Washington	Offshore	Surface Mooring
Washington	Offshore	Profiler Mooring
Washington	Shelf	Surface Mooring

*Each instrument holds numerous sensors, which each measure many data parameters (temperature, salinity, pressure, etc.)
Webpage link to OOI glossary: Glossary - Ocean Observatories Initiative

Types of data – example Oregon Inshore Surface Mooring

- 3 stationary nodes (near surface instrument frame, seafloor multi-function node, and surface buoy)
- Node webpage (select a node to see what data parameters each measures)

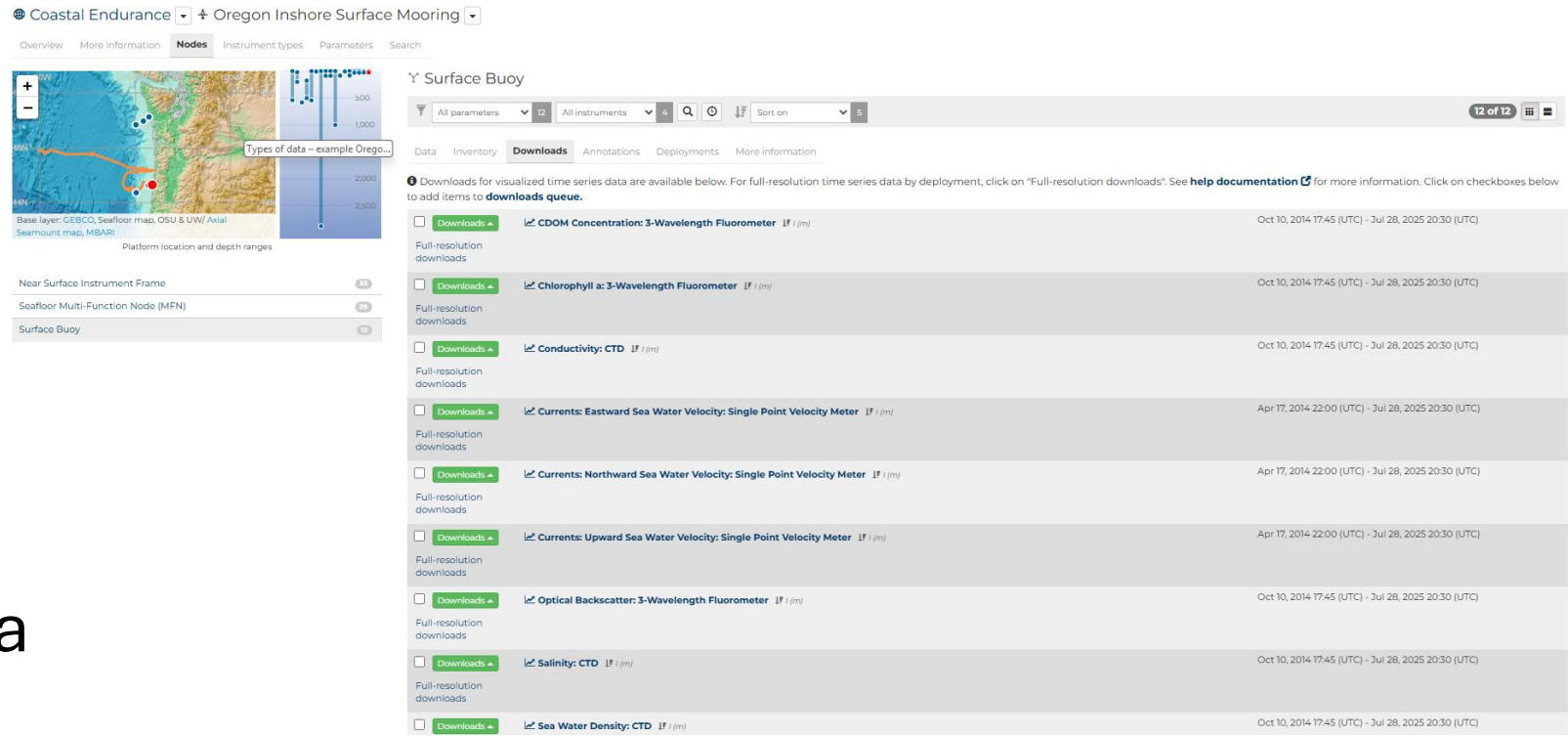




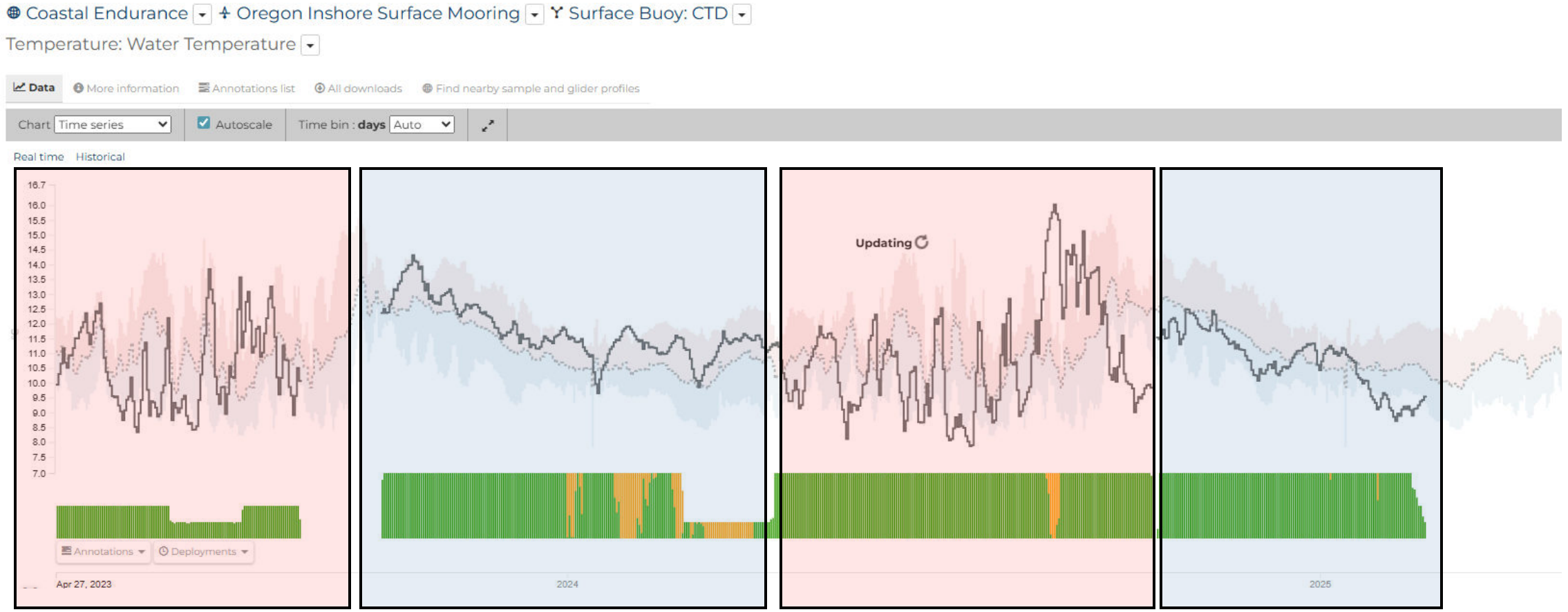
Types of data – example Oregon Inshore Surface Mooring

Surface Buoy Node

- Data: shows plots of available data
- Inventory: shows which data is good (green) or bad (red)
- Downloads: provides download link for data (shown at right)
- Who has used .csv files before?



Types of data – example Oregon Inshore Surface Mooring



Summer (upwelling)

