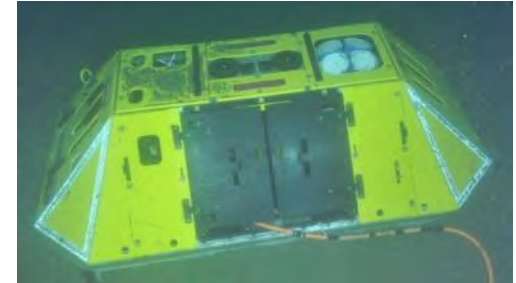




Ocean Observatories Initiative



September 27, 2016



The Endurance Array

Jack Barth (Project Scientist), Ed Dever (Project Manager/Principal Investigator),
Jon Fram (Systems Engineer), Bob Collier (former Project Manager/Principal Investigator,
cyberinfrastructure), Tom Kearney (Operations and Management)

Chris Wingard, Craig Risien, Linda Faylor, Walt Waldorf, Tully Rohrer, Stuart Pearce, David
Neiman, Russ Desiderio, Kent Fletcher, Jeff Woods, Ian Black

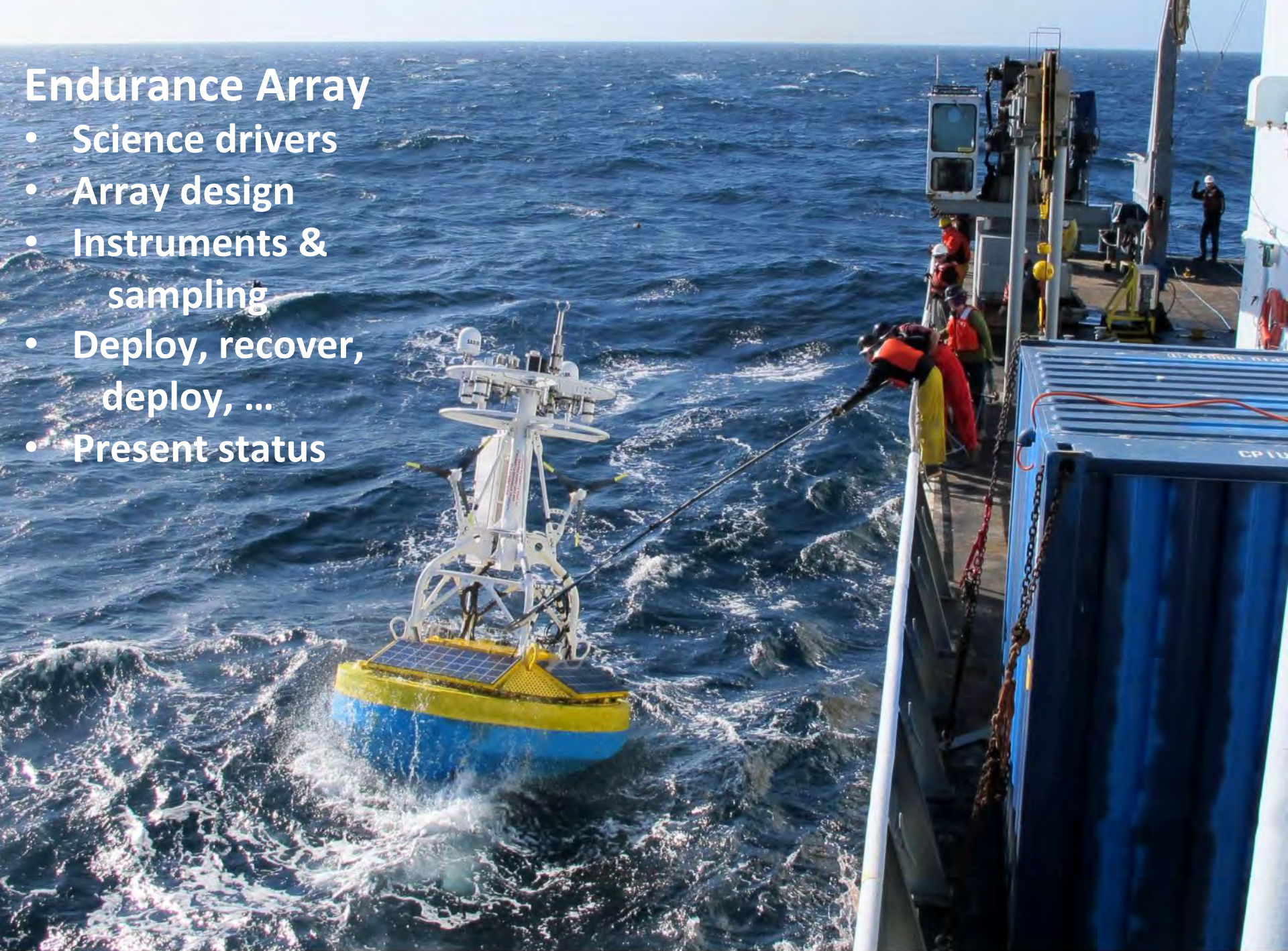
... in collaboration with our WHOI (buoys, design, etc.), UW (cabled infrastructure: **Deb
Kelley, Orest Kawka**) and Rutgers/Raytheon (cyberinfrastructure) colleagues

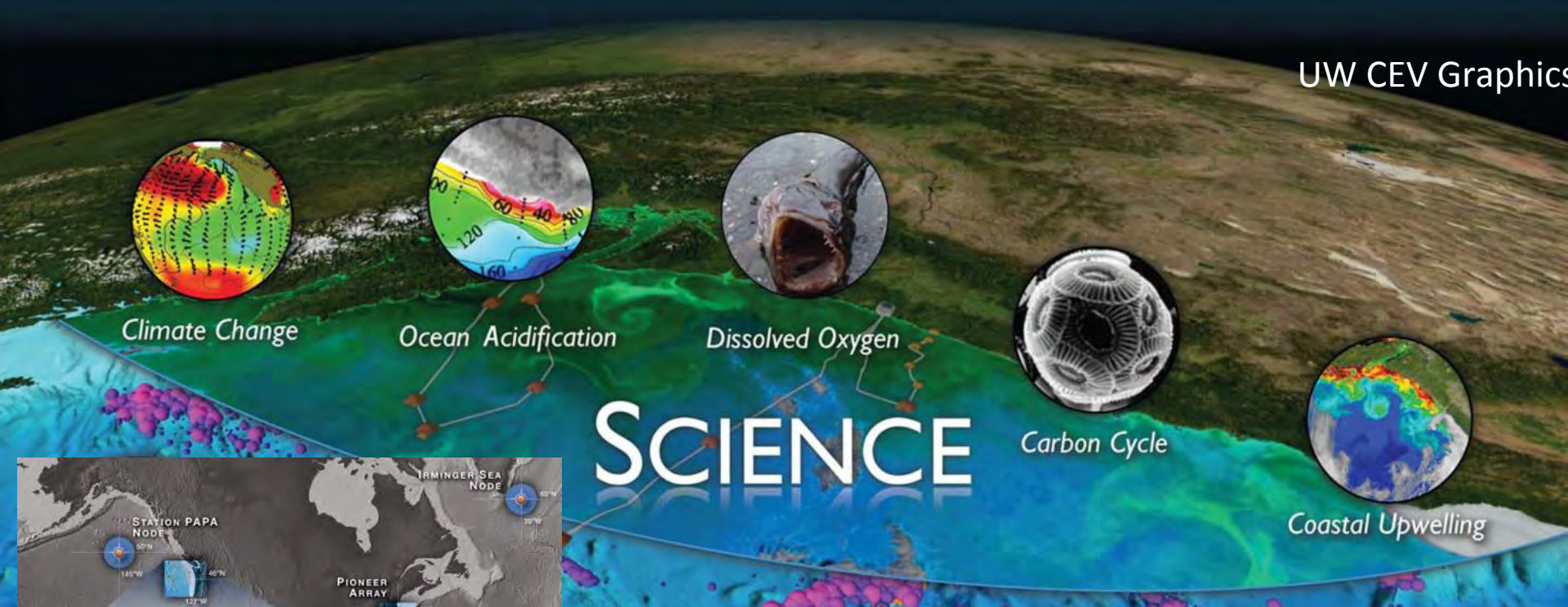
barth@coas.oregonstate.edu edever@coas.oregonstate.edu

