Ocean Observatories Initiative

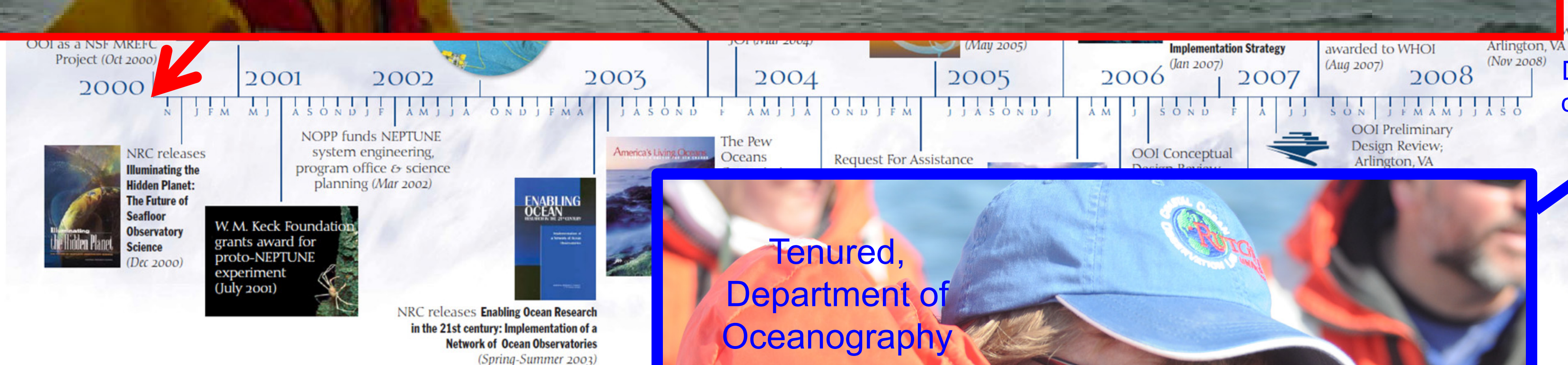
Where are we? What will be there for you? What are the opportunities?

Oscar Schofield on behalf of many

oscar@marine.rutgers.edu

Themes to be covered

- History and status
- Basic system
- OCB Science Potential
- Procedures For Data Quality



2014
During OOI construction

Overarching Science Them

Forcing and exchanges at the boundaries

- Ocean-atmosphere exchange
- Fluid-rock interactions

Dynamics of the boundary regimes

- Coastal ocean dynamics and ecosystems
- The subseafloor biosphere
- Plate-scale, ocean geodynamics

e

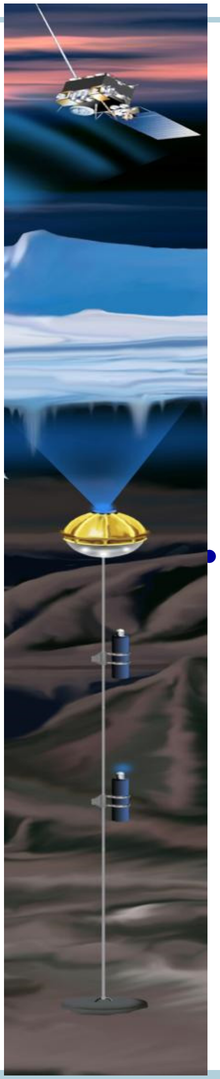
cal

- Carbon cycling, ocean acidification, ecosystem health

Over the long term the technologies have been evolving as the OOI process has evolved.

When I became initially became evolved in the plans for a future OOI autonomous systems where not considered acceptable as they were “too unproven and just a concept”.

Development of new infrastructure critical component to winning MRE-FC funds

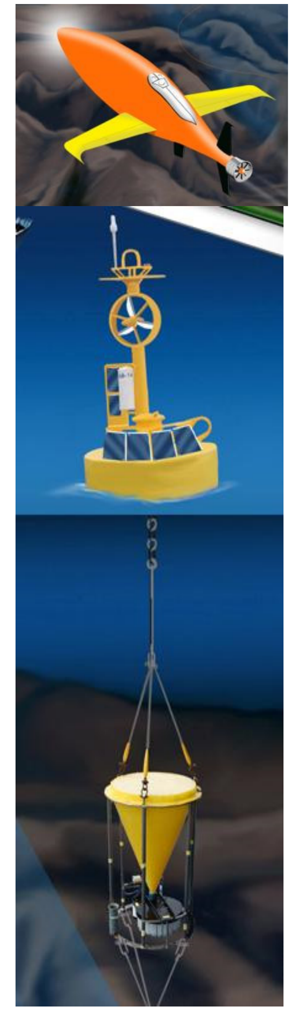


Barron, E. J., et al.. 2011. Critical infrastructure for ocean research and societal needs in 2030. Ocean Studies Board, National Research Council.

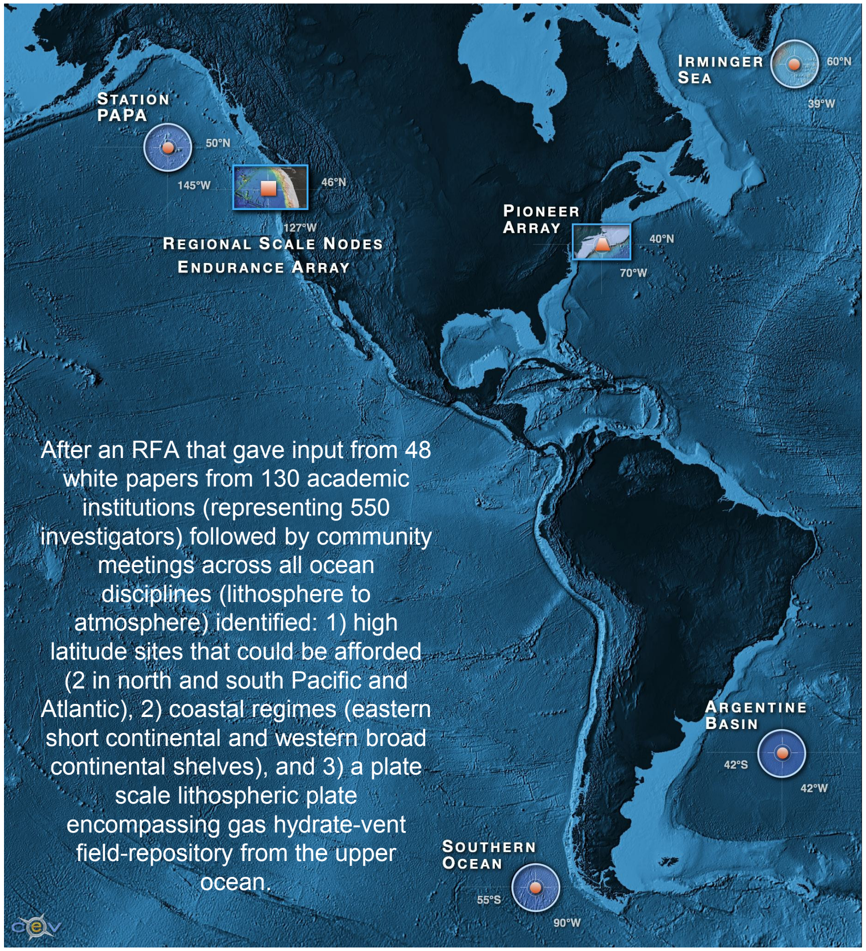
Recommendations

- **Expand abilities for autonomous monitoring** at a wide range of spatial and temporal scales with greater sensor and platform capabilities

Facilitate broad community access to infrastructure assets, including mobile and fixed platforms and costly analytical equipment



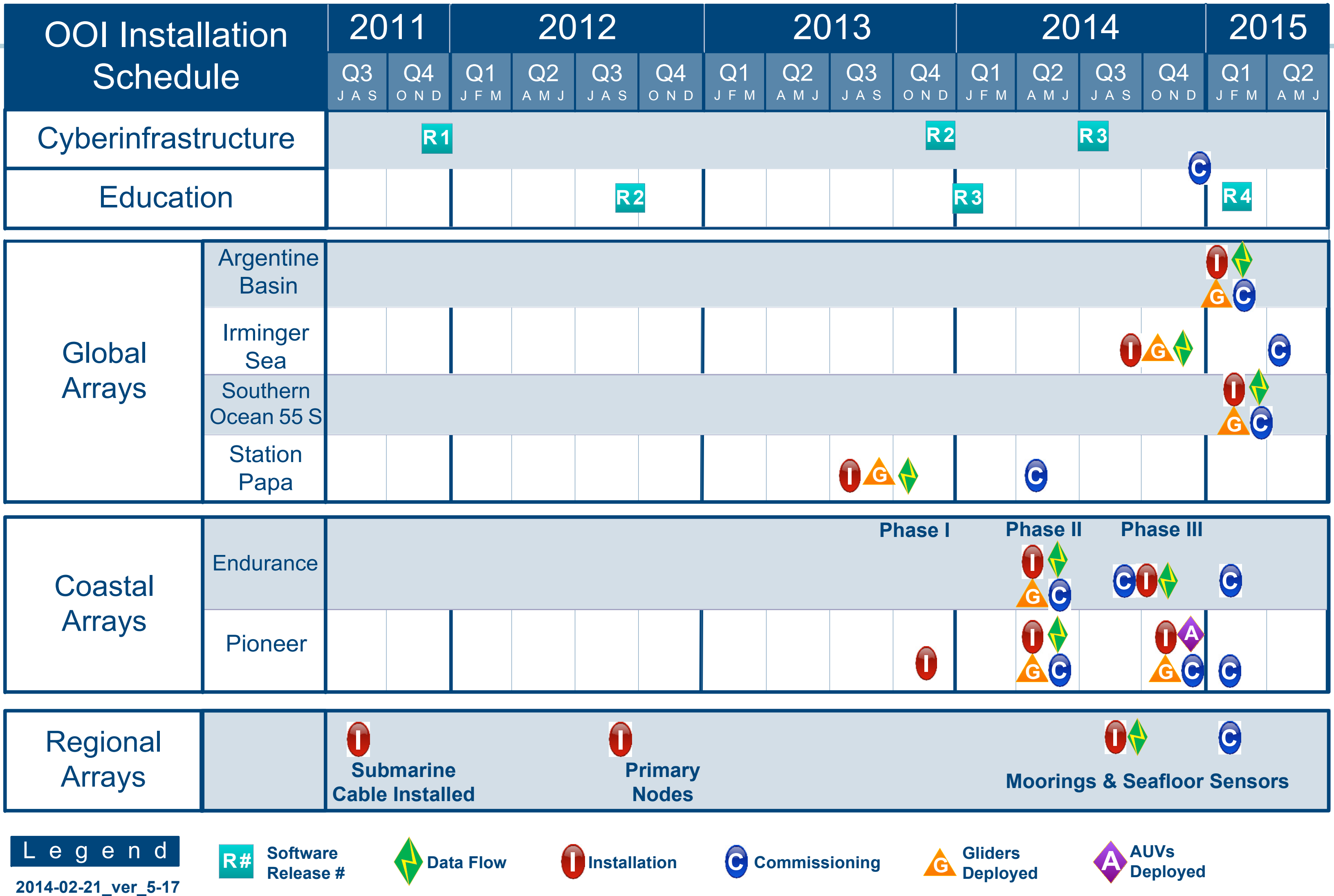
What is being built?



- A distributed network of fully open access data for sustained periods open to anyone with open access to the web the democratization of oceanography
- Ability to characterize the importance of episodic versus seasonal, annual variability over eddy, shelf and plate scales
- >800 unique sensors deployed at any given time on the network
- A network capable of absorbing new sensors as they are developed by the wider scientific community
- A scalable cyber infrastructure providing a service orientated architecture
- A system that provides web service data management with visualization
- An integrated education and public engagement suite of tools that can be directly integrated into undergraduate education modules

So what is living the dream?

Where are we in the deployment of the OOI?



OCB WHOI 2014 summer meeting
June 23 2014,

Deployed Scope of OOI (over 800 instruments distributed over all moorings, benthic packages, seafloor nodes, gliders and AUVs)

Global Arrays

Subsystems	Components	Instruments	Service Frequency
Global Arrays			
Station Papa	1 Subsurface Hybrid Profiler Mooring 2 Flanking Moorings 3 Gliders	12 32 9	Yearly
Irminger Sea	1 Surface Mooring 1 Subsurface Hybrid Profiler Mooring 2 Flanking Moorings 3 Gliders	23 12 32 9	Yearly
Southern Ocean	1 Surface Mooring 1 Subsurface Hybrid Profiler 2 Flanking Moorings 3 Gliders	23 12 32 9	Yearly
Argentine Basin	1 Surface Mooring 1 Subsurface Hybrid Profiler 2 Flanking Moorings 3 Gliders	23 12 32 9	Yearly

Coastal Arrays

Subsystems	Components	Instruments	Service Frequency
Coastal Arrays			
Pioneer	3 Surface Moorings 2 Surface-Piercing Profilers Moorings 5 Profiler Moorings 3 AUVs 6 Gliders	60 18 29 18 30	Twice a year
Endurance (Oregon Line)	3 Surface Moorings 2 Surface-Piercing Profilers Moorings 1 Hybrid Profiler Mooring 1 Benthic Experiment Package 1 Multi-Function Nodes	50 18 16 10 8	Twice a year
Endurance (Washington Line)	3 Surface Moorings 2 Surface-Piercing Profilers Moorings 1 Profiler Mooring 6 Gliders	68 18 5 30	Twice a year

Cabled Arrays

Subsystems	Components	Instruments	Service Frequency
Regional Scale Nodes			
Hydrate Ridge	Seafloor: Primary and Secondary Profiler – Winched Profiler – Wire crawler Midwater Platform@ 200m Bottom Instrument Package	16 10 5 8 6	Yearly
Axial Seamount	Seafloor: Primary and Secondary Profiler – Winched Profiler – Wire crawler Midwater Platform @ 200m Bottom Instrument Package	26 10 5 8 6	Yearly

Connected by 880km of seafloor cable, with 10KW power, internet connectivity between 7 primary nodes, multiple secondary nodes, and all distributed instrumentation

Cyberinfrastructure

Computing platforms, software applications, storage, and high speed network equipment

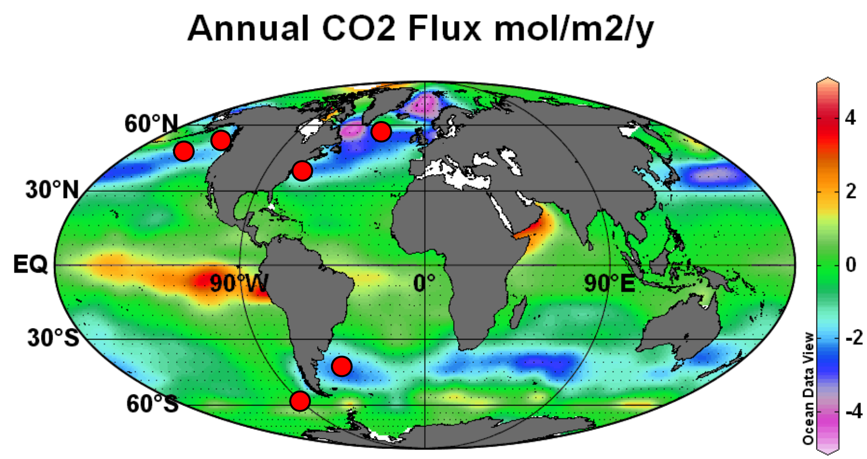
Cyber Points of Presence (CyberPoPs)
- Acquisition Points
- Distribution Points

Integrated Observatory Network – OOI Net
- Hardware / Software

Redundant computing environment

Extensive details about each component can be found on the OOI website (http://oceanobservatories.org)

Science opportunities?

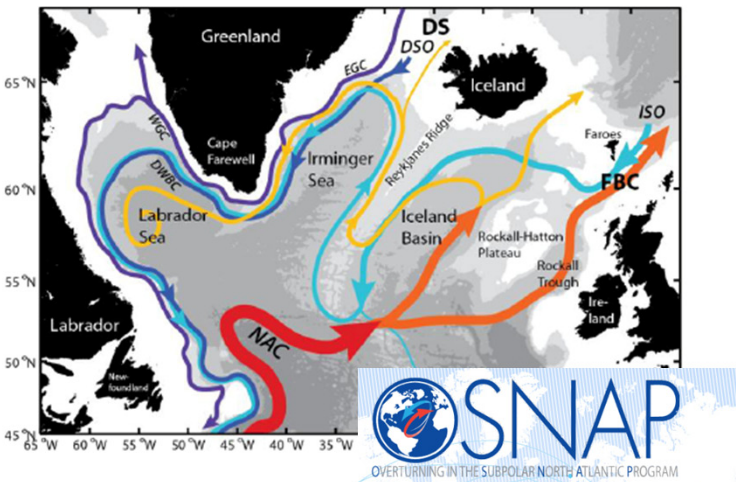


Annual air-sea carbon dioxide flux (positive out) using gridded data from Takahashi et al. (2009).