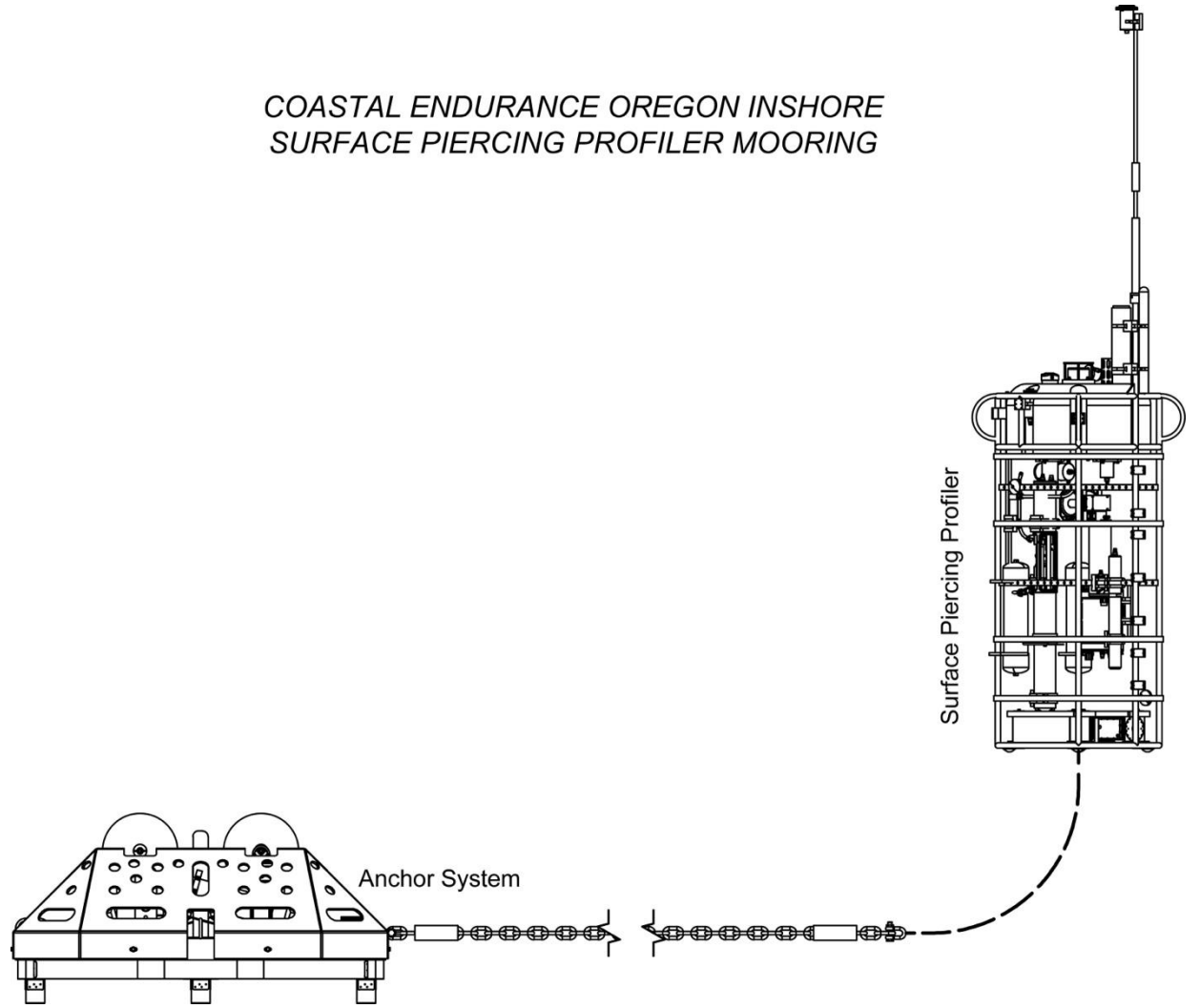
- More variability
- Lower temperatures

Winter (downwelling)

- Higher temperatures (closer to atmospheric)

Types of data – example Oregon Inshore Surface Piercing Profiler Mooring

- 1 node: surface piercing profiler
- Travels up and down in the water column to provide data at multiple depths
- We call this type of data “a profile”