jfram@coas.oregonstate.edu

Endurance Array

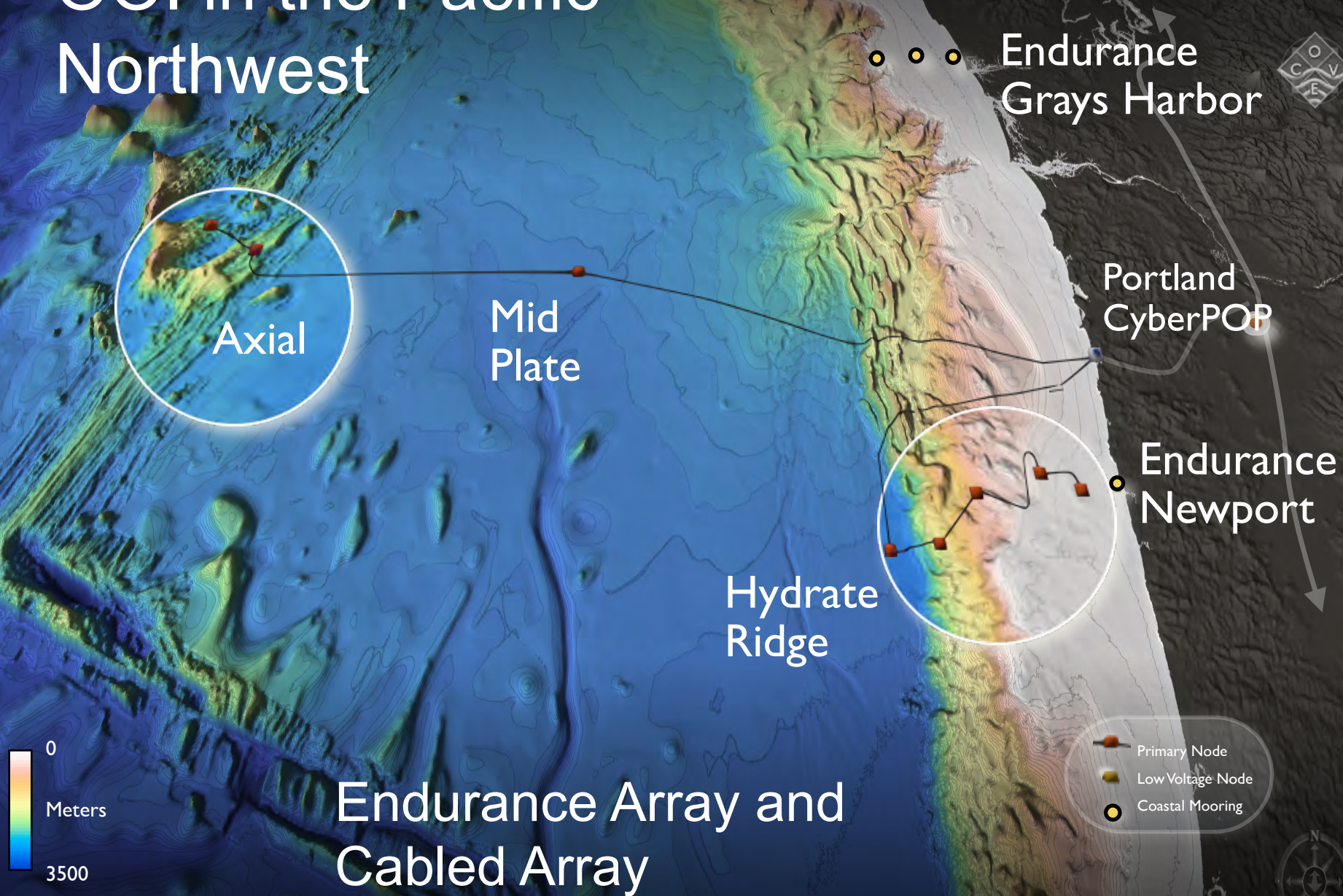
- Science drivers
- Array design
- Instruments & sampling
- Deploy, recover, deploy, ...
- Present status



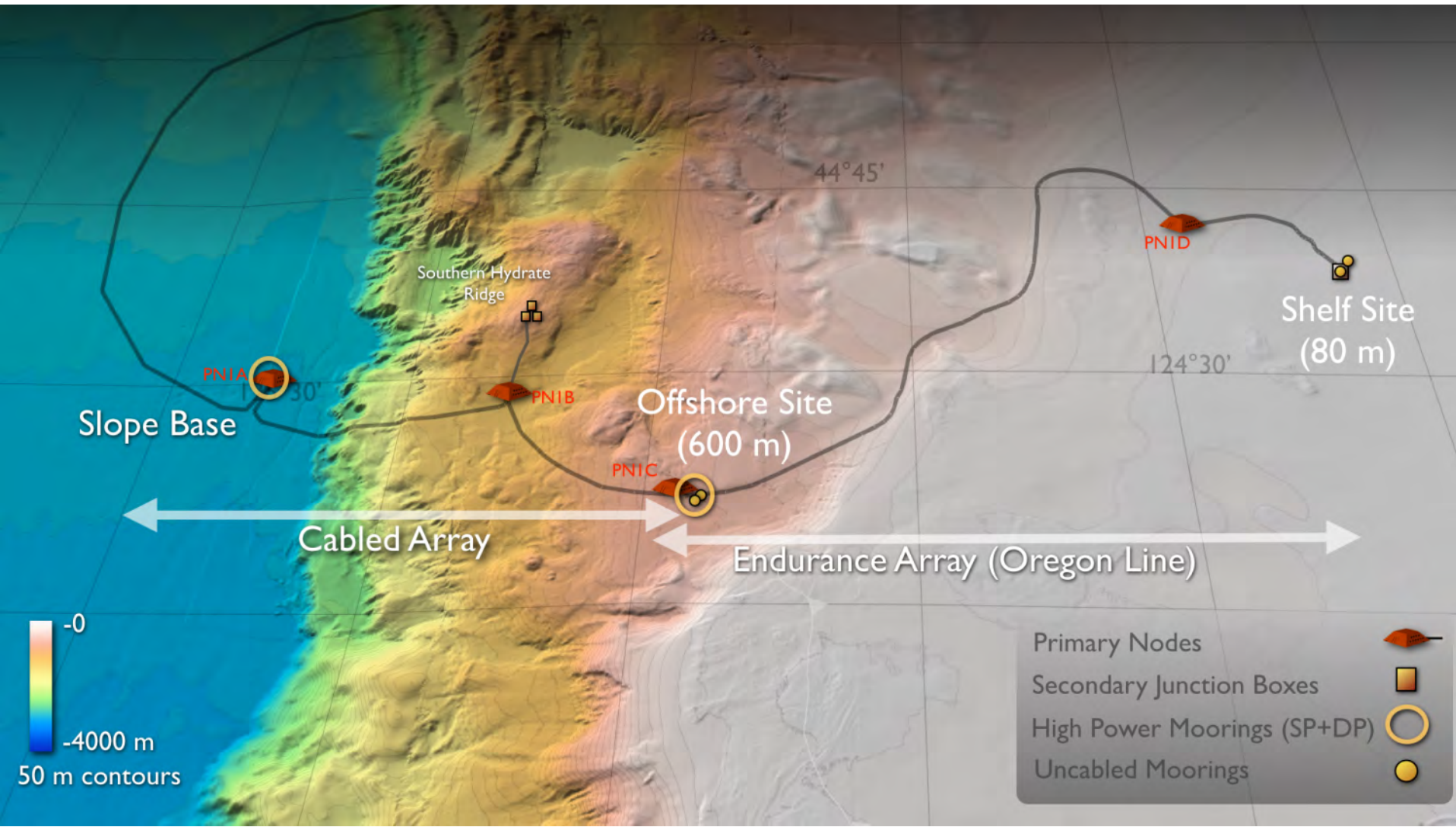


- A1 Global Biogeochemistry and Carbon Cycling
- A2 Ocean-Atmosphere Exchange
- A3 Ocean Circulation, Mixing and Ecosystems
- A7 Climate Variability and Ecosystems
- A9 Coastal Ocean Dynamics and Ecosystems -
Hypoxia on Continental Shelves
- A10 Coastal Ocean Dynamics and Ecosystems
Shelf/Slope Exchange.