OOI will support ongoing and new science programs

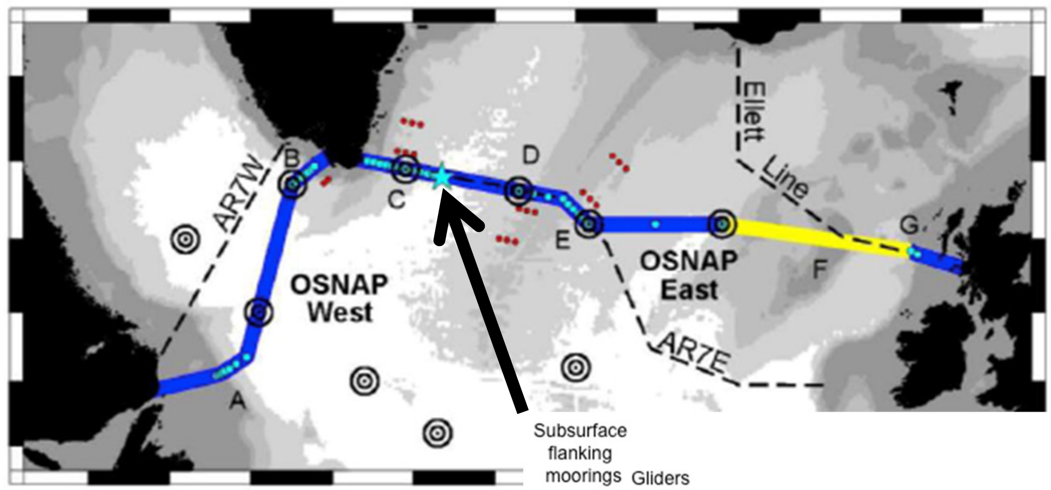
- Water mass formation and overturning

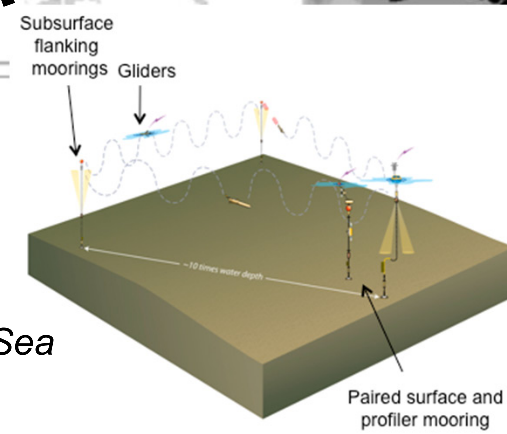
OOI part of overturning circulation experiments



1) Quantify the subpolar Atlantic Meridional Overturning Circulation (AMOC) and its intra-seasonal to interannual variability (including associated fluxes of heat and freshwater).
2) Determine the pathways of overflow waters in the North Atlantic subpolar gyre to investigate the connectivity of the deep boundary current system.
3) Relate AMOC variability to deep water mass variability and basin-scale wind forcing.
4) Determine the nature and degree of the subpolar-subtropical AMOC connectivity.

OSNAP is configured as a trans-basin observing system, across which AMOC metrics will be measured using a combination of fixed current meter arrays, repeat hydrographic occupations and gliders.

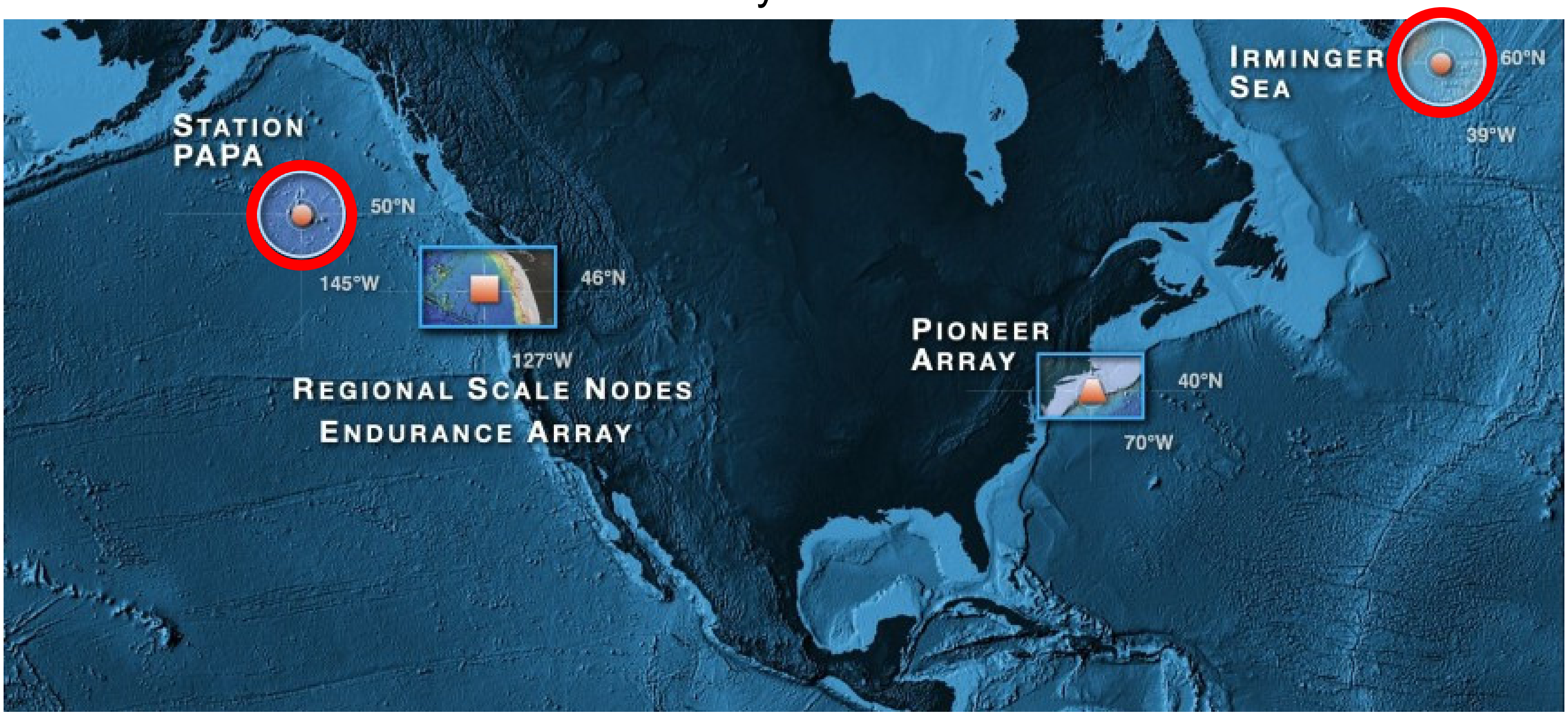




OOI array in Irminger Sea

OOI will facilitate comparison open ocean high lattitude systems

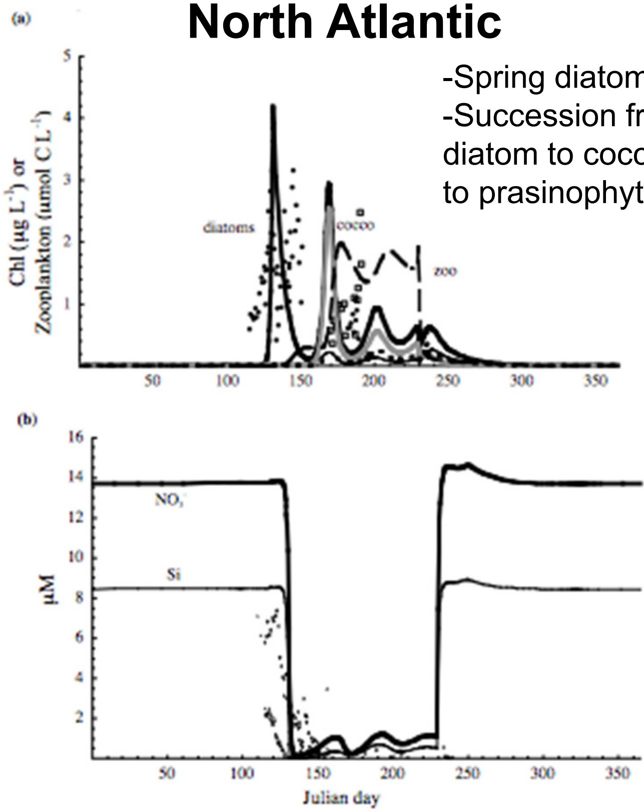
Compare magnitudes and rates of change across the NE Pacific and NW Atlantic and examining how those changes will impact ocean circulation, weather, and marine ecosystems.



Differences in microbial systems between North Atlantic and Ocean Station Papa

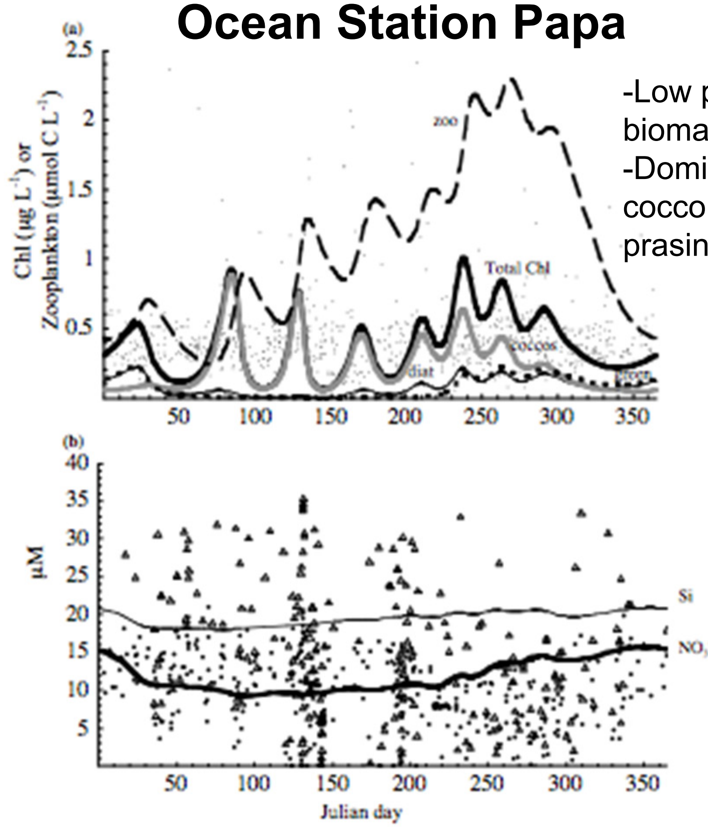
Phytoplankton functional type model showing distinct microbial responses to seasonal forcing, projected changes in the timing and stratification of these regions will alter these community dynamics

North Atlantic



-Spring diatom bloom
-Succession from the diatom to coccolithophore to prasinophytes

Ocean Station Papa



-Low phytoplankton biomass
-Dominated by coccolithophore and prasinophytes

Litchman et al 2006 Biogeosciences

Time series that could enable these comparative ecosystem studies

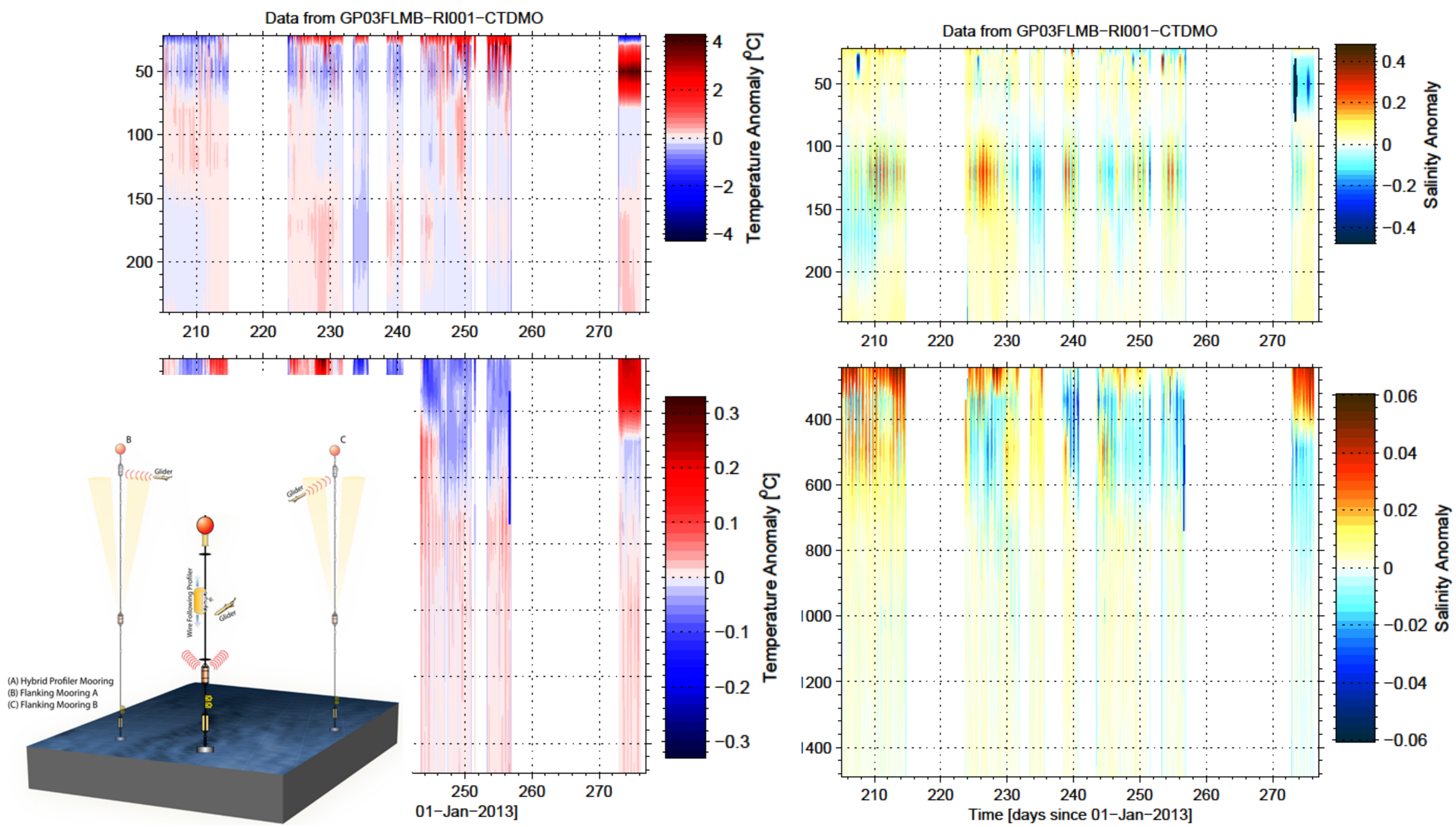
Platform and measurements

Gliders: Fluorometric chlorophyll a, optical backscatter, oxygen concentration, Conductivity, Pressure, Temperature, Depth averaged currents

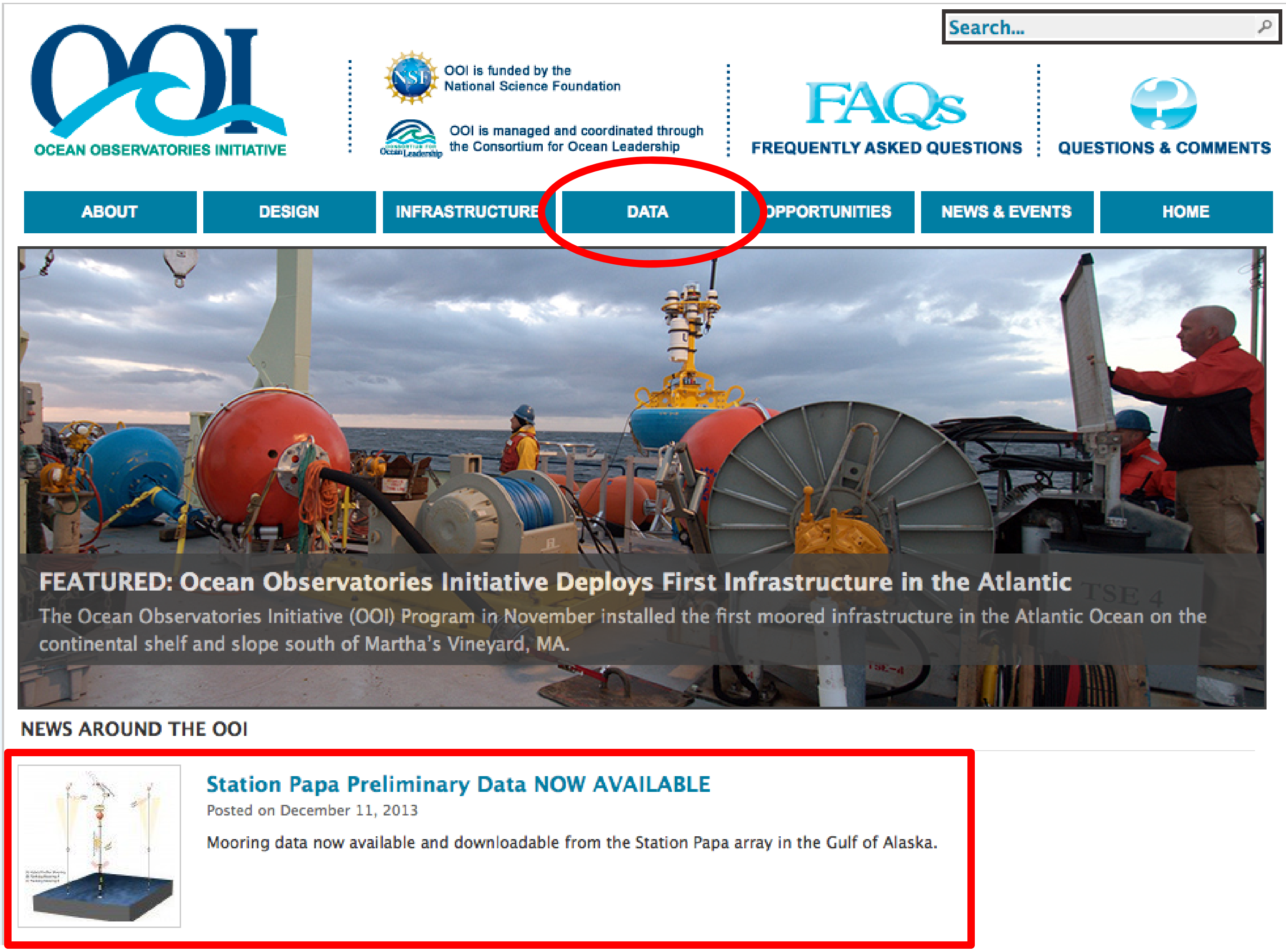
Flanking Mooring: On Mooring Riser (40meter below the surface) Fluorometric chlorophyll a and colored dissolved organic matter, optical backscatter, oxygen concentration, Conductivity, Pressure, Temperature, optical absorbance at 434 and 578 nm, pH (500 meters below surface looking up) echo intensity, velocity profile (CTDs at 30, 40, 60, 90, 130, 180, 250, 350, 500, 750, 1000, 1500)

Profiling Mooring: (Surface to 150 meters) Fluorometric chlorophyll, optical backscatter, pCo2, oxygen, spectral absorption, nitrate, spectral irradiance, conductivity, temperature (150 meter) upward looking acoustic backscatter (below 240 meters to 2400 meters) fluorometric chlorophyll a, optical backscatter, oxygen, conductivity, temperature, turbulence

Station Papa – Flanking Mooring-B



Access to Pre-commissioned Data



Access to Pre-commissioned Data

Endurance Array

5 Added by Leslie Smith, last edited by Leslie Smith on Jul 09, 2014 (view change)

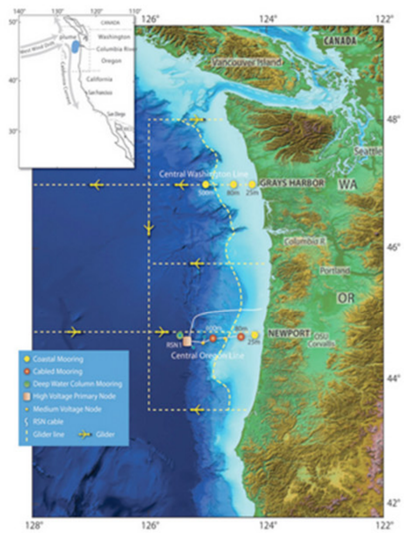
Add Tools

Welcome to the Endurance Array Preliminary Data Page

These pages provide a first look at the data to be available through the OOI. Please note, these have not been quality controlled.