Types of data – example Oregon Inshore Surface Piercing Profiler Mooring

Surface Piercing Profiler

- Data: shows plots of available data
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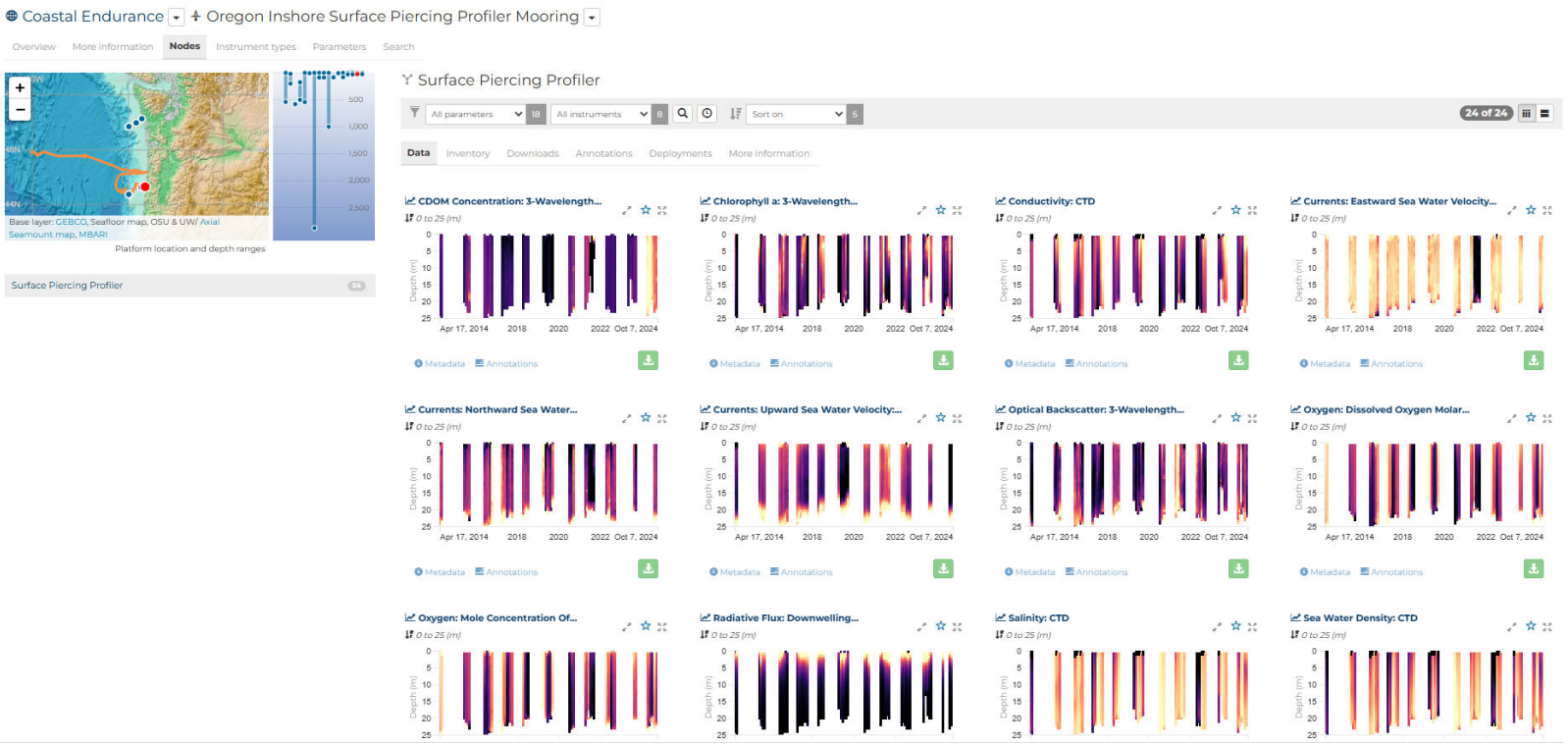


Accessing data

1. OOI: Data Explorer: examples I have shown, but it is not the most user-friendly

Accessing data

1. OOI: Data Explorer: the OOI website itself (examples I have shown, but not the most user-friendly)

- Tutorials (link to full youtube playlist):
  - Find and Visualize profiler data
  - Compare data time-series

Accessing data

1. OOI: Data Explorer: the OOI website itself (examples I have shown, but not the most user-friendly)

- Resources page:
  - Community tools and datasets
  - Educational resources
  - Tutorials
- OOI HelpDesk: ask any questions or submit requests for specific datasets from any OOI data array, platform, and node

Accessing data

1. OOI: Data Explorer: the OOI website itself (examples I have shown, not the most user-friendly)
2. Ocean Data Labs: primarily made for upper-level high school/undergrad students and educators to access data and share resources

Ocean Data Labs data access

- Data explorations (free education modules, developed for undergrads to explore data in a more accessible format)
- OOI nuggets (provide “nuggets” of easily accessible data illustrating a key point, tailored for high school and college age but could be tailored to younger levels)
    - Example: Underwater eruption and Marine Phytoplankton Blooms
- Python Notebooks (explore accessing data and making plots in python)
- Data Worksheets (printable worksheets exploring data)