OOI in the Pacific Northwest

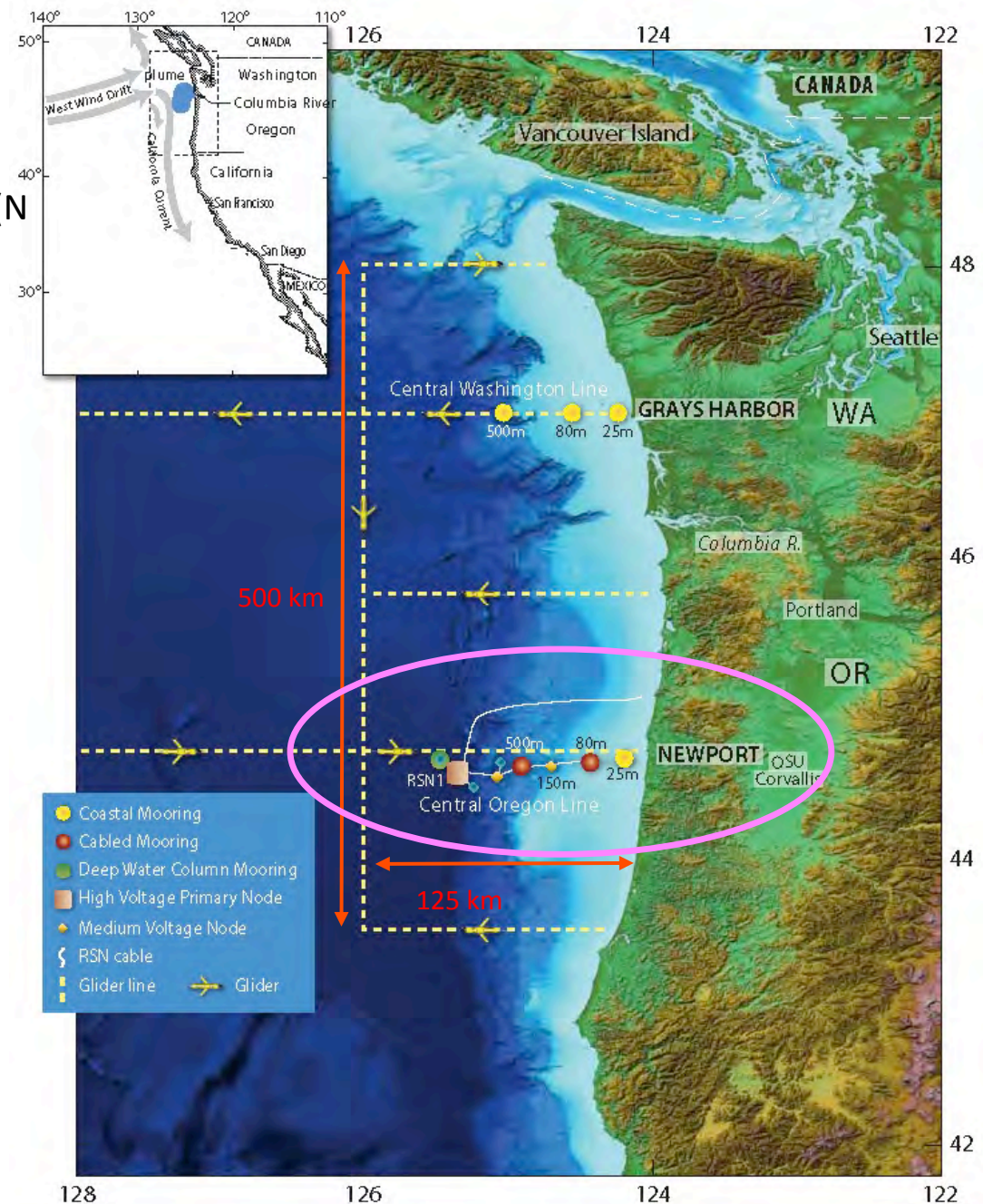


Endurance and Cabled Array off Oregon



Endurance Array

- Cross-shelf mooring lines at Newport and Grays Harbor (N & S of Columbia River)
- Oregon Line connected to the Cabled Array
- 6 deployed gliders year-round
- 20 platforms:
 - EA ~240 sensors
 - Cabled EA ~39 sensors
- Locations chosen based on existing long-term data

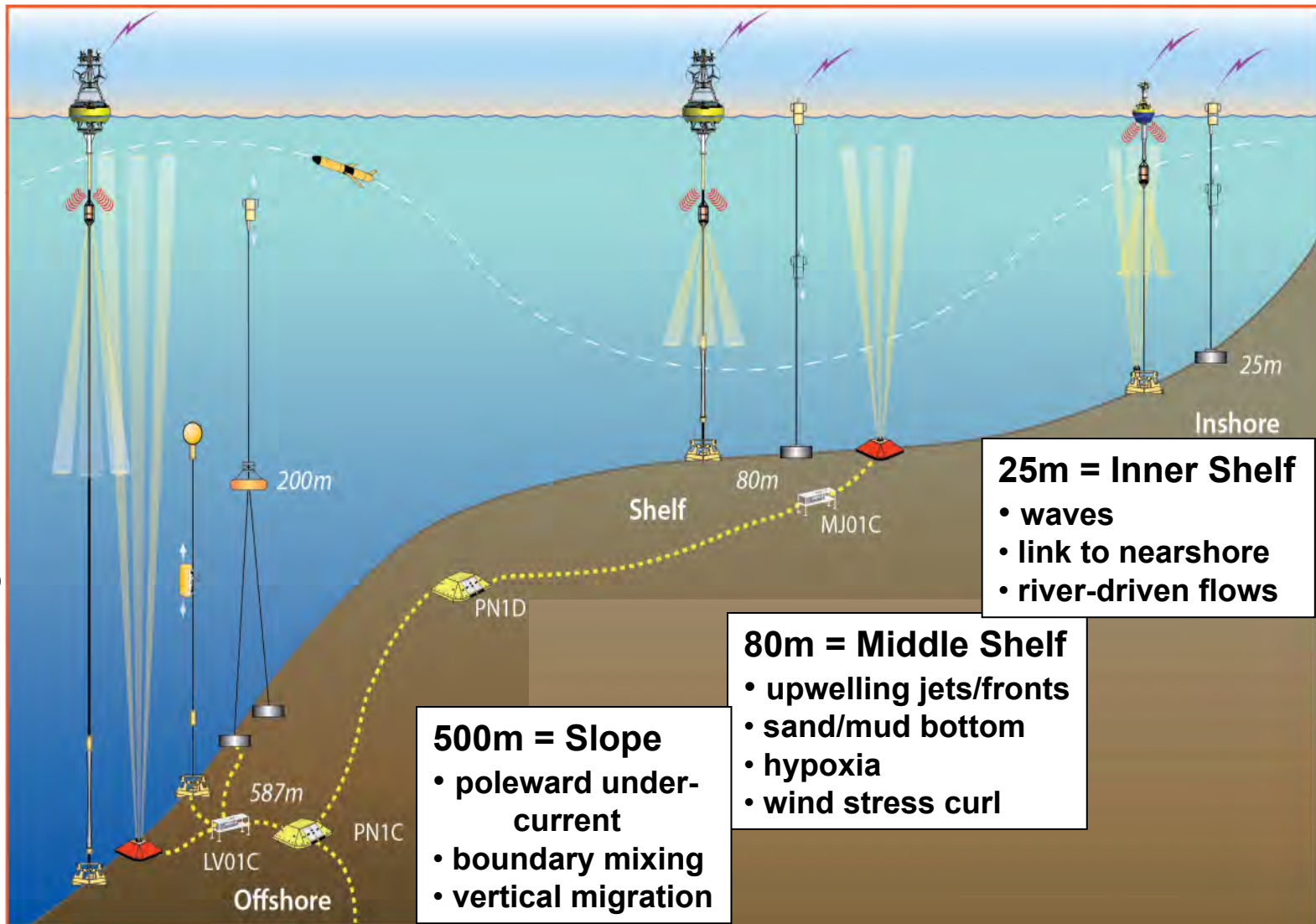


Endurance Array: Oregon Line

Endurance Array - Newport Hydrographic Line

As designed:

- Full water column
- Cross-shelf resolution
- High power, high bandwidth via cable to 80 & 500m
- Benthic platforms