The backbone of the Endurance Array includes two cross-shelf moored array lines, the Oregon Line (also called the Newport Line) and the Washington Line (also known as the rays Harbor Line). Each these lines contain three fixed sites spanning the slope (~500-600 m), shelf (~80-90 m) and inner-shelf (~25-30 m). The three sites across the shelf and slope are associated with unique physical, geological, and biological processes.

Additionally, Coastal gliders (Teledyne-Webb Slocum Gliders) will fly through the water column along saw-tooth paths, penetrating the sea surface and diving down to depth. These Coastal Gliders will be outfitted with one of two buoyancy engines allowing for maximum efficiency for either shallow (able to dive to 200 m) or deep (able to dive to 1000 m) dives. A roughly even combination of deep and shallow diving coastal gliders will be deployed, sufficient to survey the Endurance Array area.

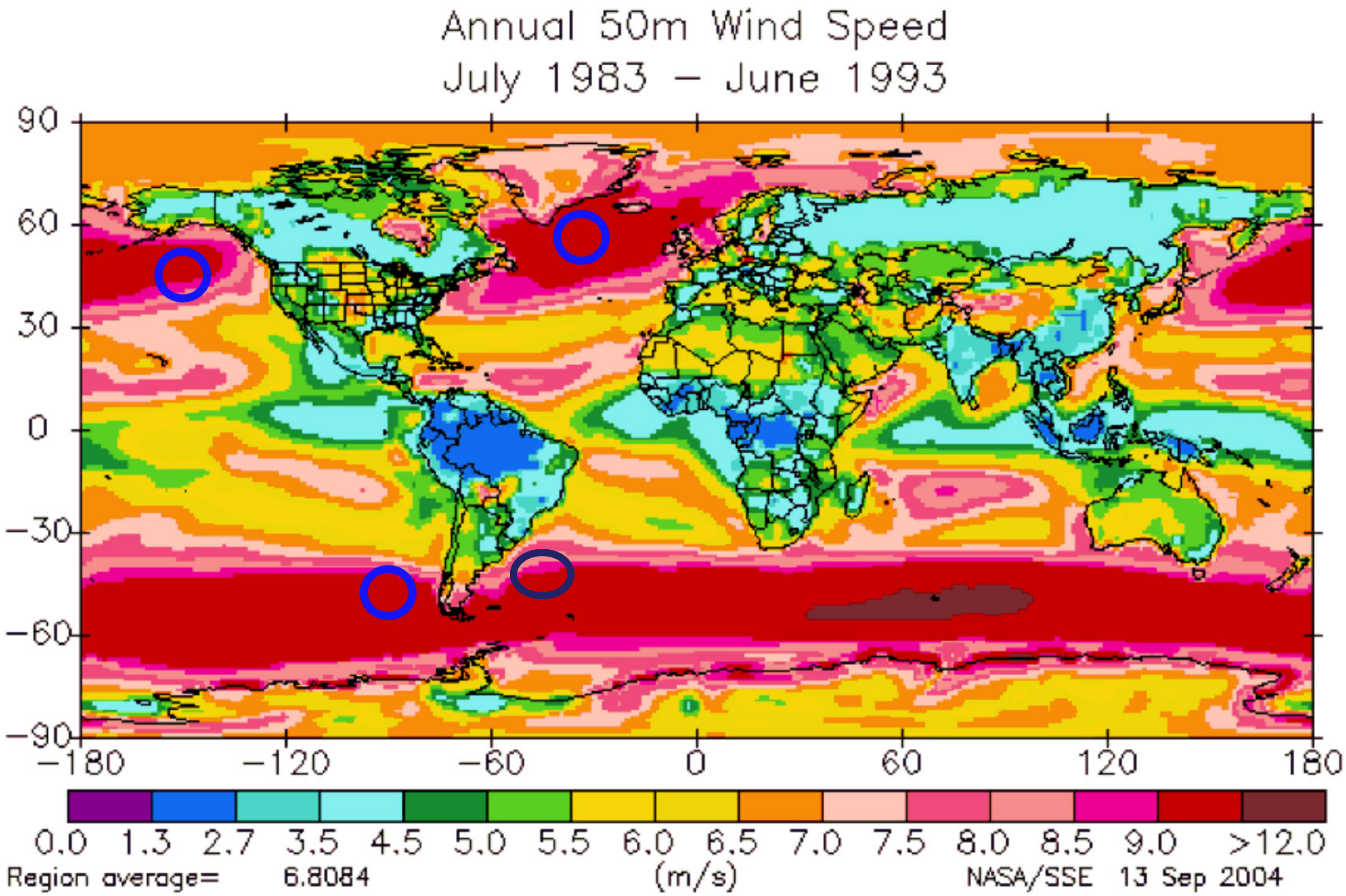


Glider sampling area:

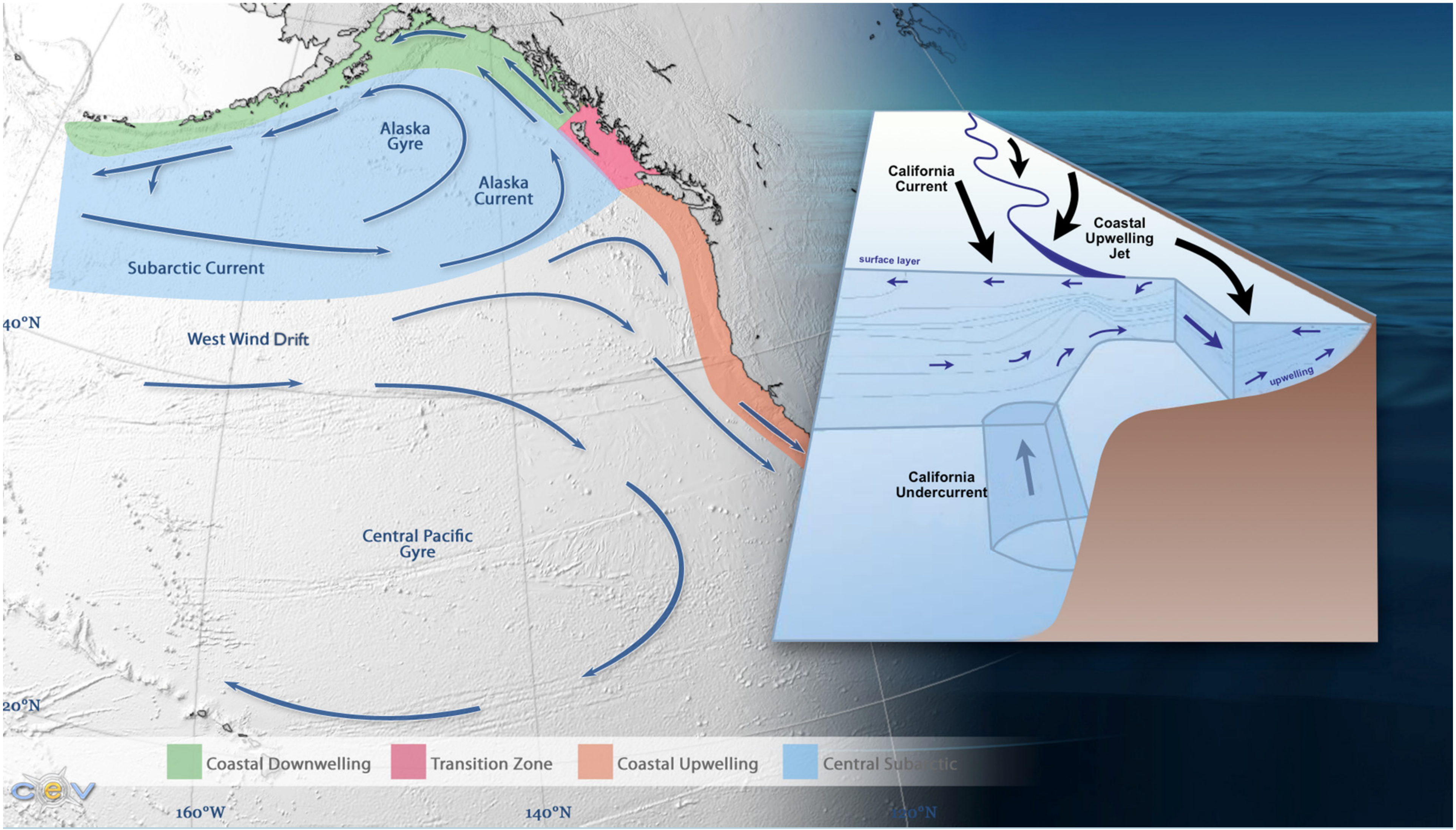
An array of ~6 gliders will travel along five east-west transect lines from approximately the 20-m isobaths to 126 W (and out to 128 W along the Oregon and Washington lines), as well as a north-south transect along 126 W and a north-south transect along the 200 m isobath.

Subsite Name	Date Deployed	Instrument Count	Data Available?
Endurance Array Gliders	2014-04	30	✓

OOI will sample the high latitudes- strongly forced, poorly observed

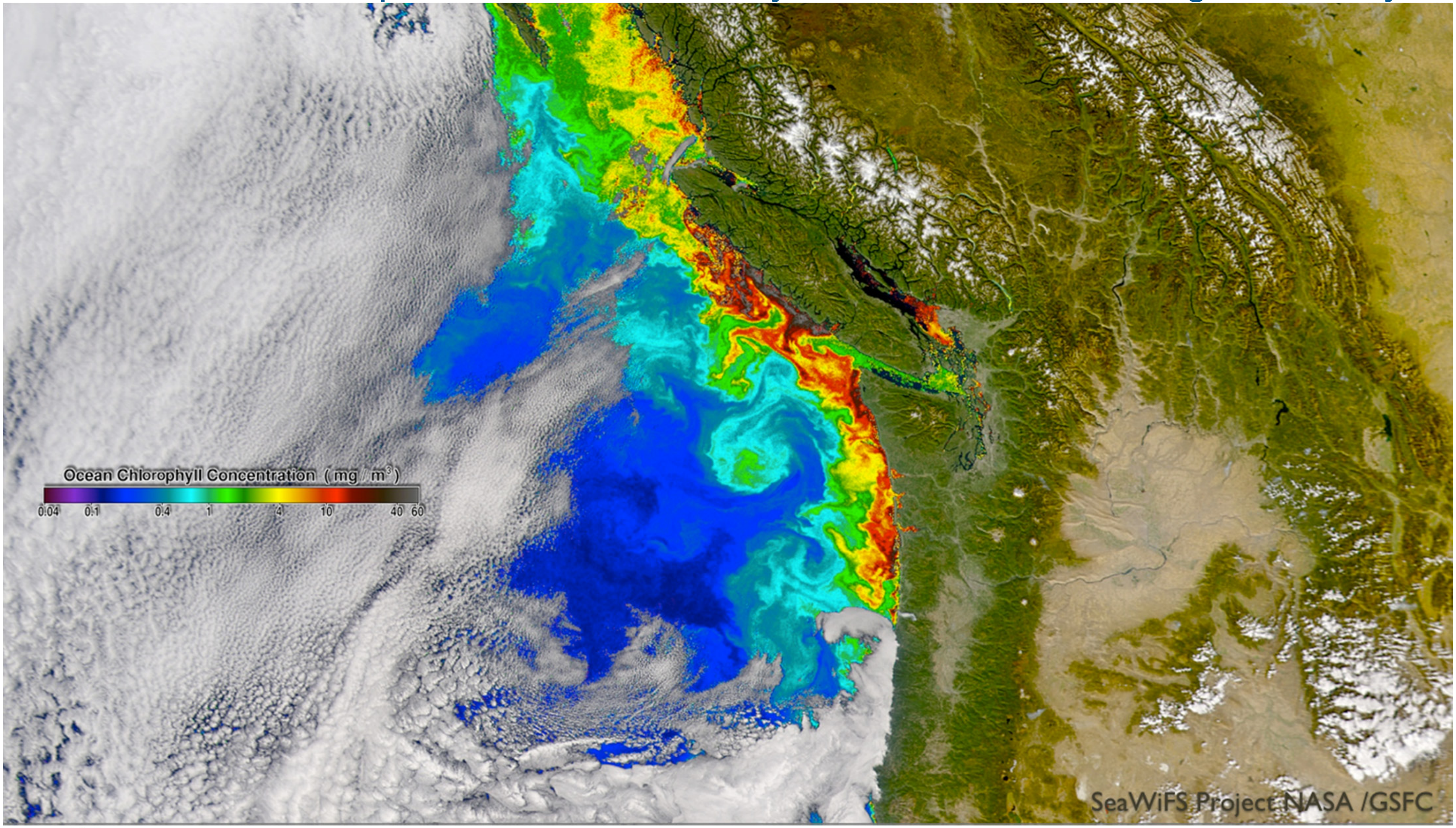


What is the coupling of the exchanges between open ocean and coastal systems?



OCB WHOI 2014 summer meeting
June 23 2014,

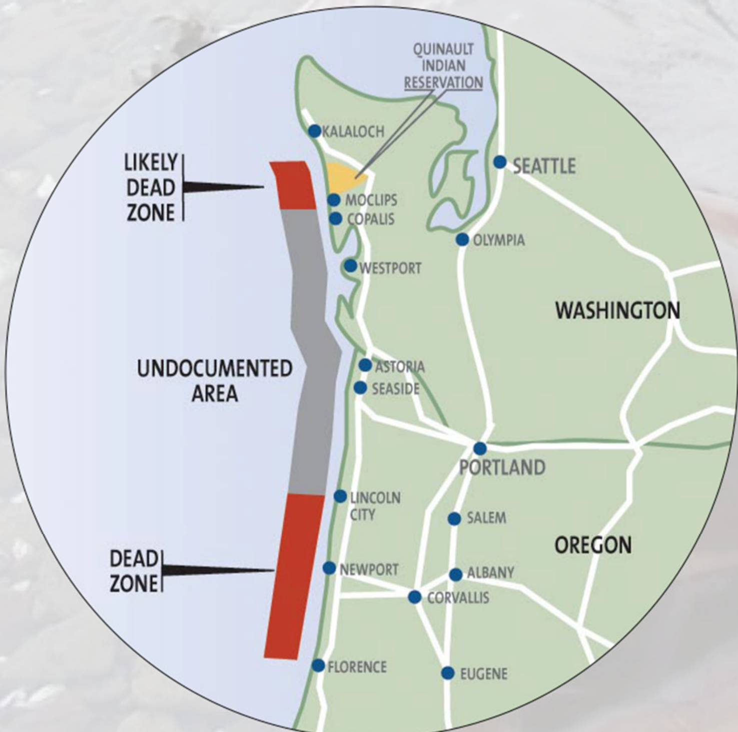
How do these deep and coastal ocean systems drive local biological activity?



OCB WHOI 2014 summer meeting
June 23 2014,

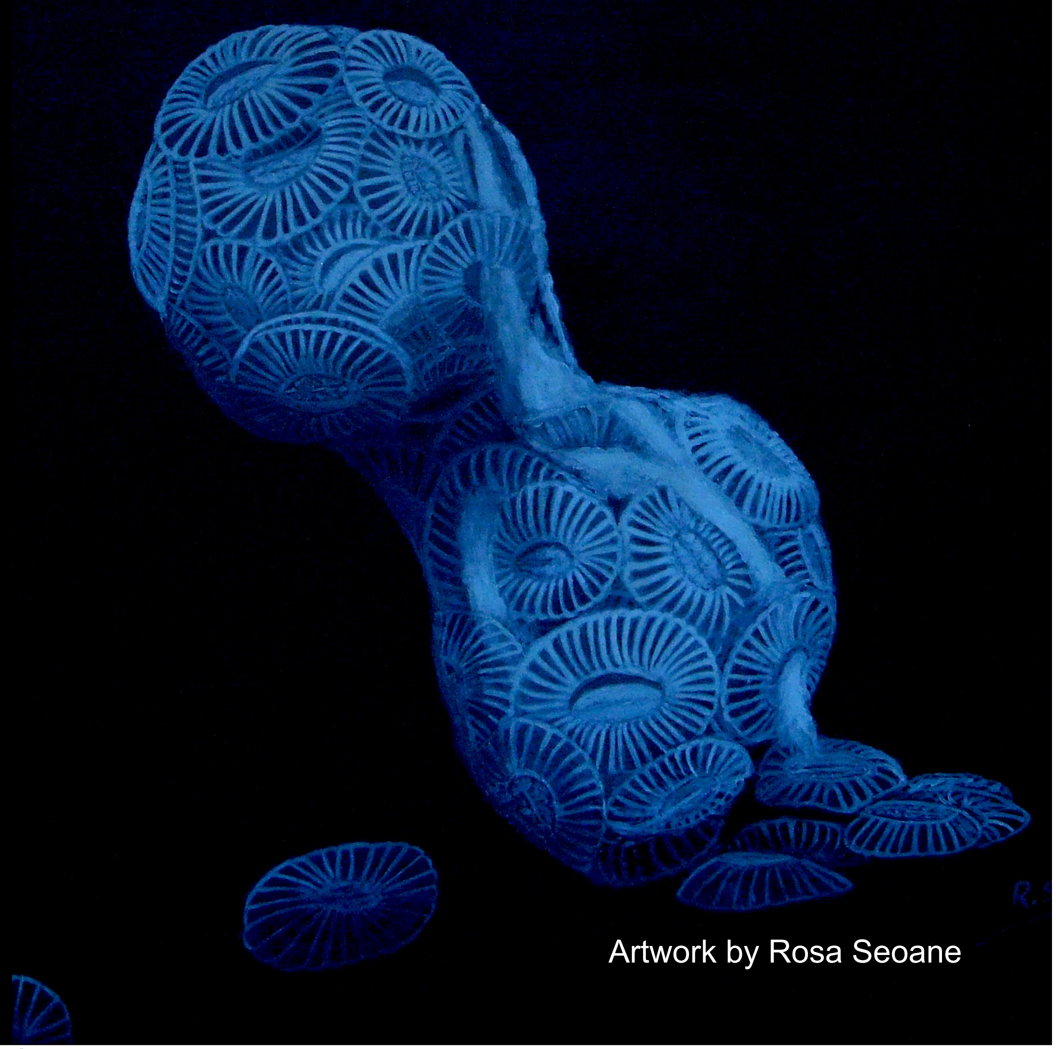
How systems being modified by shifting redox state?