Ocean Data Labs teaching resources

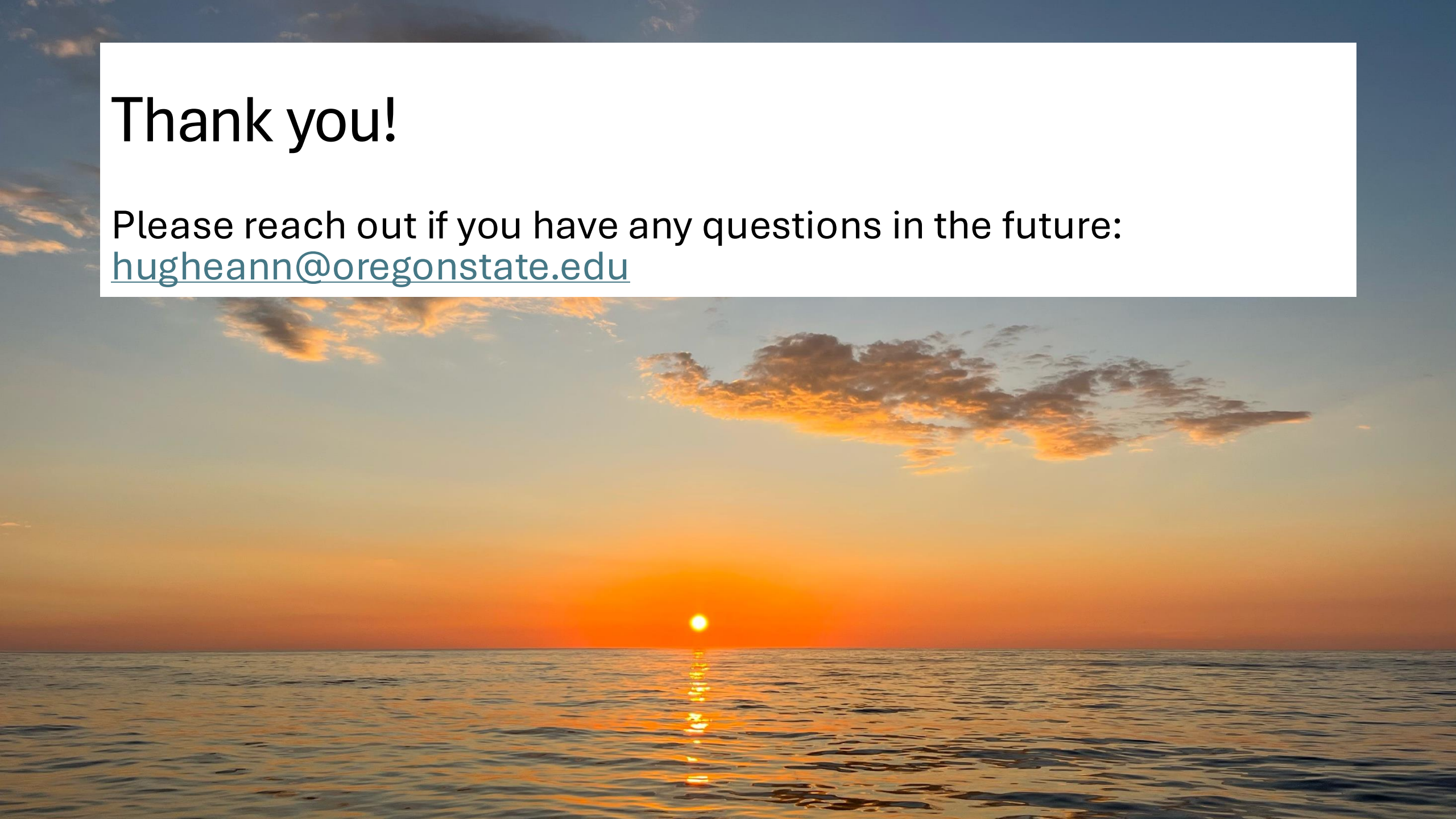
- Lesson plan examples
- Lab exercises using OOI data
- Teaching with OOI data

Accessing data

1. OOI: Data Explorer: the OOI website itself (examples I have shown, not the most user-friendly)
2. Ocean Data Labs: primarily made for upper-level high school/undergrad students and educators to access data and share resources
3. NANOOS (The Northwest Association of Networked Ocean Observing Systems): visualization data tools and products for easier use

NANOOS (The Northwest Association of Networked Ocean Observing Systems)

- NANOOS Visualization System (NVS)
- NANOOS – Products
- NANOOS Mobile Apps
- NANOOS Education Resources: lesson plans (grades 6-12), partners, and resources for students and teachers



Thank you!

Please reach out if you have any questions in the future:
hugheann@oregonstate.edu