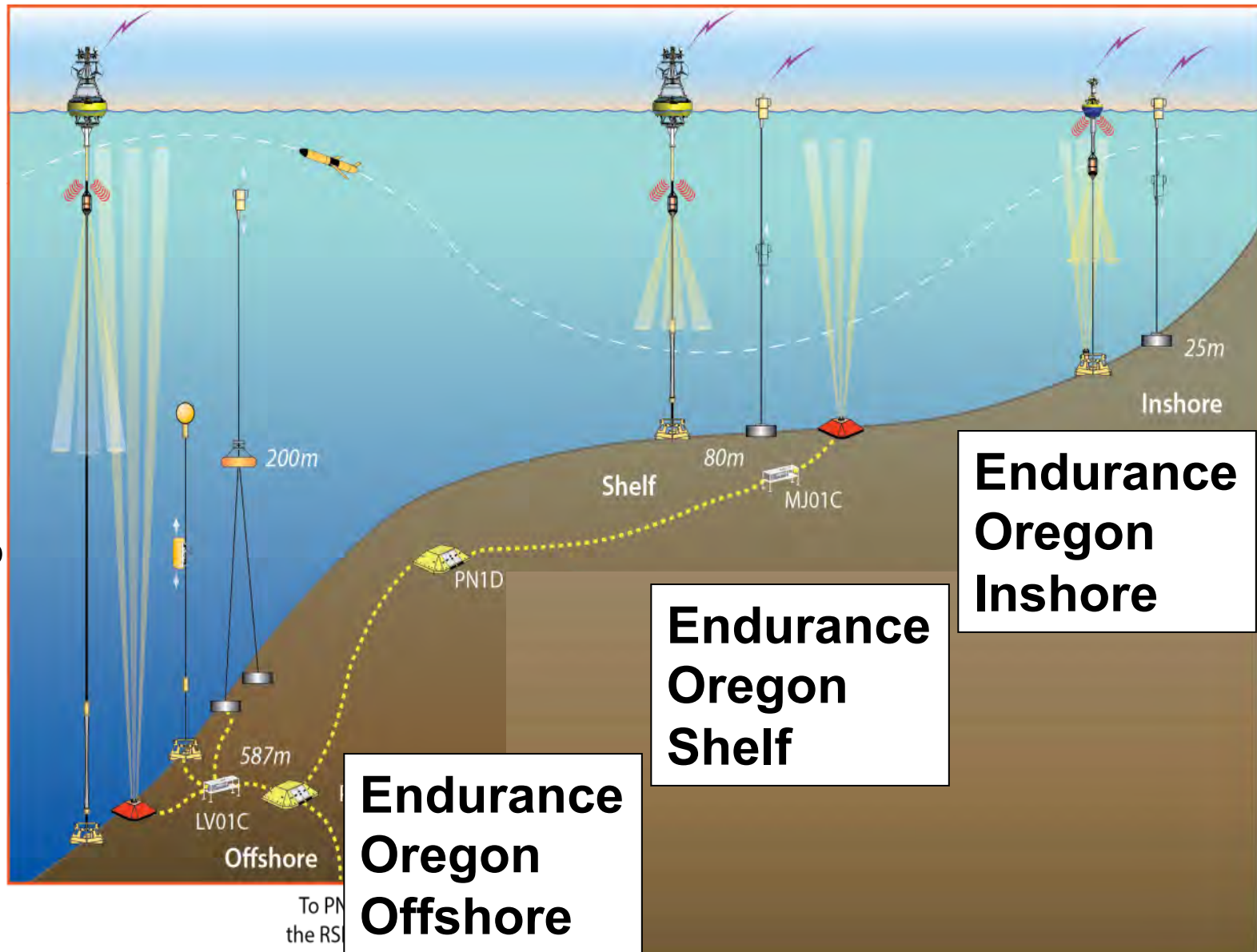


Endurance Array: Oregon Line

Endurance Array - Newport Hydrographic Line

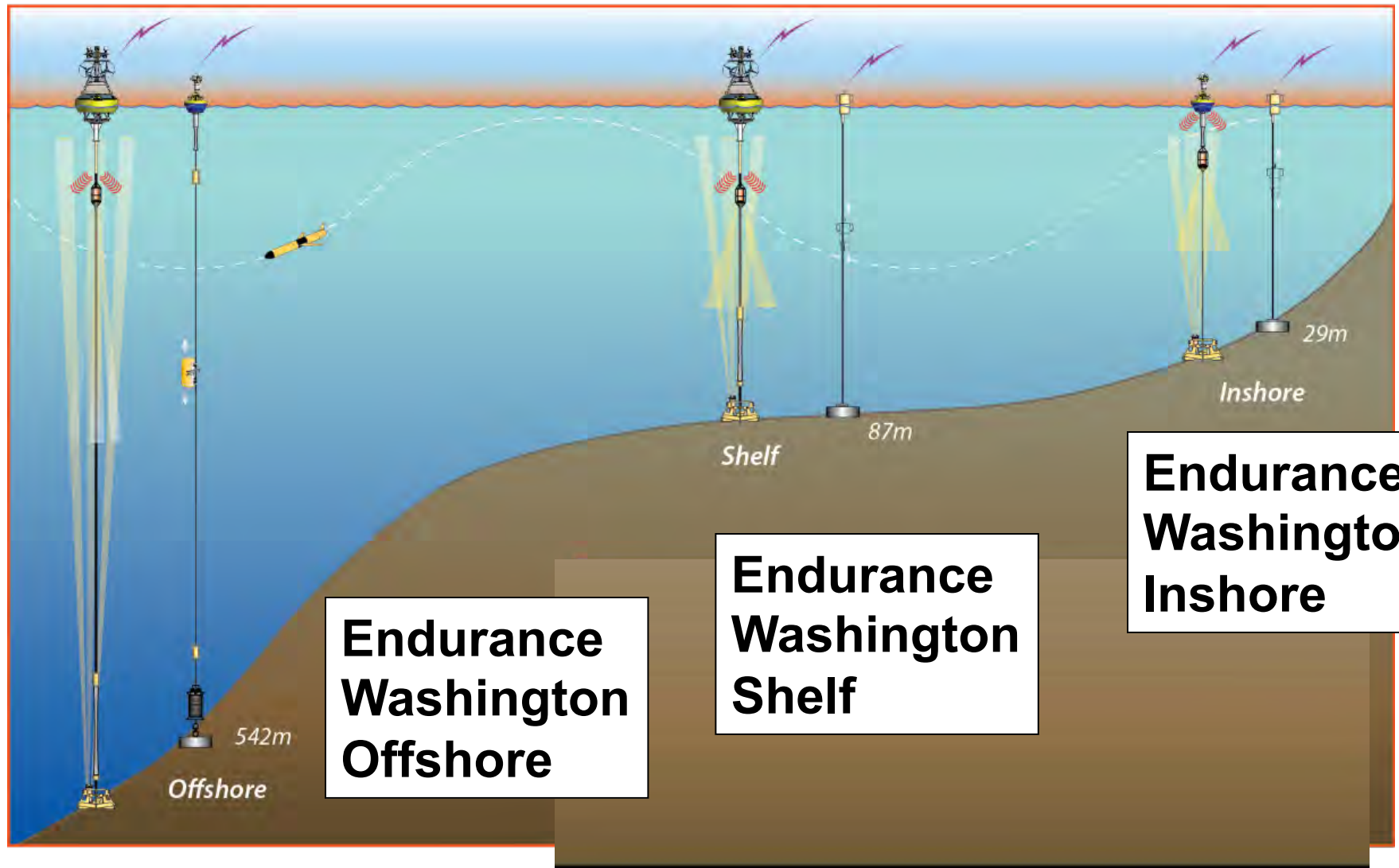
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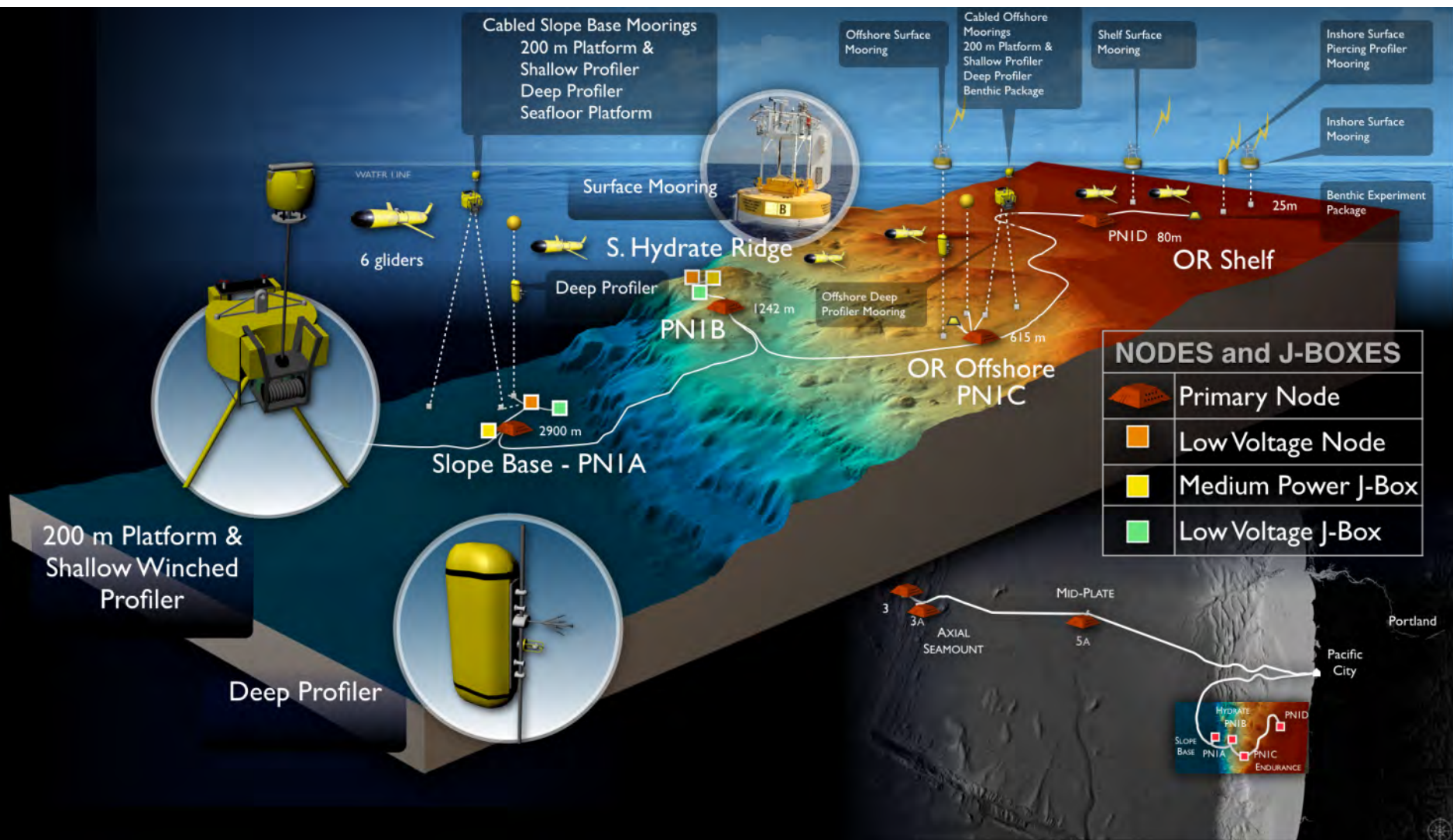