Hypoxia - Dead Zones



How systems being modified by shifting pH?

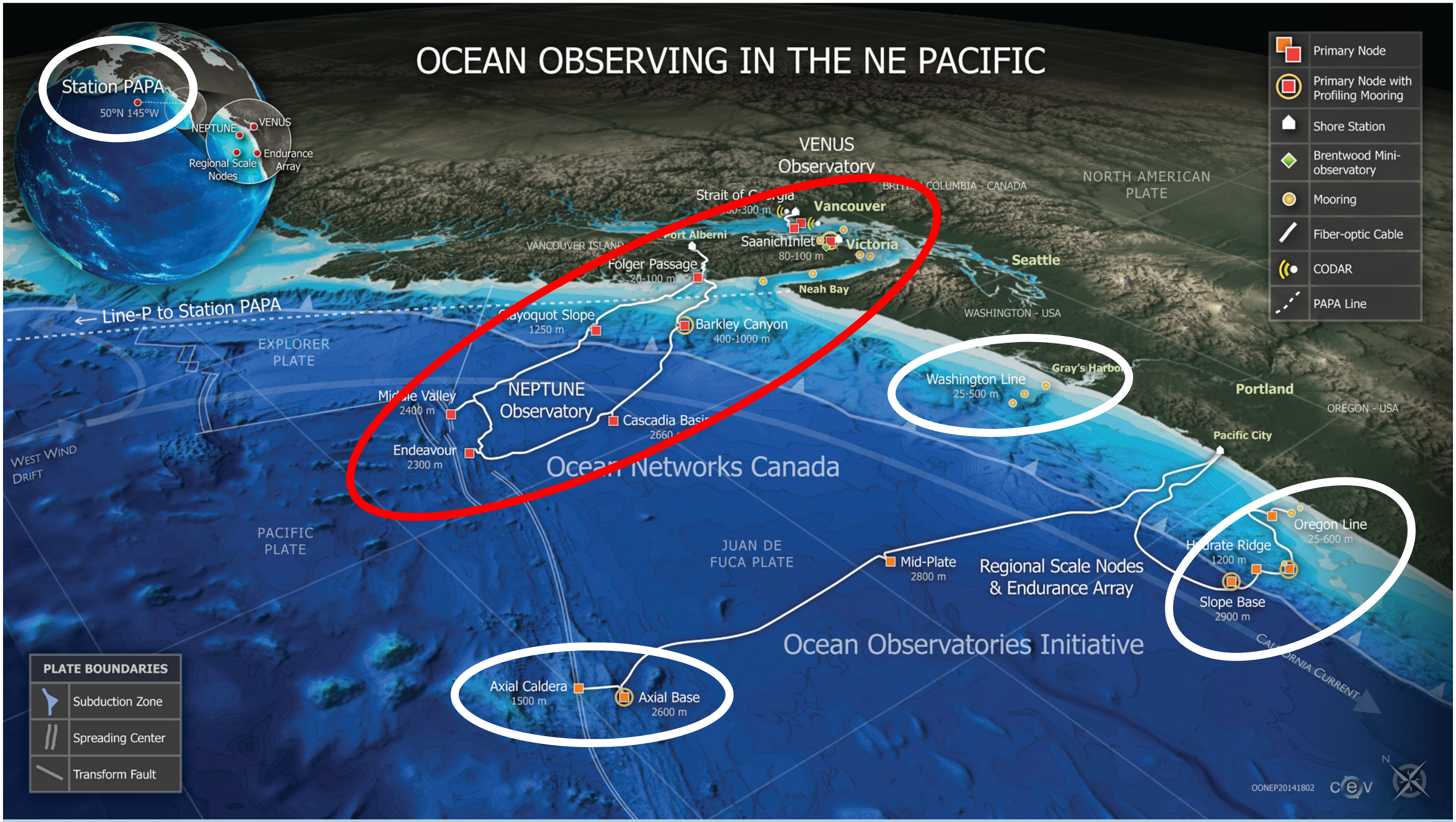
How will the world react to an acidified ocean?



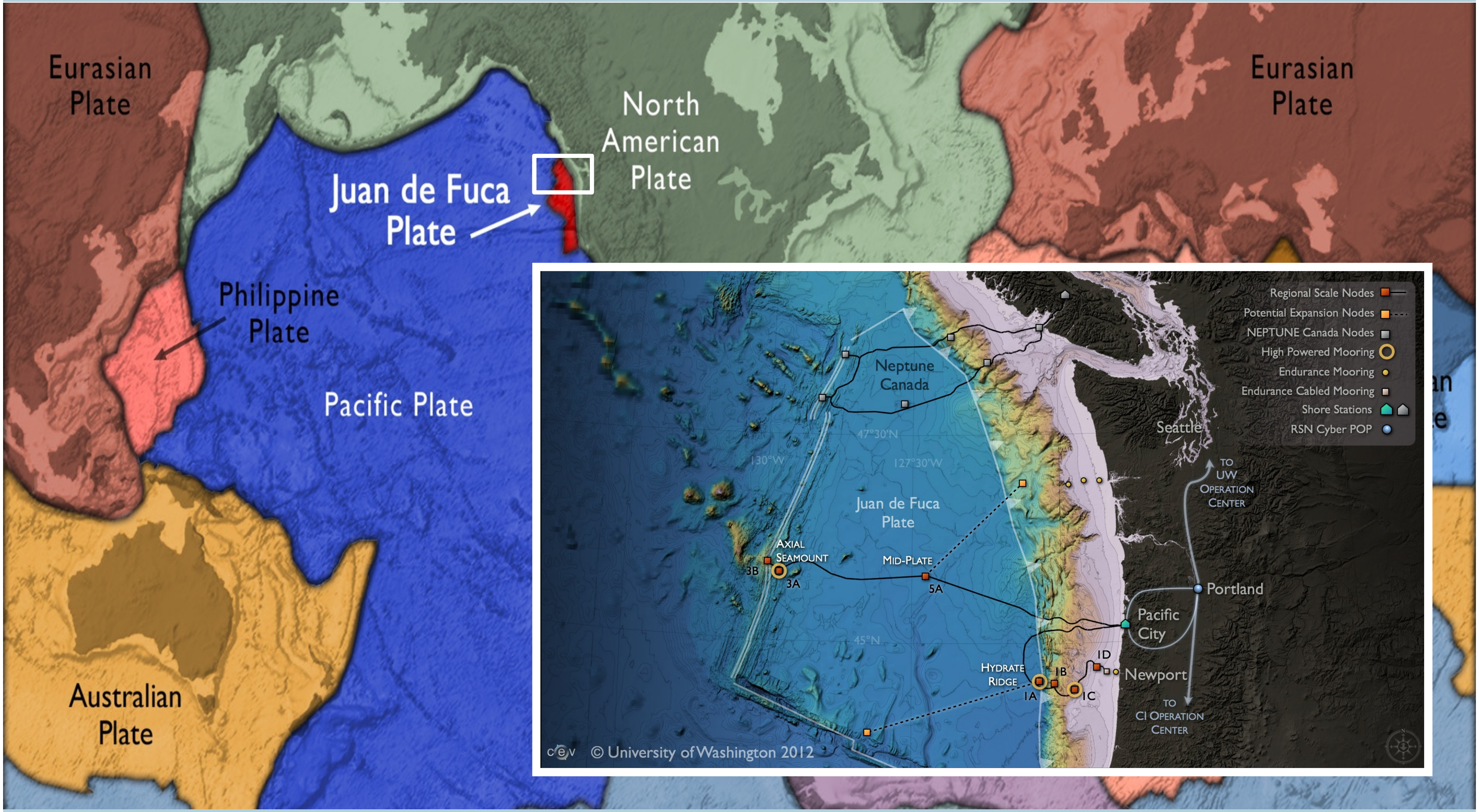
Artwork by Rosa Seoane

Melting coccolithophorrids

NE Pacific Observatory Assets



Spanning the Juan de Fuca Plate



OCB WHOI 2014 summer meeting
June 23 2014,

Data Products from NE Pacific observatories

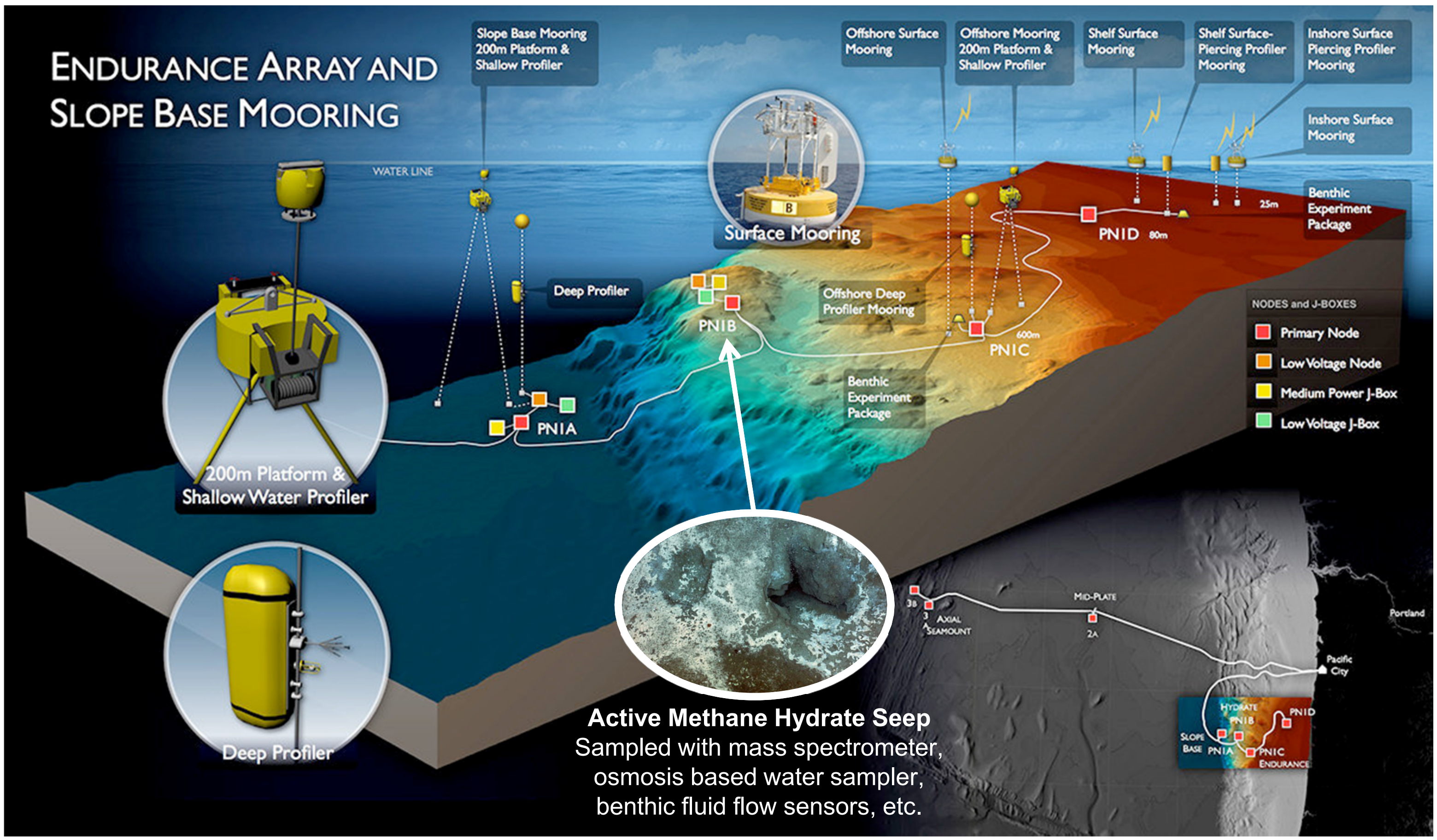
Data Products (Types)	Air-Sea Interface	Water Column	Seafloor
Physical/Geological			
Humidity	★🍁		
Air Temperature	★🍁		
Precipitation	★🍁		
Barometric pressure	★🍁		
Wind Velocity	★🍁		
Turbulent fluxes	★	★🍁	🍁
Wave properties	★🍁	★🍁	★🍁
Water Temperature	★🍁	★🍁	★🍁
Salinity	★🍁	★🍁	★🍁
Density	★🍁	★🍁	★🍁
Water velocity	★🍁	★🍁	★🍁
Barotropic velocity		★🍁	
Suspended Solids		★🍁	★🍁
Seismic activity		★🍁	★🍁
Pressure (Depth)		★🍁	★🍁
Imagery (optical)		★	★🍁
Seafloor temperature			★🍁
Ground motion			★🍁
Seafloor pressure and tilt			★🍁
Seafloor uplift/deflation			★🍁
Benthic fluid flow			★🍁
Scanning sonar		★🍁	★🍁
Hydrothermal discharge flux			🍁

Data Products from NE Pacific observatories

Data Products (Types)	Air-Sea Interface	Water Column	Seafloor
Chemical/Biological			
pCO2	★🍁	★🍁	★
Irradiance	★🍁	★	
Inherent Optical Properties	★🍁	★🍁	
Chlorophyll a (fluorescence)	★🍁	★🍁	★
CDOM	★🍁	★🍁	
pH	★🍁	★🍁	★🍁
Dissolved O2	★🍁	★🍁	★🍁
Nitrate		★🍁	★🍁
Hydrophones		★🍁	★🍁
Hydrothermal vent water samples			★🍁
Microbial particulate DNA		★🍁	★🍁
Vent/Seep Fluid Chemistry			★🍁
Resistivity (e.g. [Cl^-])			★🍁
Bioacoustic scattering		★🍁	
Sedimentation rate			🍁

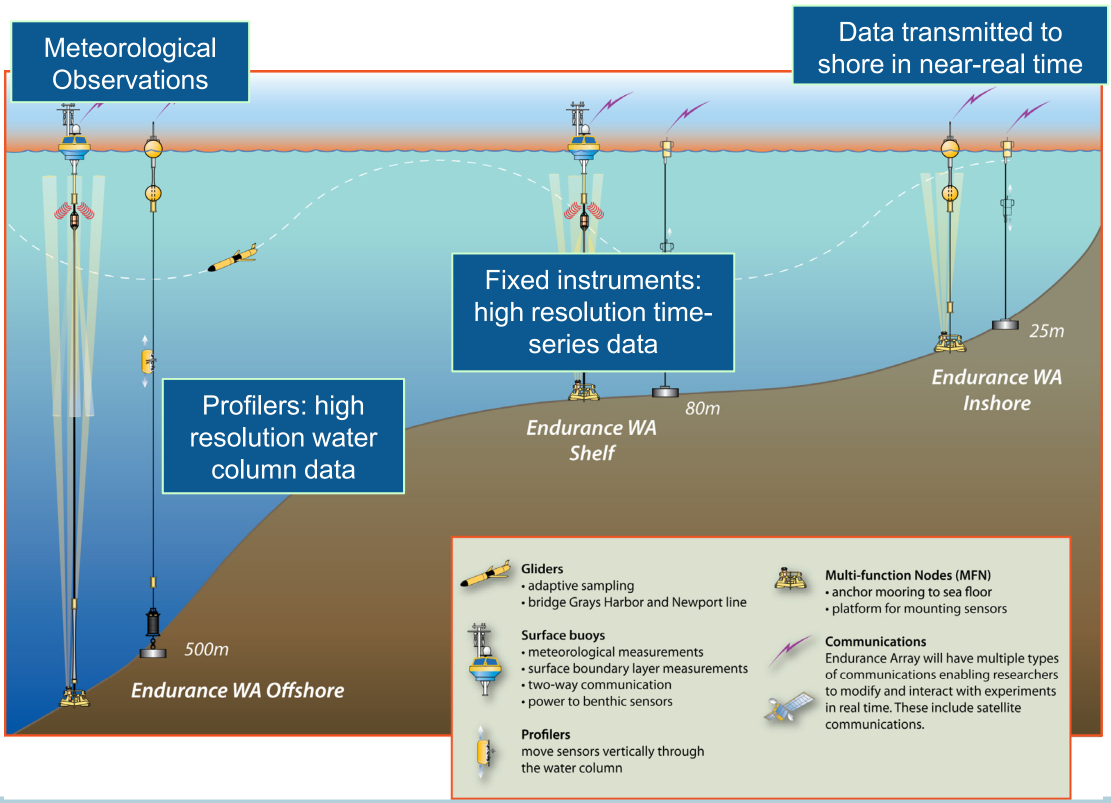
Shelf/Slope Mixing and Biophysical Interactions

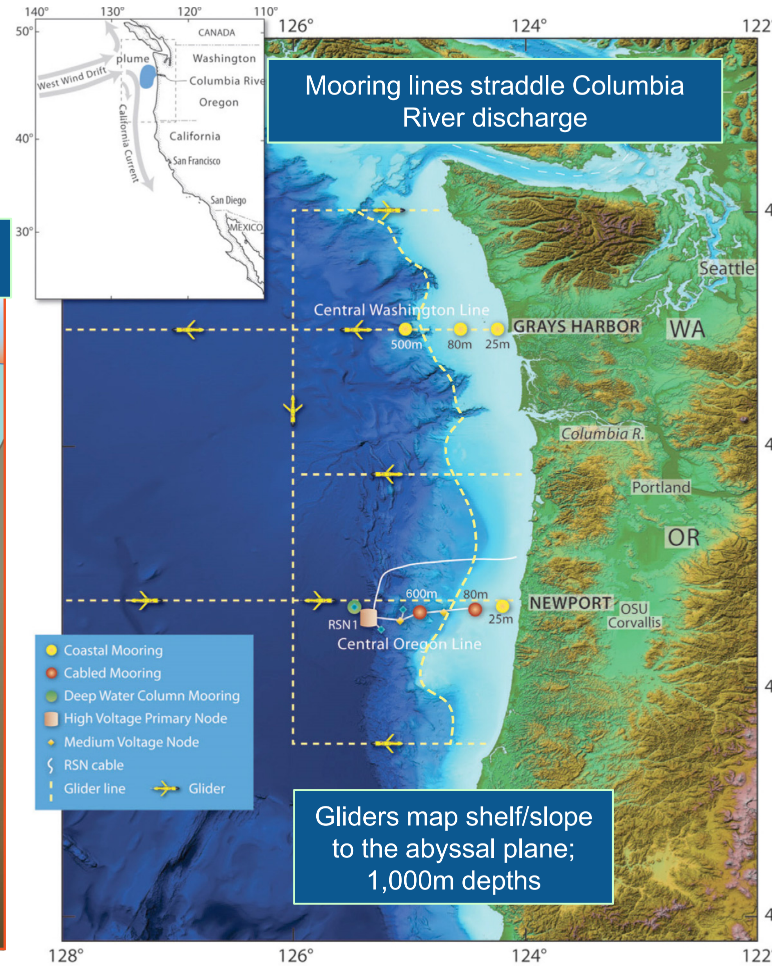
Understanding processes along the shelf/slope gradient, quantifying exchanges, observing shallow methane hydrates.