Endurance Array: Washington Line

Endurance Array – Grays Harbor Line

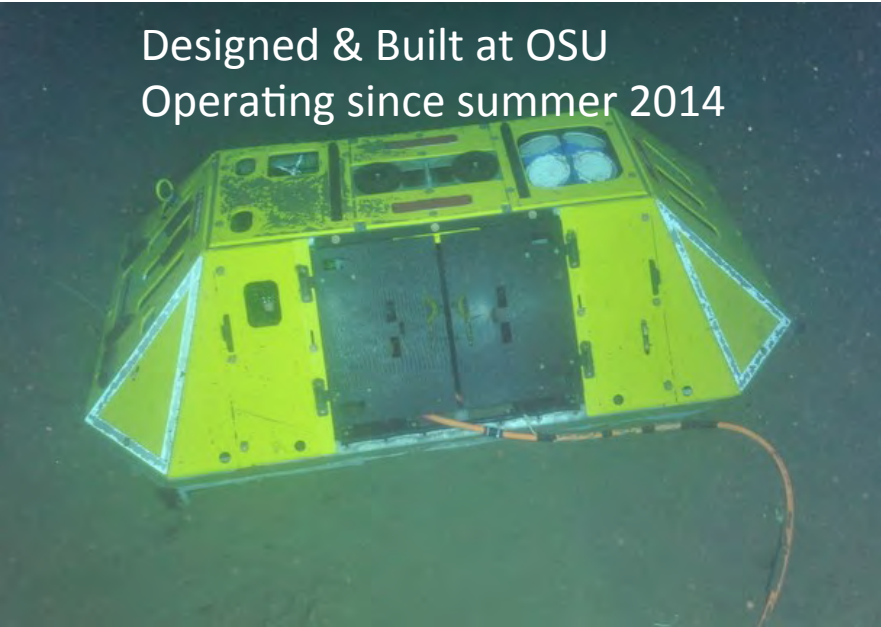


Cabled Array off central Oregon



Cabled Benthic Experiment Package

Designed & Built at OSU
Operating since summer 2014



Kent Fletcher



Instruments

- CTD, O₂, pH, pCO₂
- Chl-a, OBS, CDOM
- ADCP, fast point velocity,
- hydrophone
- Opt. Atten. & Absorp.
- Multi-frequency bioacoustics (on nearby platform)



Endurance Array: Washington Line

BIG BUOYS

- wind, rain, humidity
- air pressure & temperature,
- long & short wave radiation
- wave spectra, air-sea pCO₂
- surface CT & velocity

GLIDERS

- CTD, O₂, PAR
- Chl-a, OBS, CDOM
- velocity

WIRE FOLLOWING PROFILER

- CTD, O₂, PAR
- Chl-a, OBS, CDOM
- point velocity

7m on MOORINGS

- CTD, O₂,
- Chl-a, OBS, CDOM
- point velocity
- Spec. Irrad., NO₃,
- Opt. Atten. & Absorp.
- pH, pCO₂, ADCP

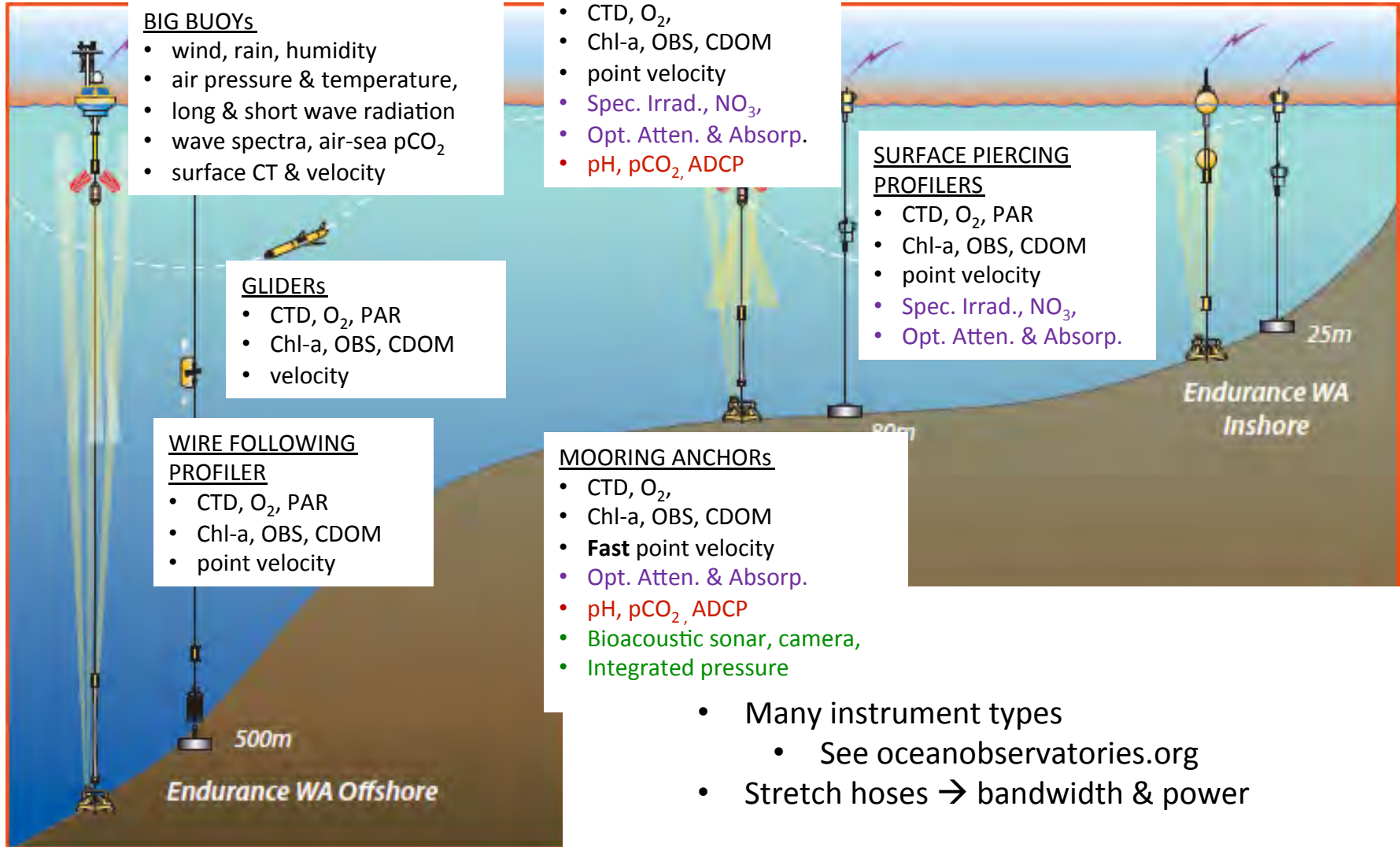
SURFACE PIERCING PROFILERS

- CTD, O₂, PAR
- Chl-a, OBS, CDOM
- point velocity
- Spec. Irrad., NO₃,
- Opt. Atten. & Absorp.

MOORING ANCHORS

- CTD, O₂,
- Chl-a, OBS, CDOM
- **Fast** point velocity
- Opt. Atten. & Absorp.
- pH, pCO₂, ADCP
- Bioacoustic sonar, camera,
- Integrated pressure

- Many instrument types
 - See oceanobservatories.org
- Stretch hoses → bandwidth & power



OOI's Timeline

- Design & Build
 - Started 1-Sep-2009
 - 5+1 year build.
- All Endurance platforms and sensors have been deployed
- Operate and Maintain



Default Sampling Strategy

- Big Surface Moorings
 - Burst interval 15 min to 1 hour, depending on sensor
 - Mooring powered by wind & solar. Some instruments with batteries.
- Inshore Surface Moorings
 - Burst interval 15 min to 1 hour, depending on sensor
 - Mooring powered by lithium batteries. Some instruments with batteries.
- Wire Following Profiler
 - 3 profiles per day
 - 25 cm vertical resolution
- Coastal Surface Piercing Profiler
 - 2-3 profiles per day, depending on depth & sea state
 - 25 cm vertical resolution (1.5 cm for CTD, 300 cm for nitrate)
- Cabled Infrastructure
 - Always on except for reagent or lamp-limited sensors
 - Bioacoustic sonar and camera share power source
- Gliders

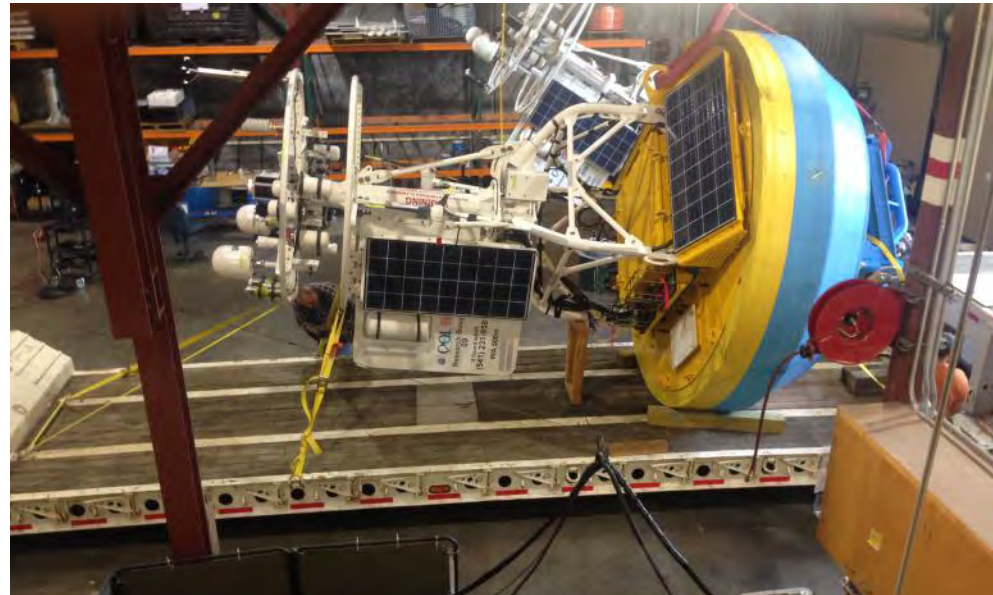
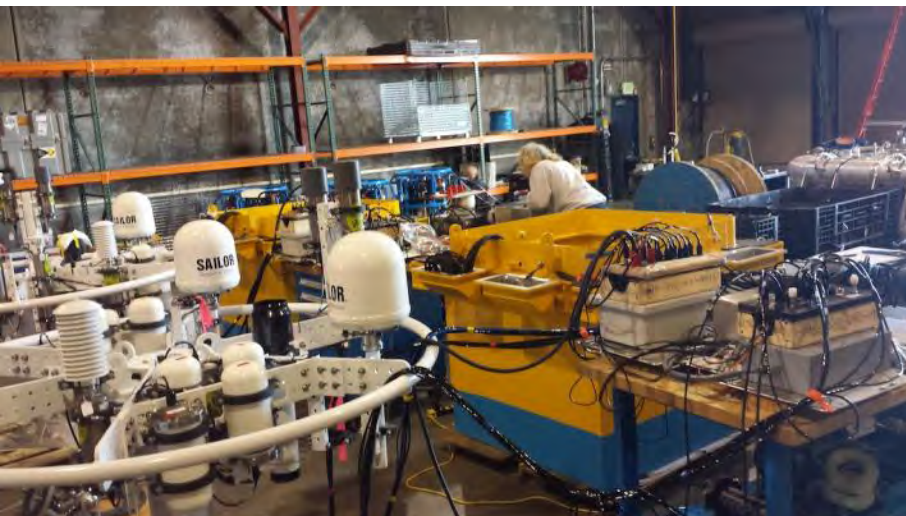
Details in document posted
to oceanobservatories.org

Uncabled platforms
telemeter decimated data
at least twice a day

Mooring Integration Ocean Observing Center



Collaboration with WHOI on mooring design



Shipping & Dockside Reassembly



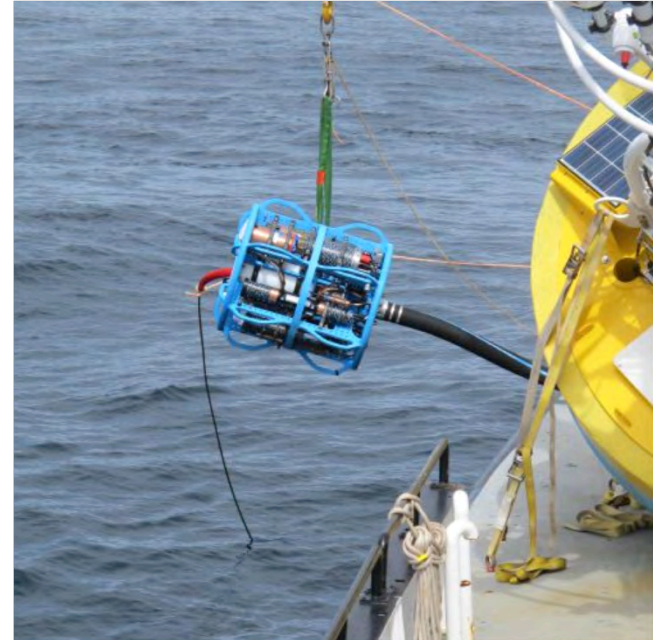
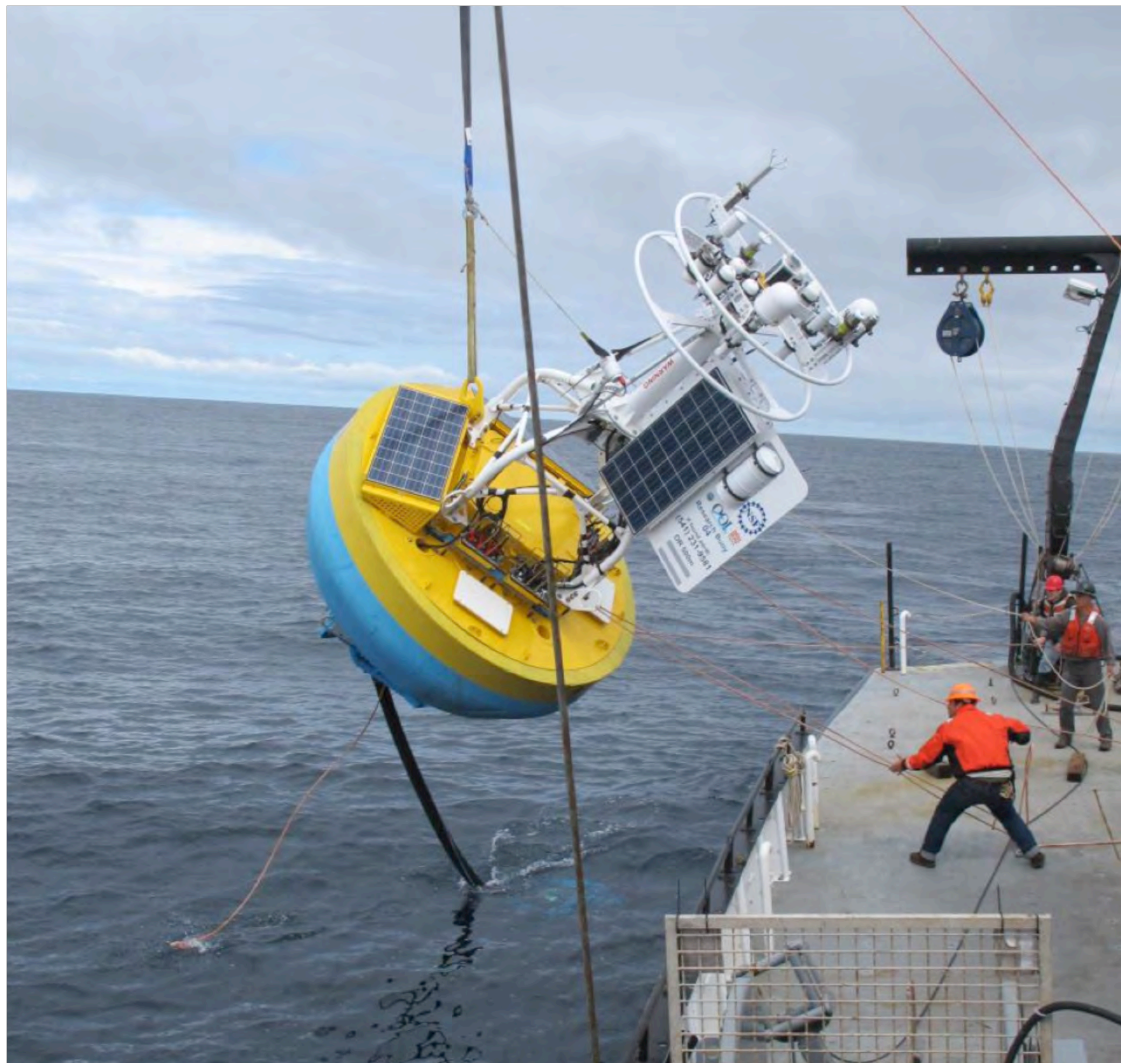
OOC Parking lot