Coastal Ocean Dynamics and Ecosystems

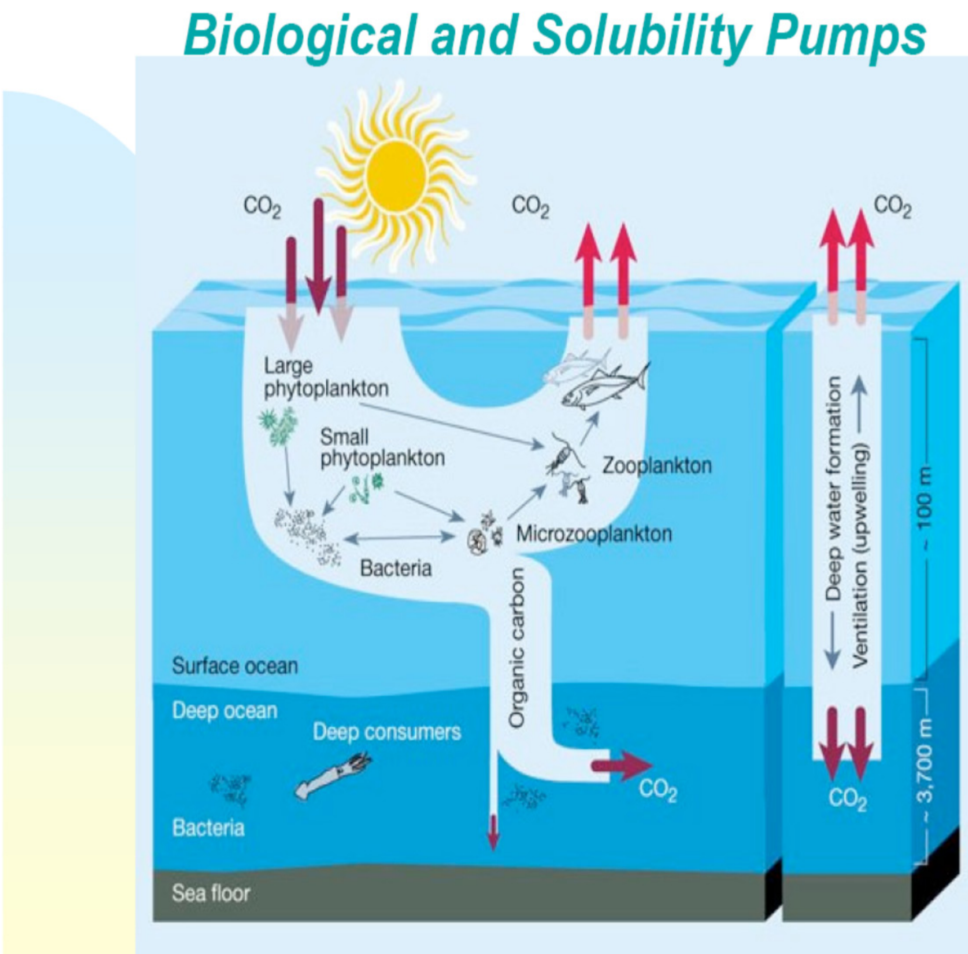
Understanding spatial and temporal complexity of the coastal ocean (upwelling, circulation, mixing) and quantifying interactions between atmospheric and terrestrial forcing.





OCB WHOI 2014 summer meeting
June 23 2014,

Can we sample a water column?



The Chisholm figure that launched 1000s of proposals

-technologies available to sample the upper, mesopelagic, deep and sea floor represents diverse communities who unfortunately do not interact

-technologies for the different parts of the water column are distinct

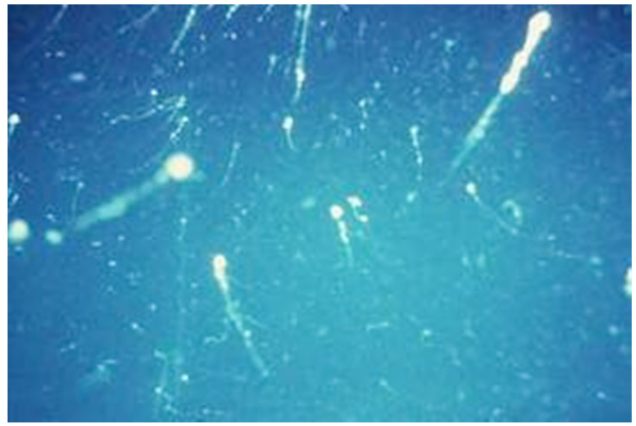
-many of the technologies we need to "constrain" the arrows of the flow do not yet exist

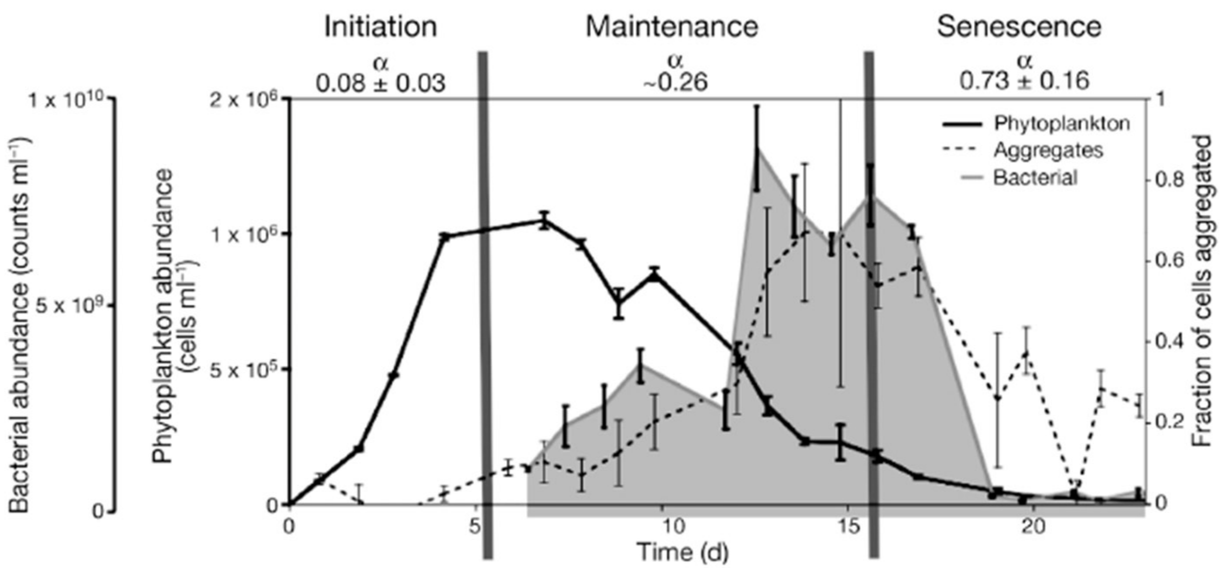
-many of the processes that drive the size of the arrows we do not know

Ocean-Atmosphere Exchange

Examining the exchange of gas and energy between ocean and atmosphere: carbon dioxide, heat, methane, water vapor

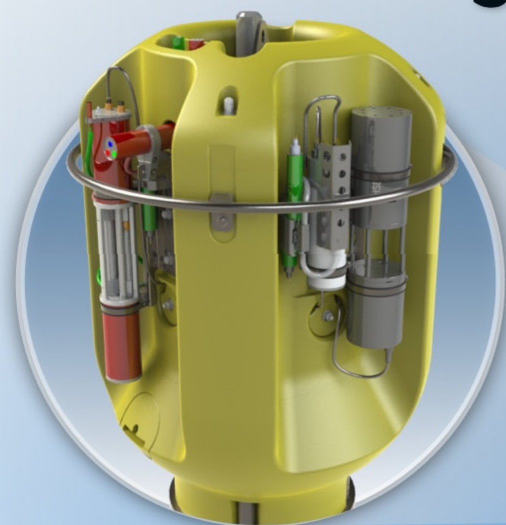
What might someone focus on with the existing infrastructure?
Timing of Marine Snow Formation, bloom dynamics defined by detailed OOI moored time series,
Spatial glider surveys, combined with satellite imagery, and models





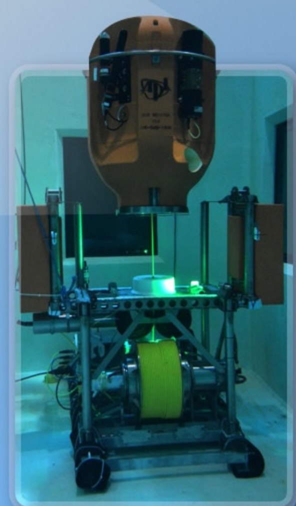
Kahl et a. 2008

Assets to the NE Pacific system have OCB relevant features



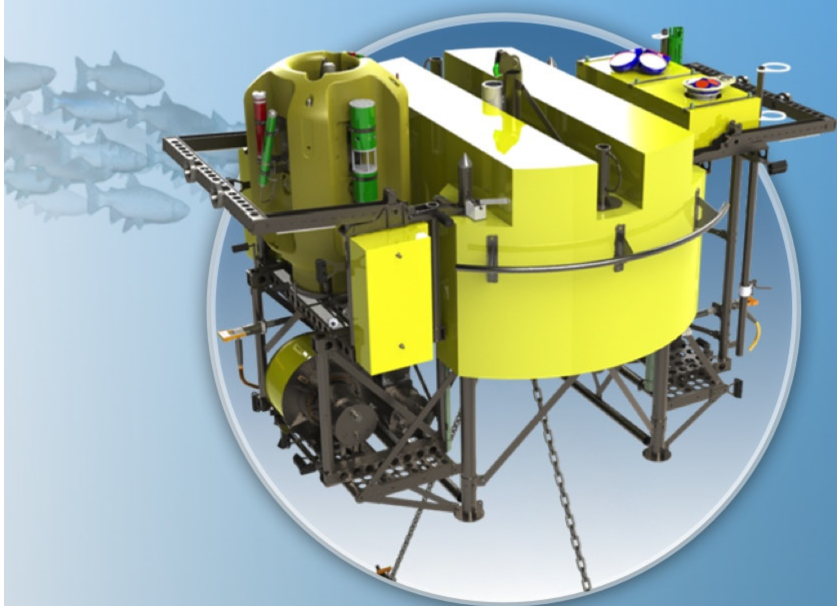
SHALLOW PROFILER

- Fluorometers
- Seawater CO2 Partial Pressure
- Photosynthetically Active Radiation
- Spectral Irradiance
- 3-D Single Point Current Meter
- Conductivity, Temperature, Pressure
- Dissolved Oxygen
- Nitrate
- Seawater pH
- Spectrophotometer



Assets to the NE Pacific system have OCB relevant features

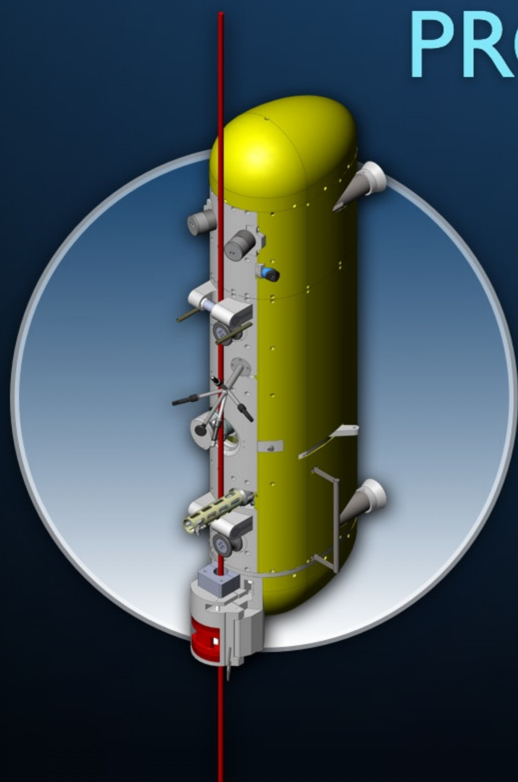
200-METER PLATFORM



- Velocity Profiler
- Digital Still Camera
- 5-Beam, 600 kHz Acoustic Doppler Current Profiler
- Broadband (Passive) Acoustic Receiver
- Conductivity, Temperature, Pressure
- Dissolved Oxygen
- 2-Wavelength Fluorometer
- Seawater pH

Assets to the NE Pacific system have OCB relevant features

DEEP PROFILER



-CTD
-oxygen
-velocity
-optical attenuation
-chlorophyll fluorescence
-optical backscatter

Assets to the NE Pacific system have OCB relevant features

SEAFLOOR MOORING PACKAGE

Digital Still Camera

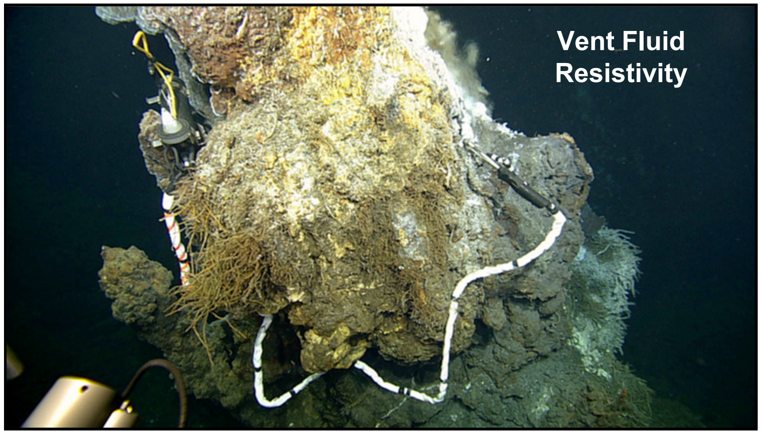
Acoustic Doppler Current Profiler

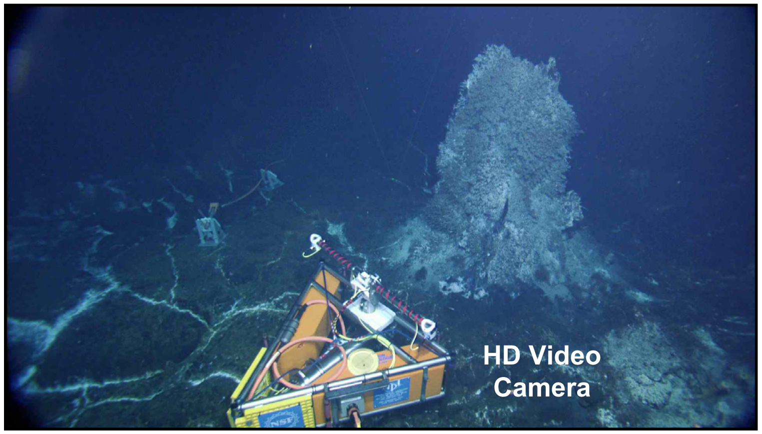
- Broadband Hydrophone
- Acoustic Doppler Current Profiler (150 kHz)
- Conductivity-Temperature-Depth
- Dissolved Oxygen Sensors
- Optical Attenuation Sensor
- ✳ Turbulent Flow Current Meter
- ✳ pH and CO_2 Sensors
- ✳ Digital Still Camera
- ✳ Zooplankton Sensor

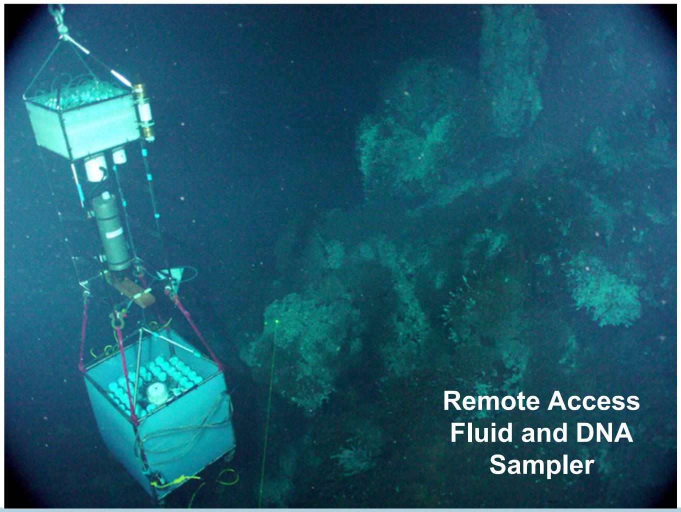
✳ shared with Endurance Array

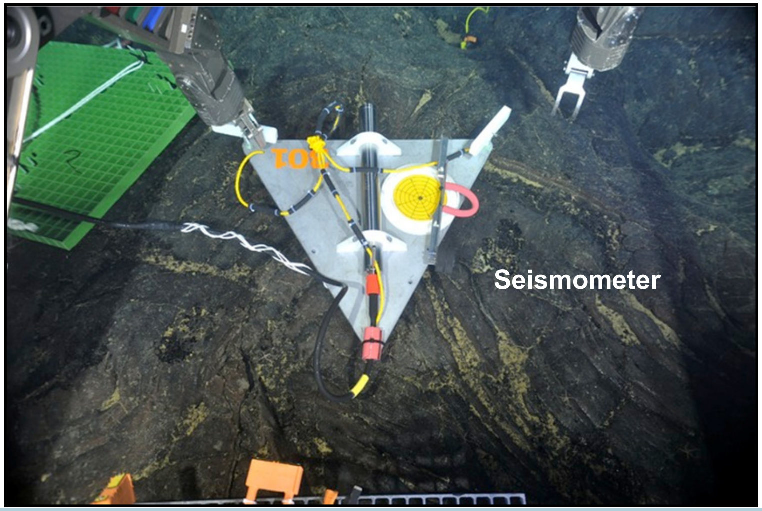
Mid-Ocean Ridge

Examining heat and chemical exchanges between the oceanic crust and seawater.