Packed Deck



Deploy

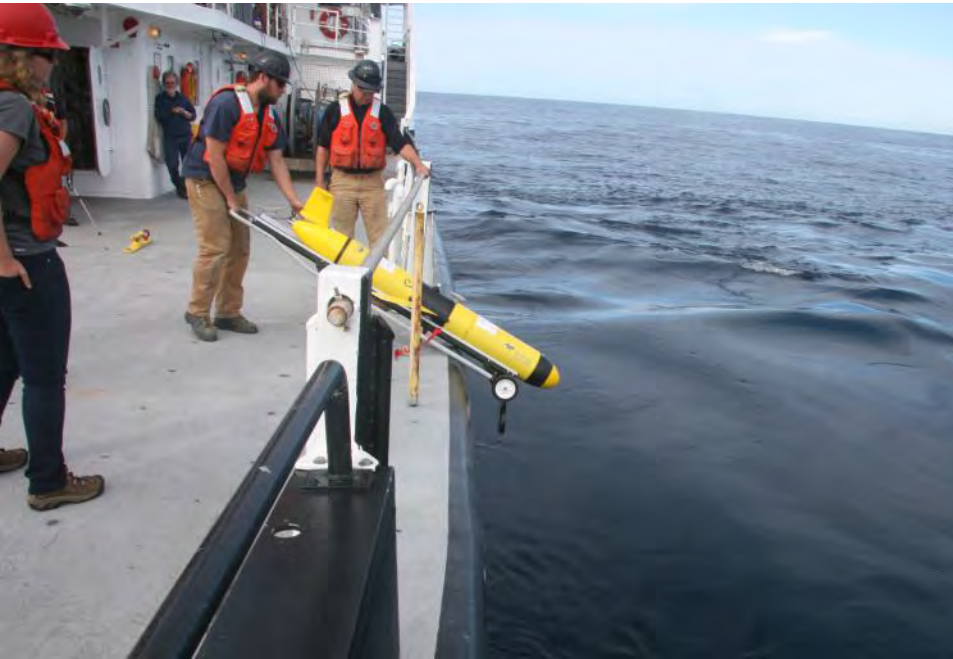
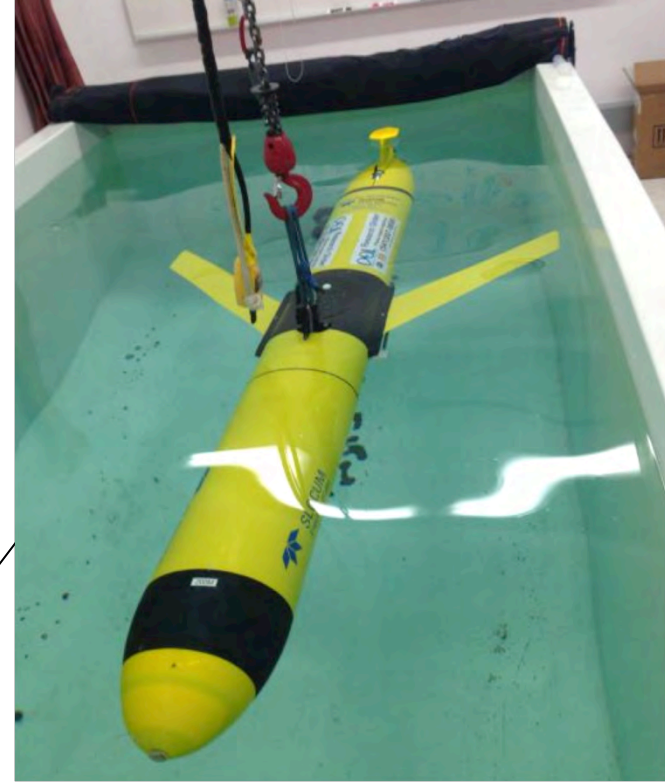
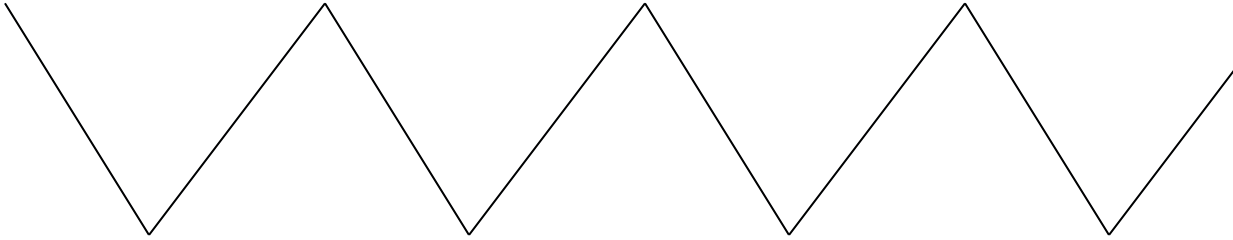


2016 Operational Schedule

	2016											
	January	February	March	April	May	June	July	August	September	October	November	December
Argentine Basin	Shipment	Refurb									Palmer Cruise	
55 South	Shipment											Palmer Cruise
Irminger							Armstrong Cruise					
Papa						Brown Cruise Jun-Jul						
Pioneer	-Glider Cruise	- 2/1 Quarterly Info Days			Armstrong Cruise		-Reseed gliders via Armstrong			Armstrong Cruise		
Endurance	- Ship out fm WHOI - Reseed Gliders			Thompson Cruise Apr-May			- Ship out fm WHOI - Reseed Gliders			Atlantis Cruise		
RSN	-1/19 Quarterly Info Days						Sikuliaq Cruise Jul-Aug					

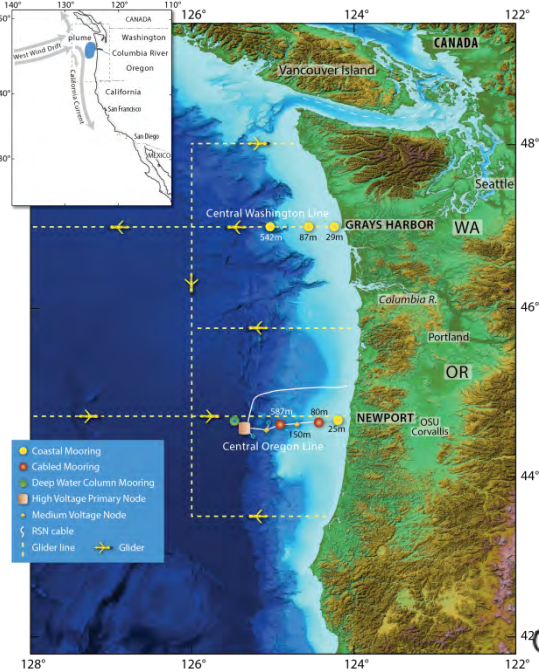
Endurance Array Gliders

- Lithium batteries → 3 month deployments
- 20 km per day
- CTD, O₂, PAR, Chl-a, OBS, CDOM, velocity