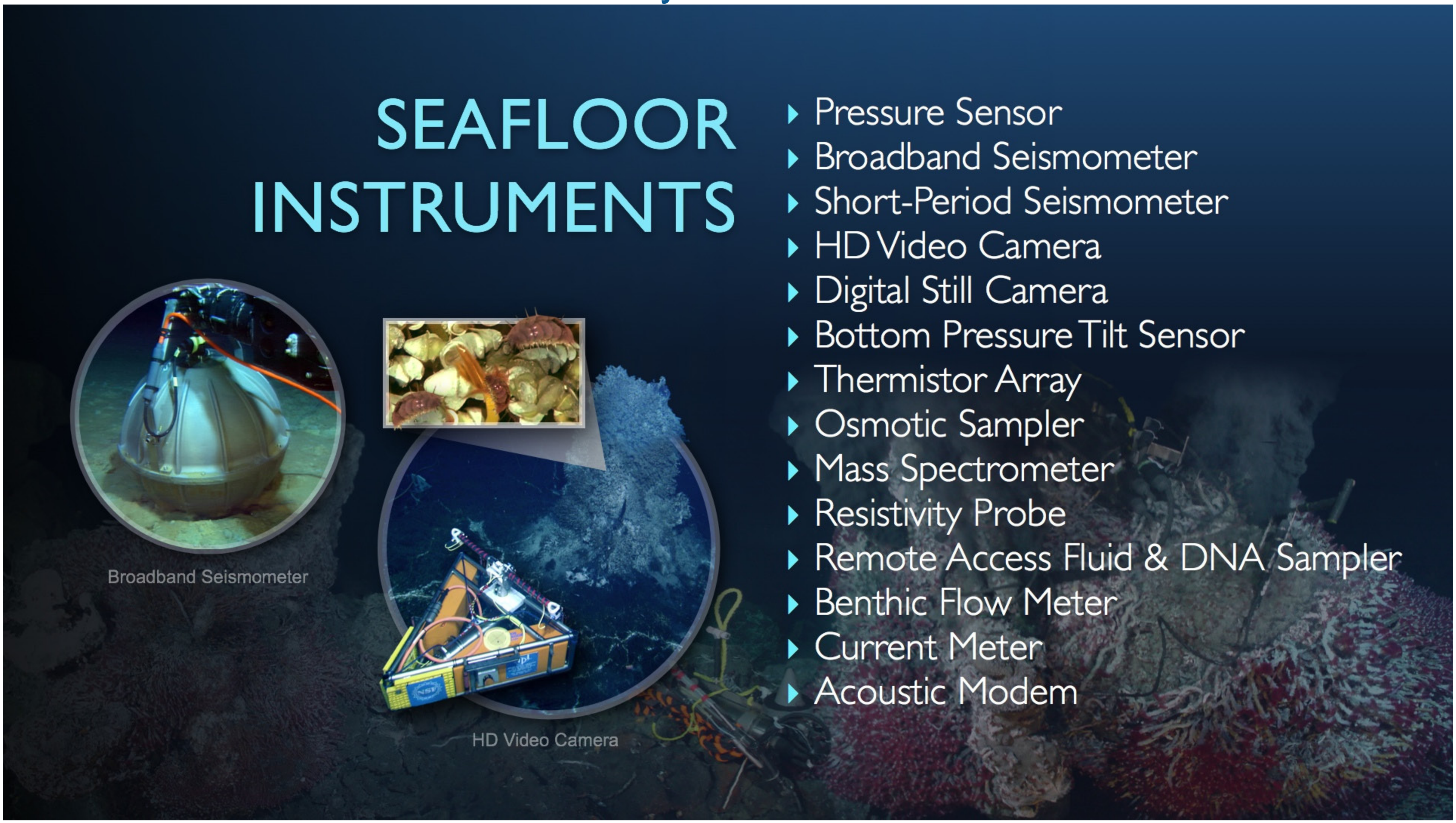




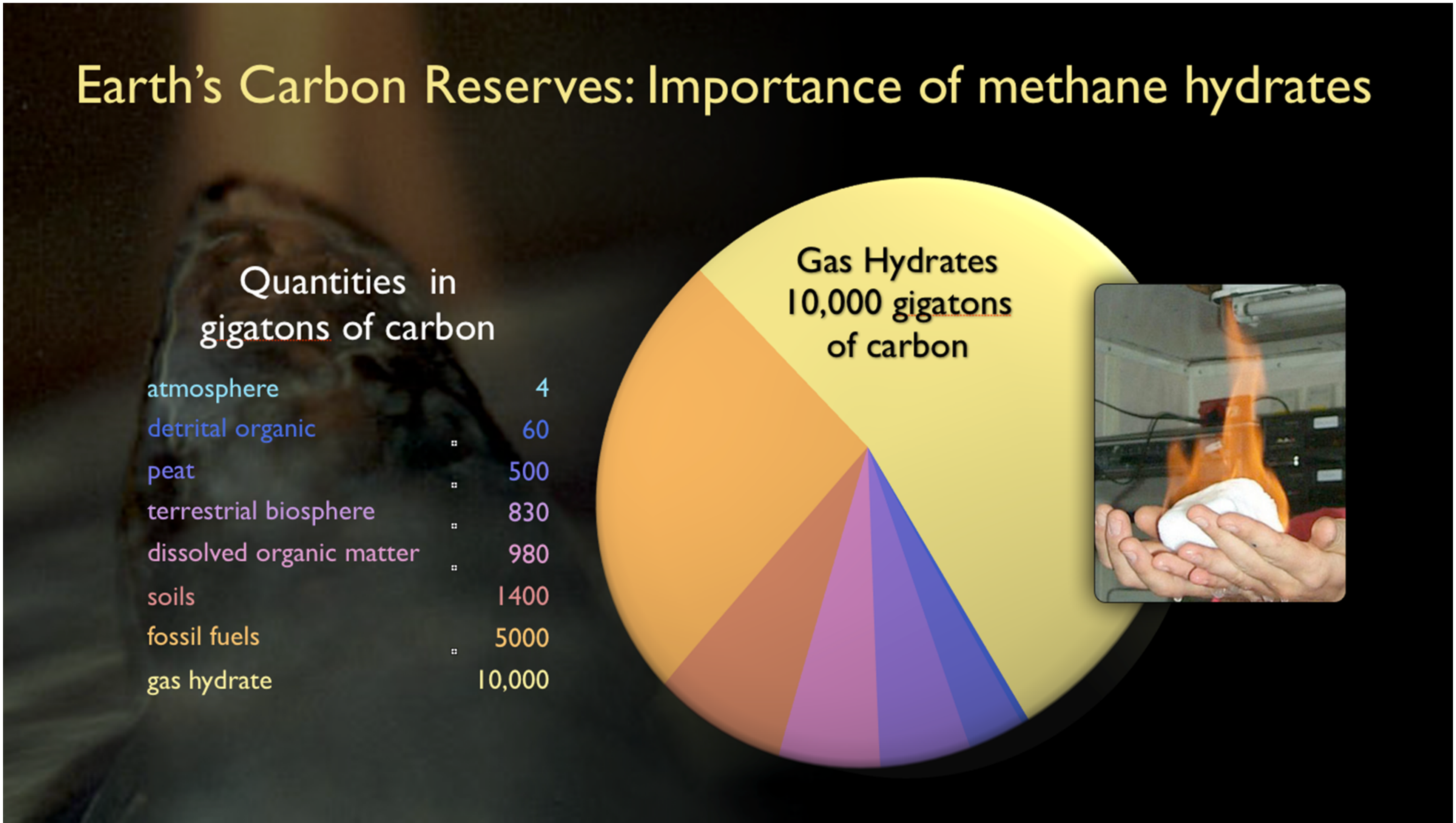


Images from: www.interactiveoceans.washington.edu/

Assets to the NE Pacific system have OCB relevant features

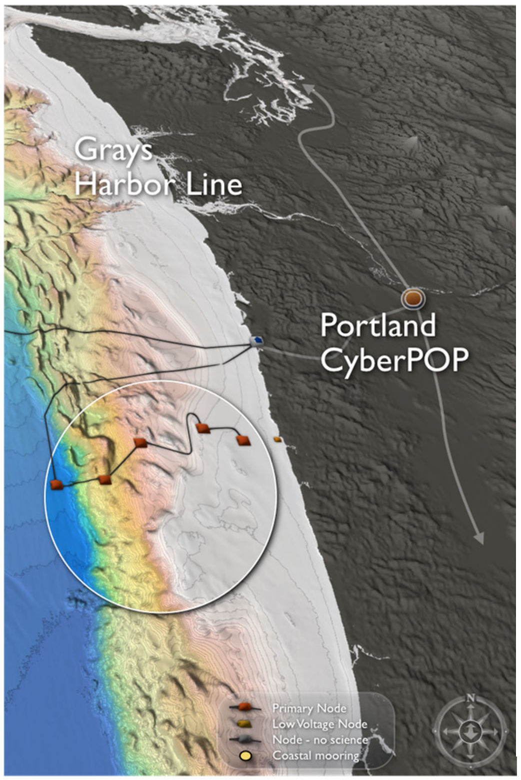


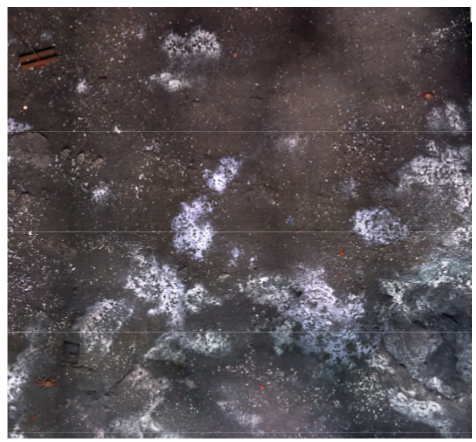
How does shifting system impact carbon storage in sea-floor?



Regional Cabled Network

An engineering driver is to sample the lithosphere, methane hydrate, and overlying water column

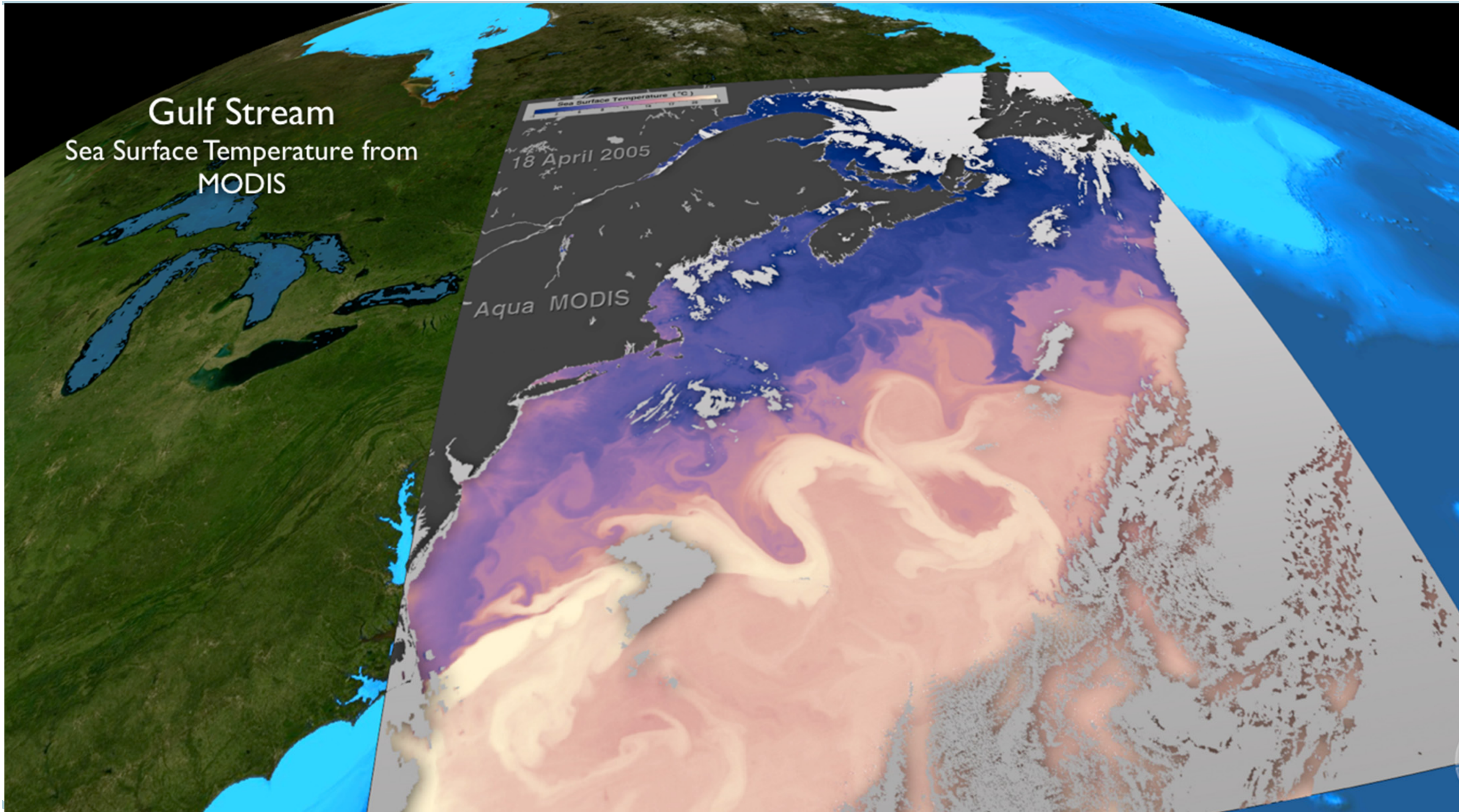




Seafloor Photomosaic of an Experimental Site – in Hydrate Ridge Area

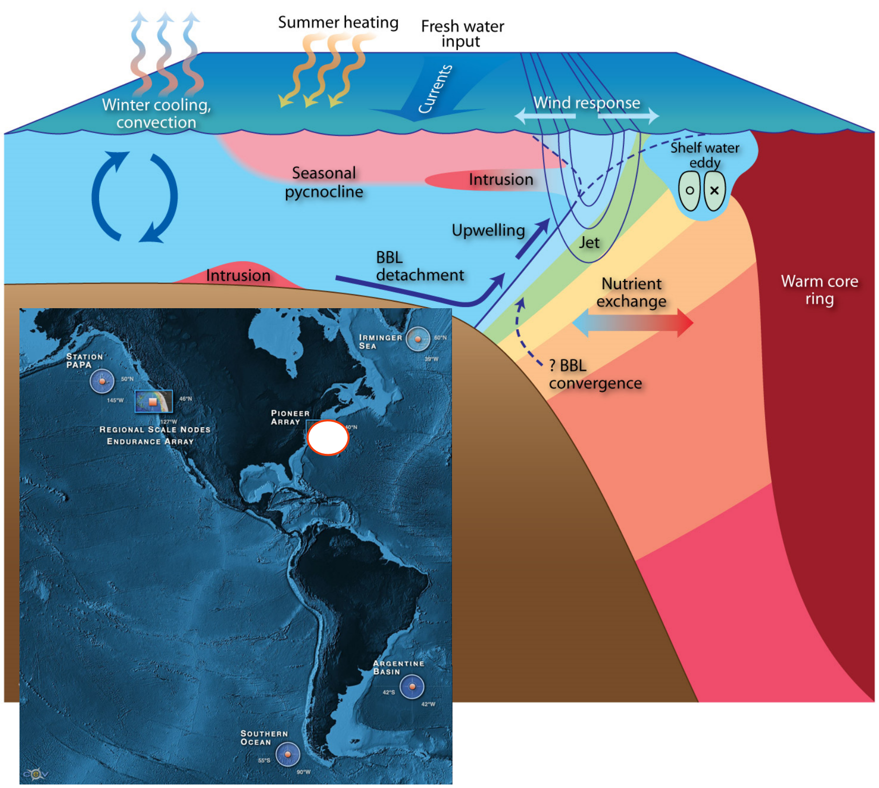
- **Observing Requirements:** High frequency physical, chemical, and biological data below, within the methane hydrate, and the overlying water column.
- **Engineering Drivers:** High power and bandwidth required to support seismic, chemical, and geophysical and water column measurements. Sensors require high frequency information to resolve rapid responses

Are the compact continental shelves of the west US coast biogeochemically similar to the more reubinstic shallow continental shelves of the east coast?



Coastal Node: Pioneer Array

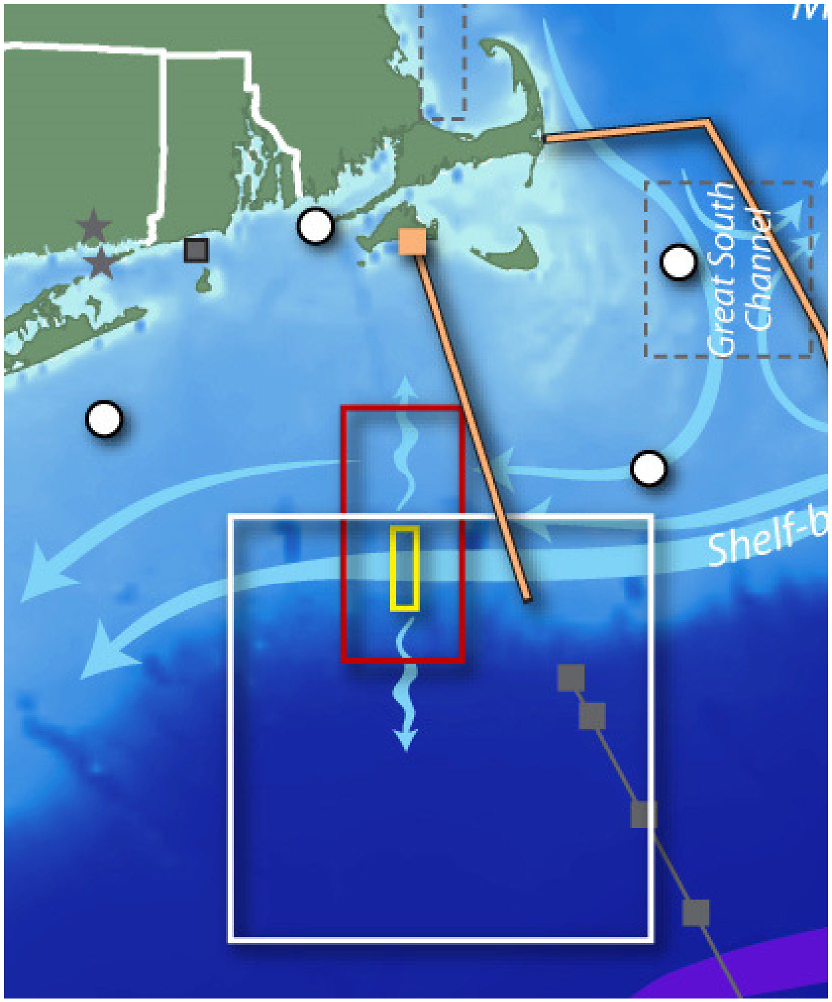
How exchanges between a broad shelf with the a deep ocean that is bounded by an energetic western boundary system structure physics, chemistry, and biology of continental shelves



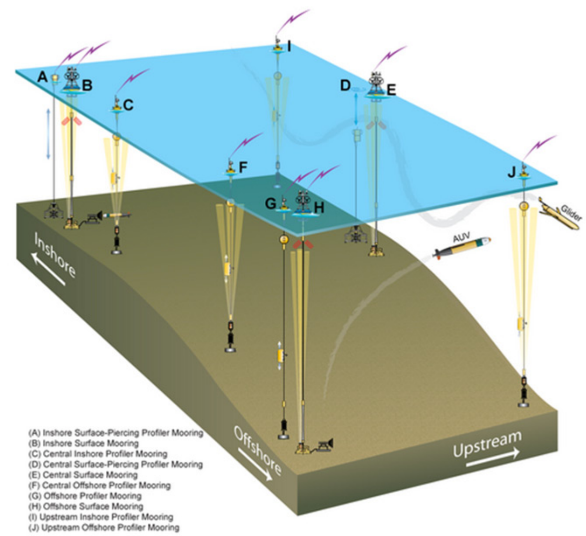
- Observing Requirements:
  Nested simultaneous observations resolving short time scales and multiple spatial scales, data from air-sea interface to sea floor, multidisciplinary sensor suites, real-time data, high resolution adaptive sampling
- Engineering Drivers:

High turbulence resulting in high frequency heterogeneity in space/time, high rates of bio-fouling, human presence, rapid response cabailities

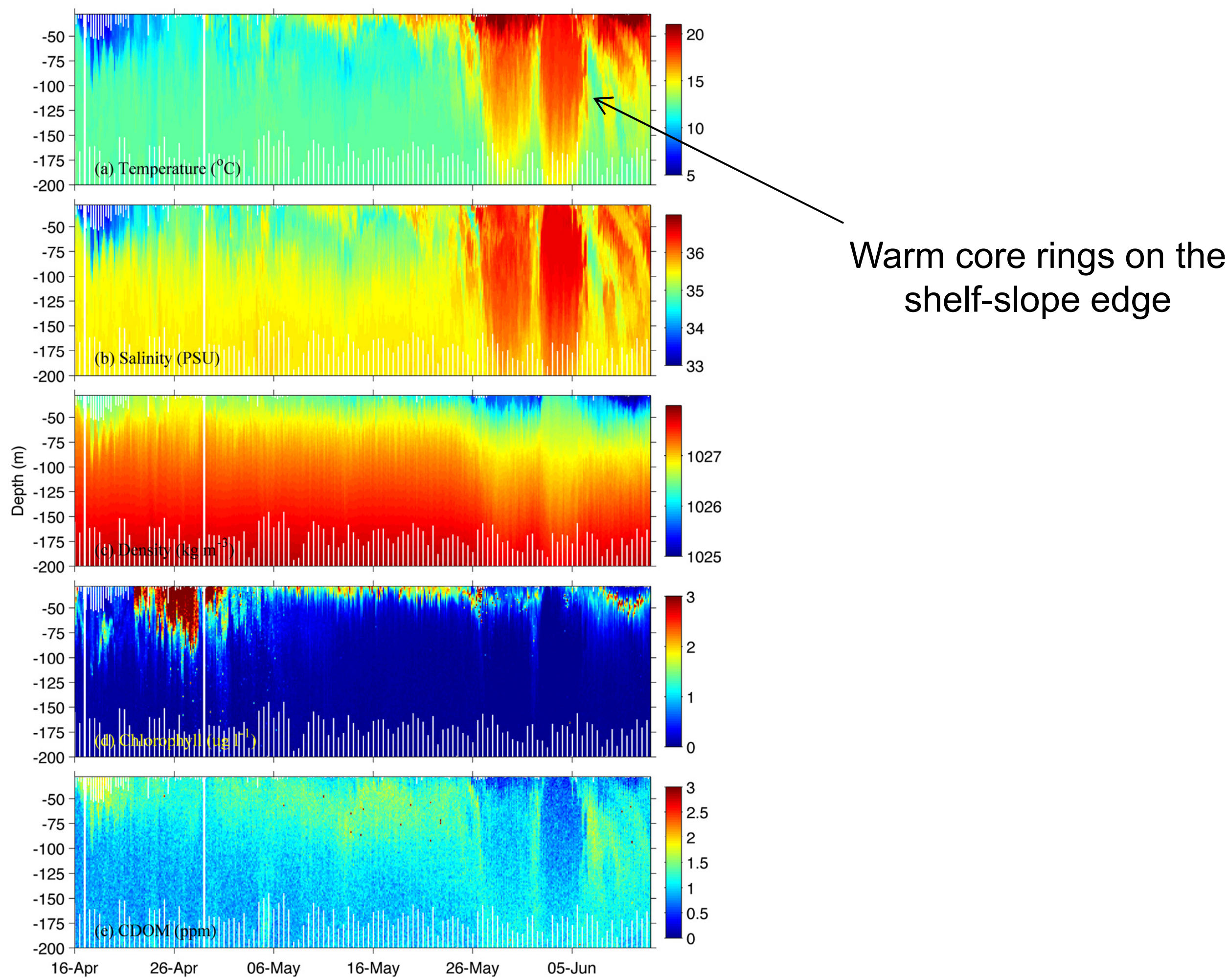
Coastal Node: Pioneer Array



Engineering Design: Multi-element, multi-scale, fixed and mobile assets, relocatable, reconfigurable to resolve processes Network consists of surface profiling floats, subsurface floats, coastal gliders, and docking AUVs

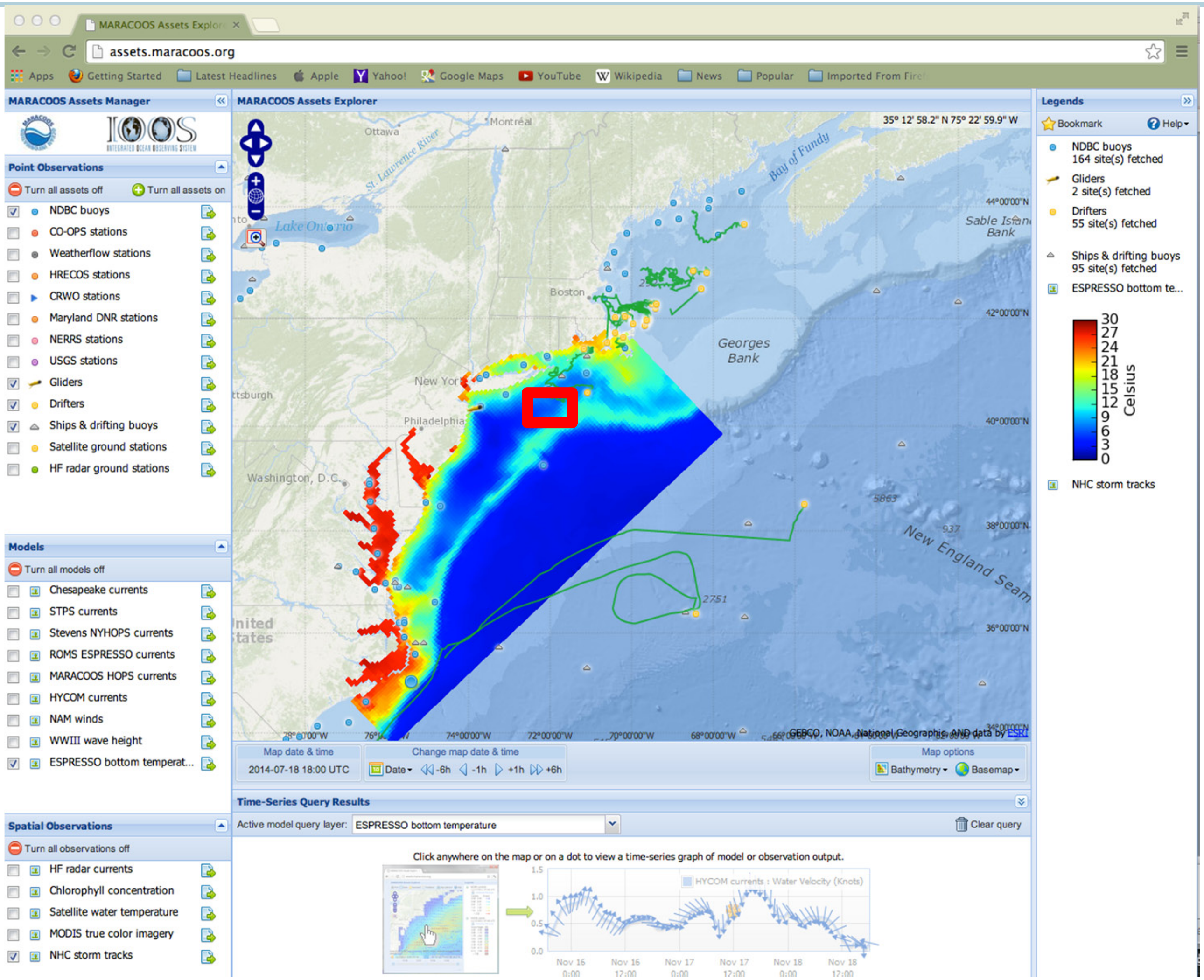


Like Ocean Station Papa, pioneer array preliminary data is now beginning to flow



OCB WHOI 2014 summer meeting
June 23 2014,

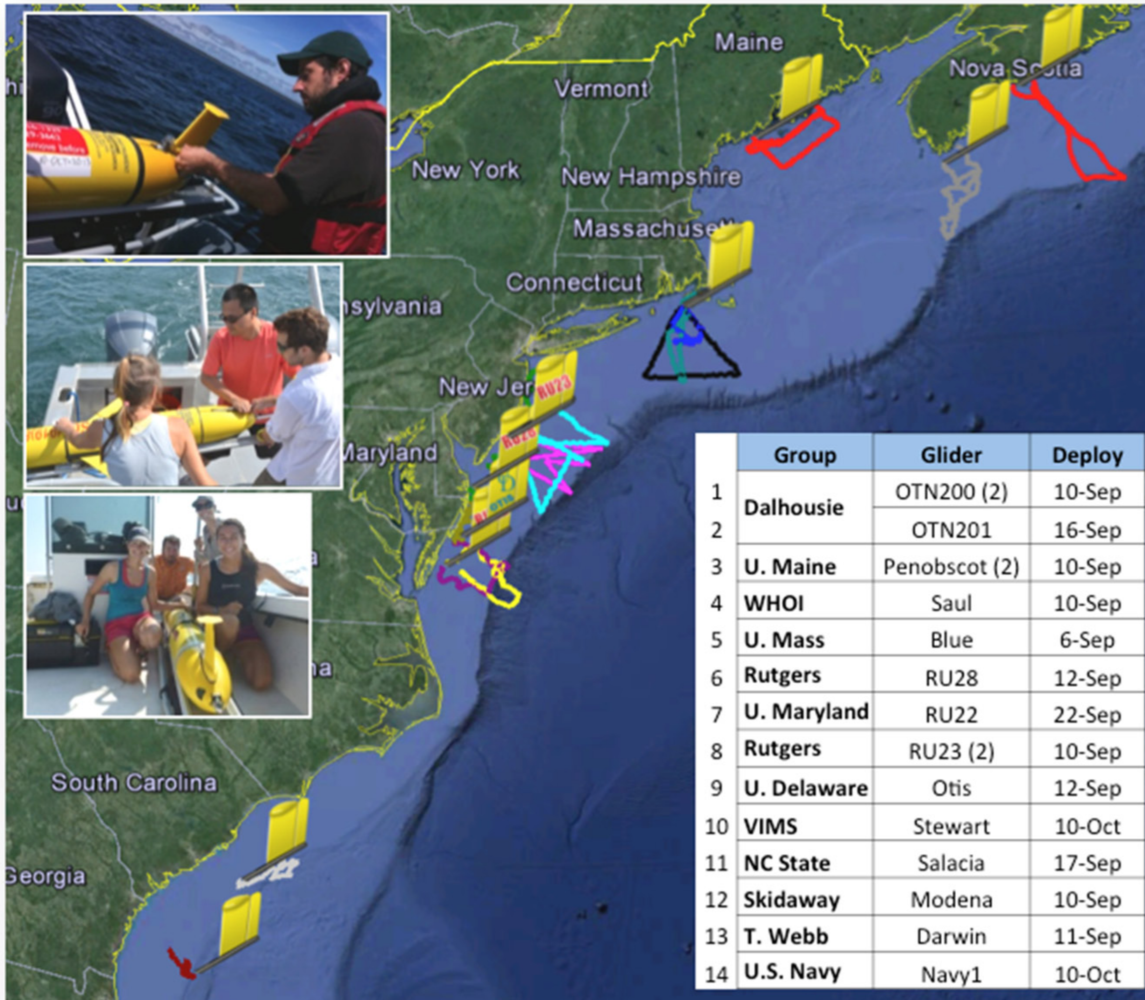
OOI embedded within national investments such as NOAA's IOOS



OCB WHOI 2014 summer meeting
June 23 2014,

Embedded and increasing central national/international efforts

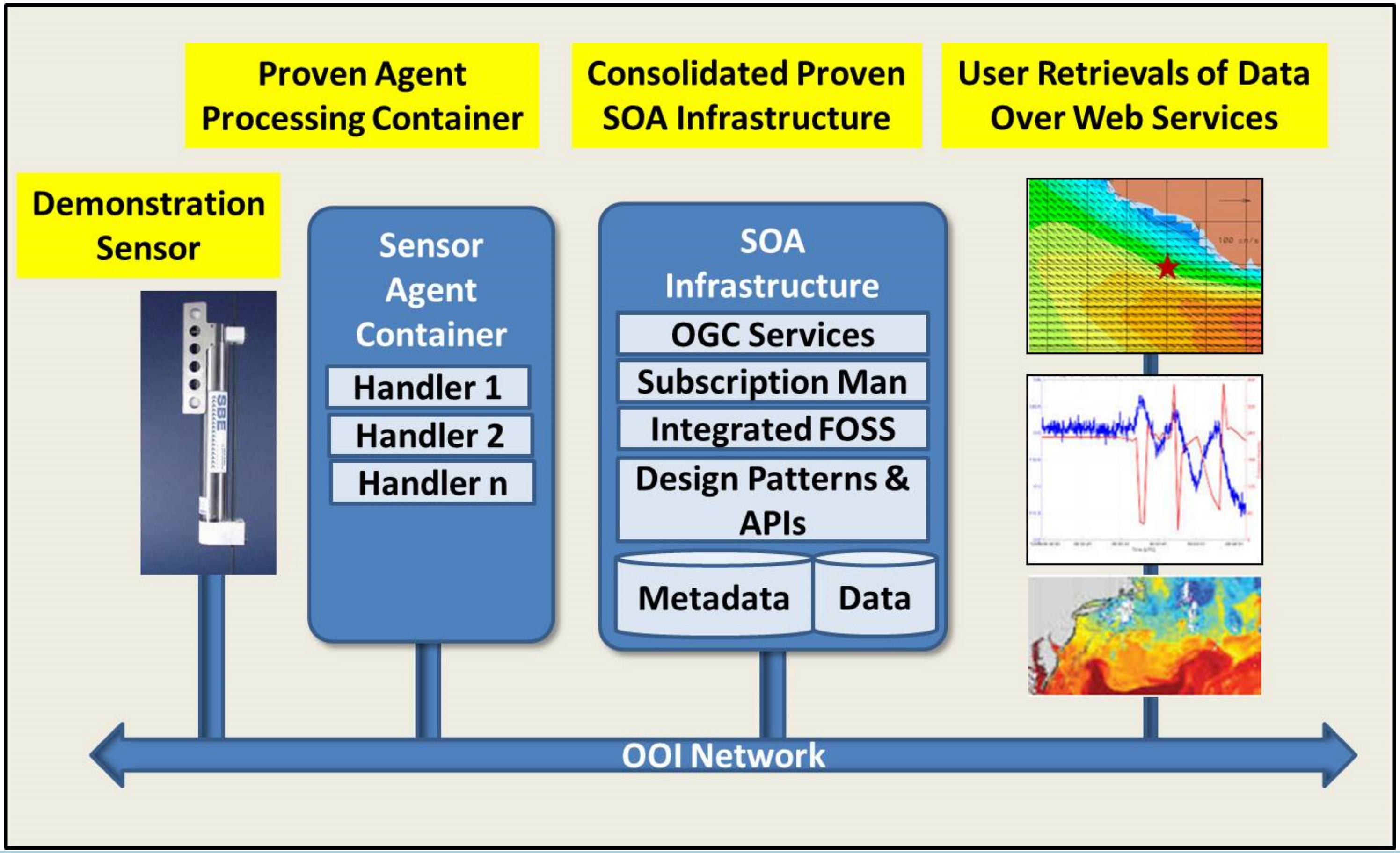
GLIDERPALOOZA 2013



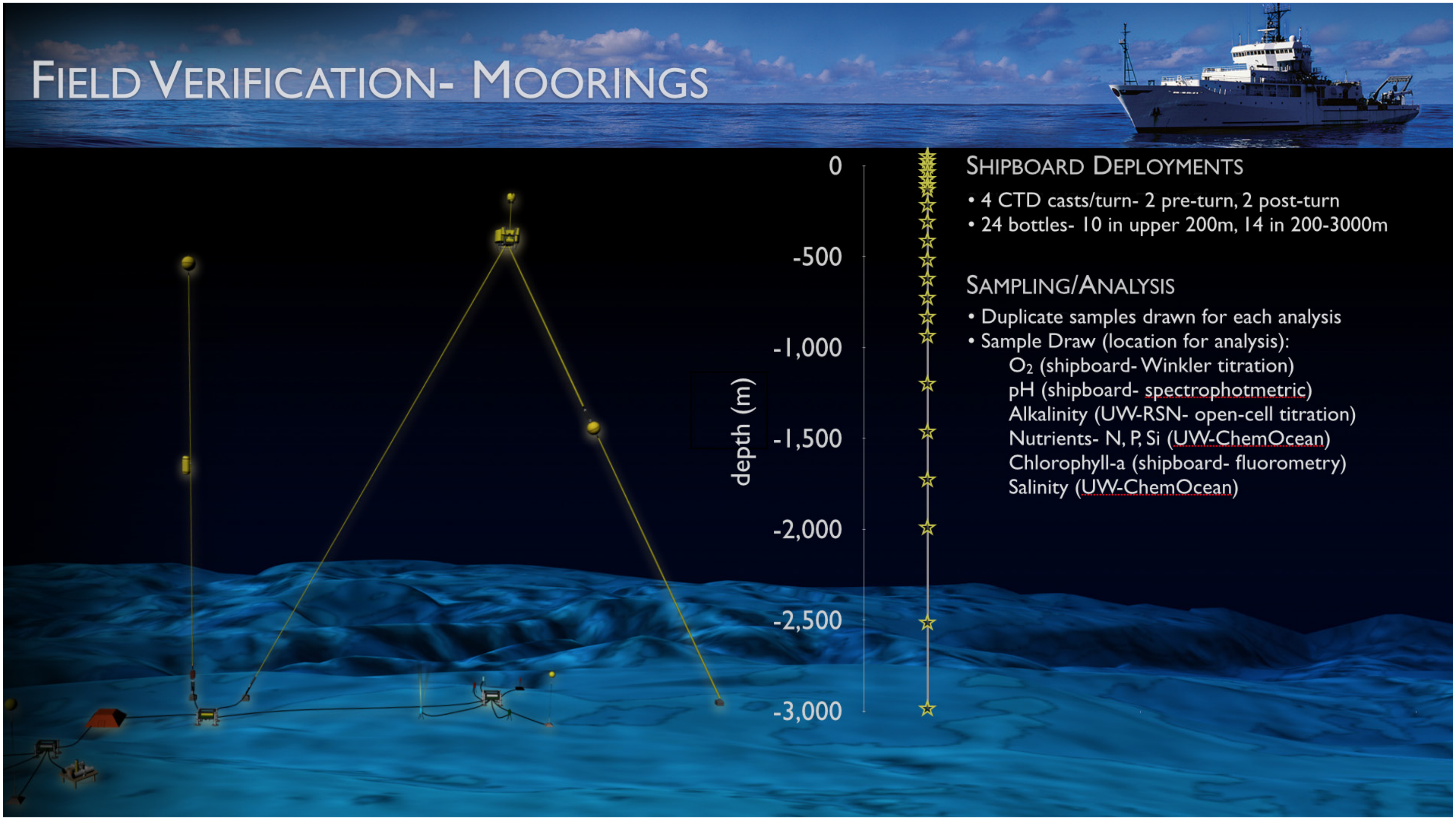
	Group	Glider	Deploy
1	Dalhousie	OTN200 (2)	10-Sep
2		OTN201	16-Sep
3	U. Maine	Penobscot (2)	10-Sep
4	WHOI	Saul	10-Sep
5	U. Mass	Blue	6-Sep
6	Rutgers	RU28	12-Sep
7	U. Maryland	RU22	22-Sep
8	Rutgers	RU23 (2)	10-Sep
9	U. Delaware	Otis	12-Sep
10	VIMS	Stewart	10-Oct
11	NC State	Salacia	17-Sep
12	Skidaway	Modena	10-Sep
13	T. Webb	Darwin	11-Sep
14	U.S. Navy	Navy1	10-Oct

Web based services

Technical Approach Uses Proven SOA Infrastructure to Integrate OOI Data



Ship and Shore-based sensor verification



At-sea protocols

Deployment and post-deployment procedures

Deployment documentation

- Pre-deployment checklists *[CP02PMUI-00001_checklist.pdf]*
- Mooring deployment logs *[CP02PMUI-00001_deployment-log.pdf]*

Post-deployment data assessment

- Adjacent CTD cast(s) (temp,sal,oxy,chl,turb) *[see quick look report]*
- Shipboard systems (met, surface t-sal, ADCP) *[SCS_WSPD.gif, SCS_WDIR.gif]*
- Water samples and lab analysis (sal,oxy,chl,etc) *[Pioneer1_salinity_oxygen.xlsx]*

At-sea procedures

Post-deployment procedures

Deployment documentation

- Pre-deployment checklists *[CP02PMUI-00001_checklist.pdf]*
- Mooring deployment logs *[CP02PMUI-00001_deployment-log.pdf]*

Post-deployment assessments

- Adjacent CTD cast(s) (temp,sal,oxy,chl,turb) *[see quick look report]*
- Shipboard systems (met, surface t-sal, ADCP) *[SCS_WSPD.gif, SCS_WDIR.gif]*
- Water samples and lab analysis (sal,oxy,chl,etc*) [Pioneer1_salinity_oxygen.xlsx]*
- Quick-look report *[3204-00023_Poineer_1_Quick_Look_Cruise_Report.pdf]*
- Lessons learned *[internal working documents]*

OOI Developing the infrastructure to enable education and public engagement (EPE)

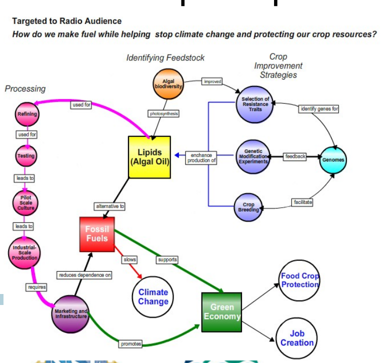
OOI is constructing a series of software tools and a web-based social network to engage a wide range of education users spanning from faculty, graduate and undergraduate students, informal science educators and the general public.

The software will be designed to provide scientists and educators a suite of tools that will enable them to enhance their undergraduate education and engage the general public using real-time and streaming data provided by the OOI.

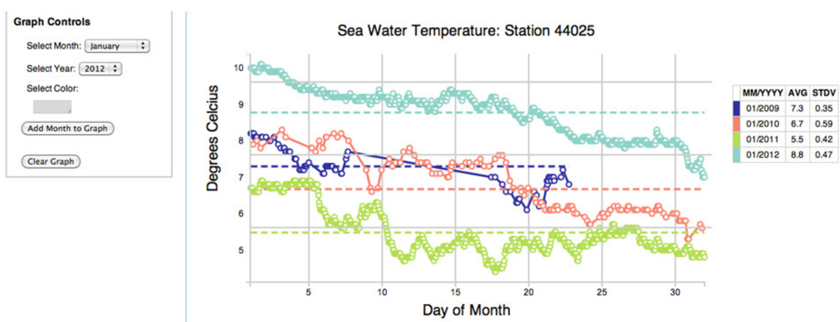
Expanding the model

Developing tools to increase the crowd sourcing & educational opportunities with OOI Education and Public Engagement team (EPE)

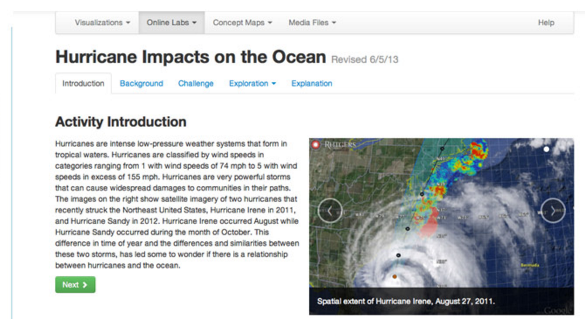
Concept Maps



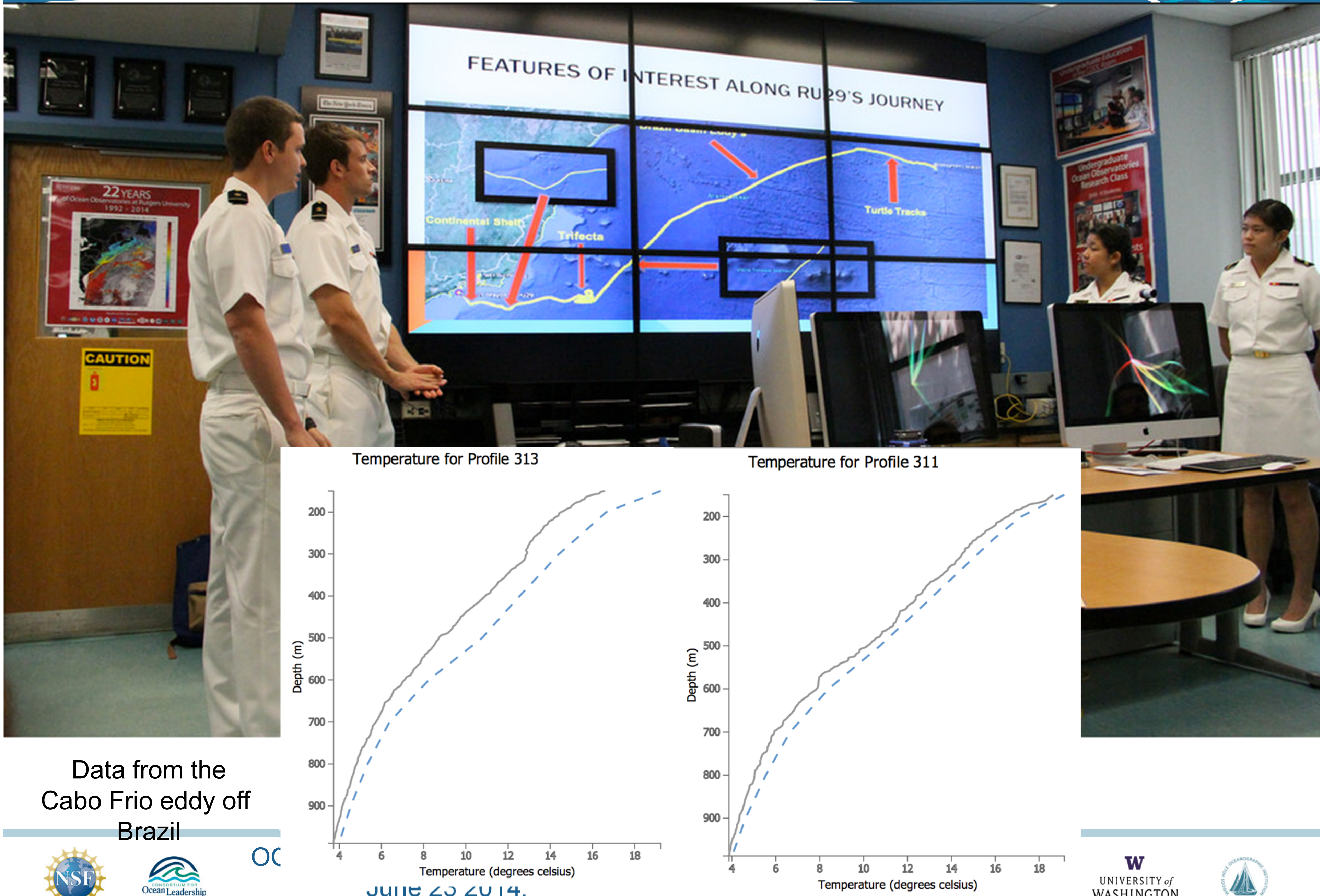
Data Visualization Tools



Lab Lesson Builder



June 18 2014: Naval Academy Interns Assessing NOAA Global Skill Using an Ocean Robot



Data from the Cabo Frio eddy off Brazil

Web access to allow all to explore the ocean

Ocean Predictive Skill
Assessments in the South Atlantic:
Crowd-sourcing of Student-Based Discovery

Rachael Sacatelli, Tobias Schofield, Katherine Todoroff, Angela Carandang*, Alyson Eng*, Ian Lowry*, Harrison Mather*, Antonio Ramos**, Sebastiaan Swart***, Marcelo Dottori****, Nilsen Strandskov, Josh Kohut, Oscar Schofield and Scott Glenn

Rutgers University
Coastal Ocean Observation Lab
New Brunswick, NJ, USA

*United States Naval Academy
Annapolis, MD, USA

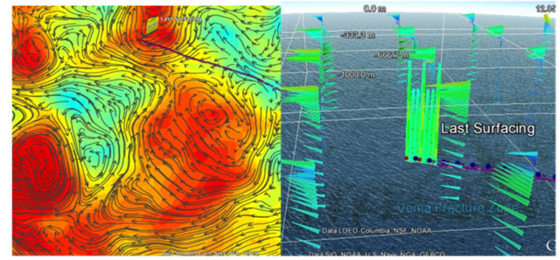
**Universidad de Las Palmas de Gran Canaria
Las Palmas, Gran Canaria

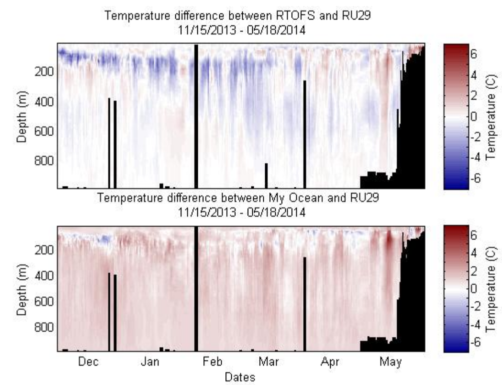
***Council for Scientific and Industrial Research, Cape Town, South Africa

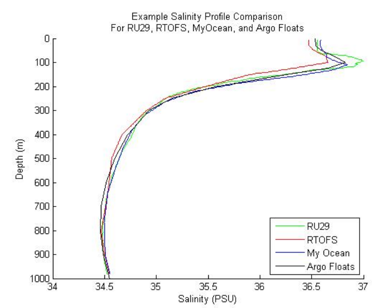
****Universidade de São Paulo,
São Paulo, Brazil

MTS manuscript submitted July 14th 2014

Student project using OOI EPE tools to show the MyOcean global model is biased high relative to the NOAA RTOFS and real ocean using ocean glider and argo.







Conclusions

- Open access high frequency diverse data for sustained periods of time
- Ability to enable science as is, provide a infrastructure to expanded by investigators, and can provide leverage to other programs
- Coupled to tools to enable teaching and shared community education resources

Operating and Maintaining the OOI

The OOI team will execute processes, procedures, work instructions to meet operational requirements and deliver data products. Activities include:

Marine hardware and instrumentation

System status monitoring, reporting and corrective actions

Pre-deploy (test, integration, calibrate), Deploy (platform ops, command/control)

Vehicle ops, alarms/alerts, sampling strategies, data QC

Recovery, post-recovery (refurb, calibrate), data recovery

Performance monitoring and reporting, Asset management, Incident Reporting

Data delivery (system services and products)

Cybersecurity, System monitoring, status display, software maintenance

Performance measurement, network and application enhancement

Hardware/Software – Development, Maintenance, Quality assessment

Maintenance and improvement of data products, algorithms, metadata

Data QA/QC enhancements, user request and support