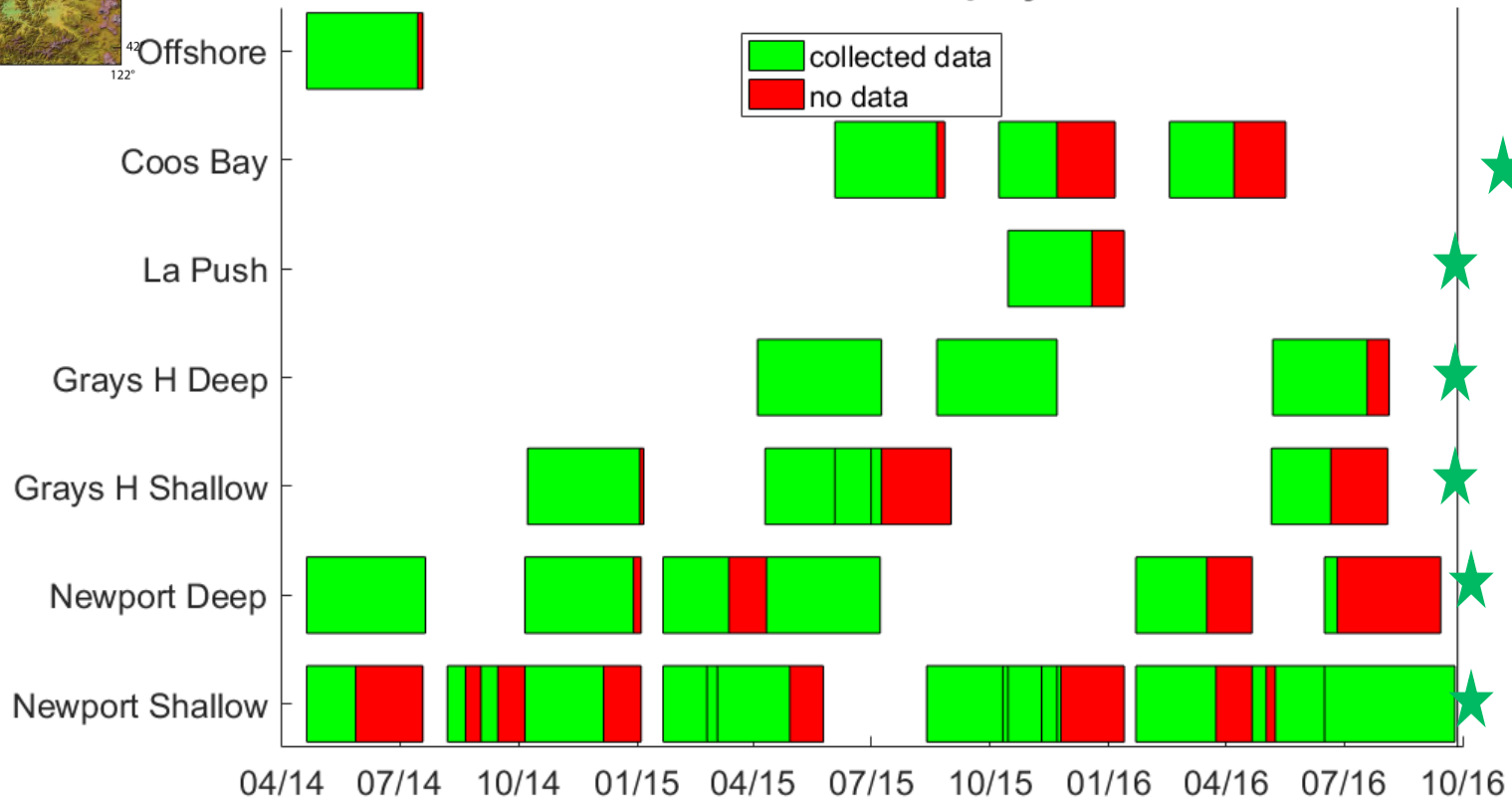


Endurance Array Glider Coverage

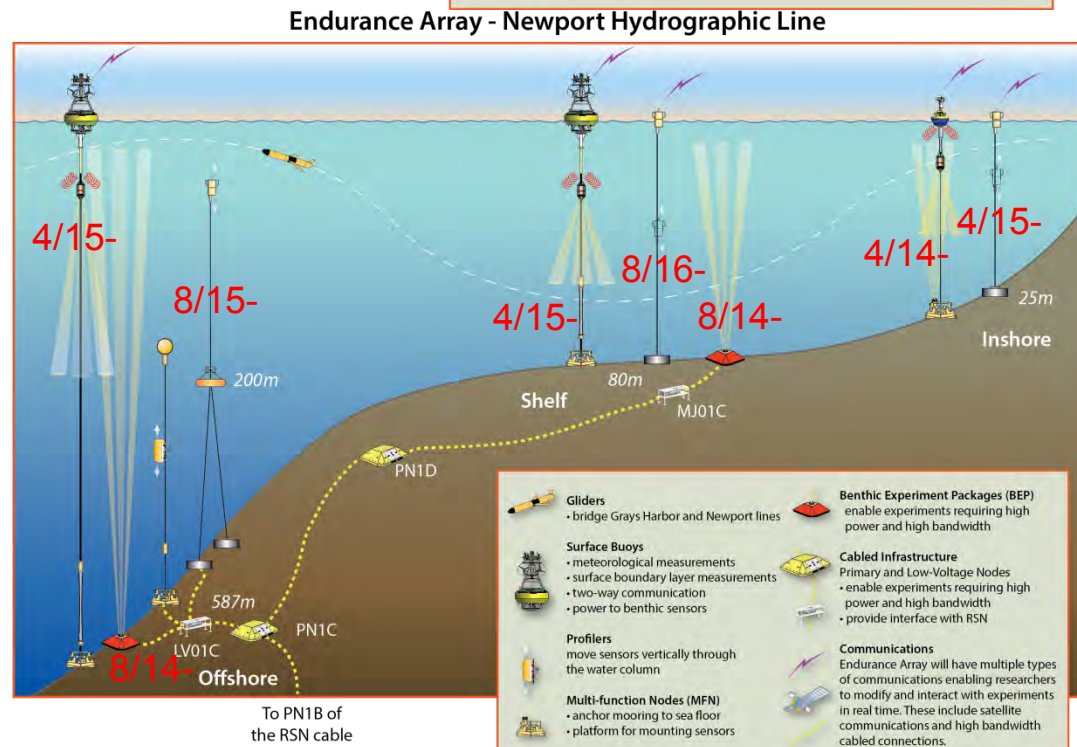
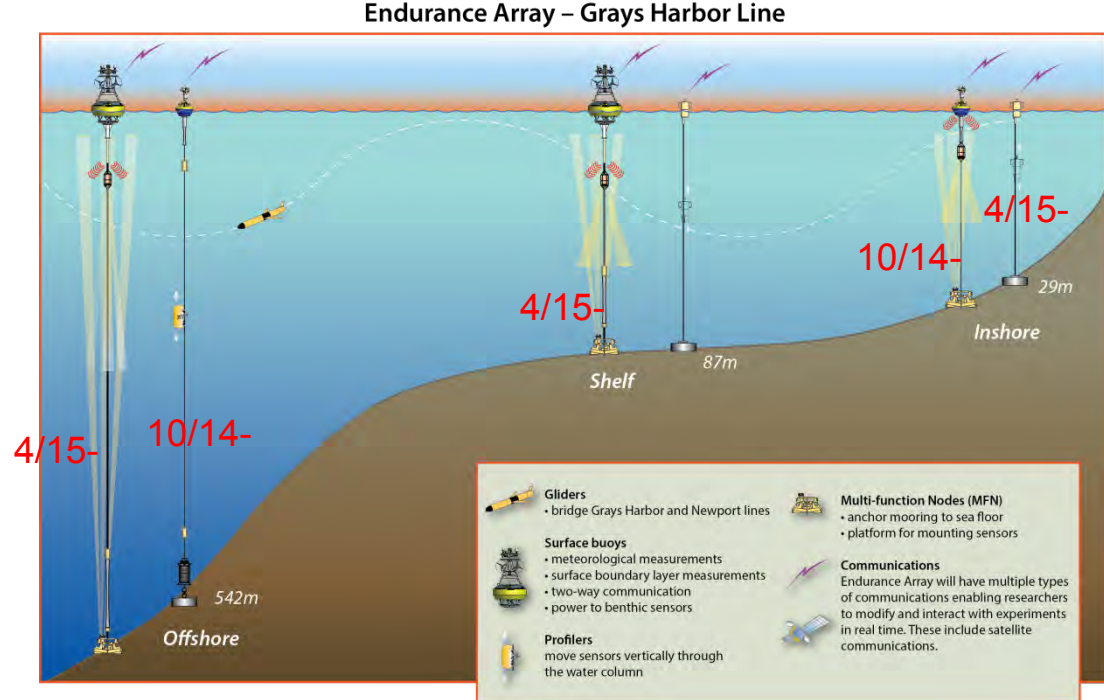
- 6 planned, 2 averaged
- ADCP sometimes off (battery, electronics)
- Science bay sometimes off (battery)



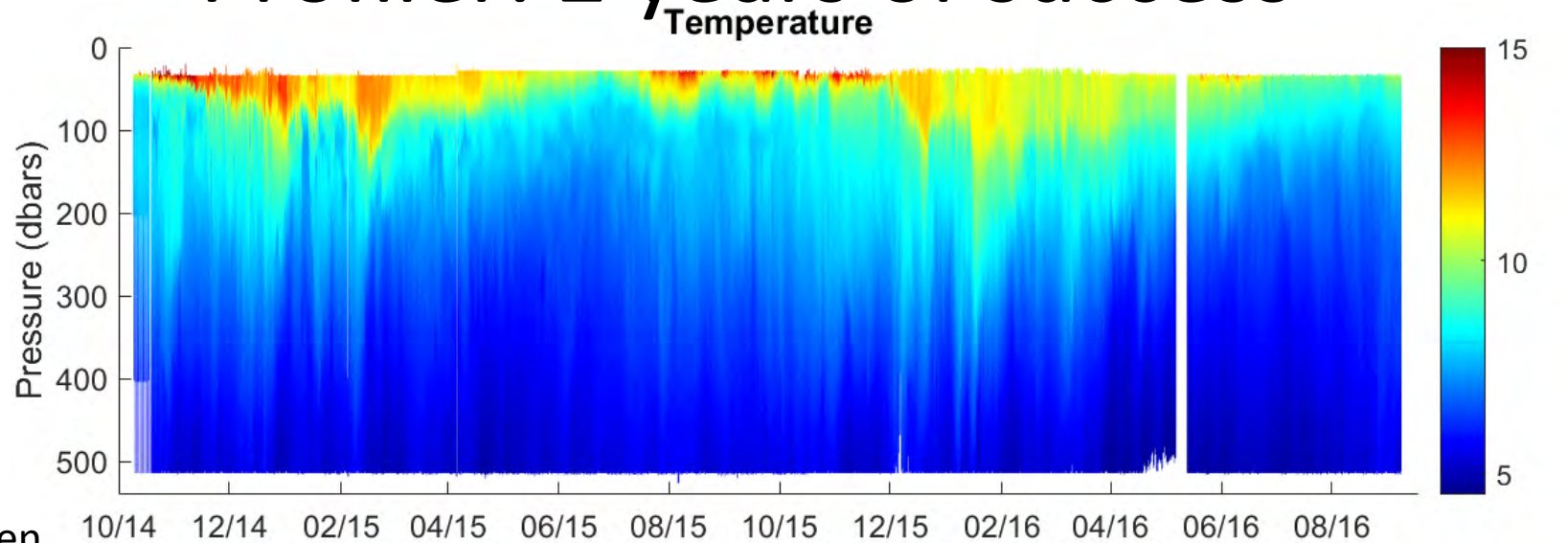
Endurance Glider Deployments



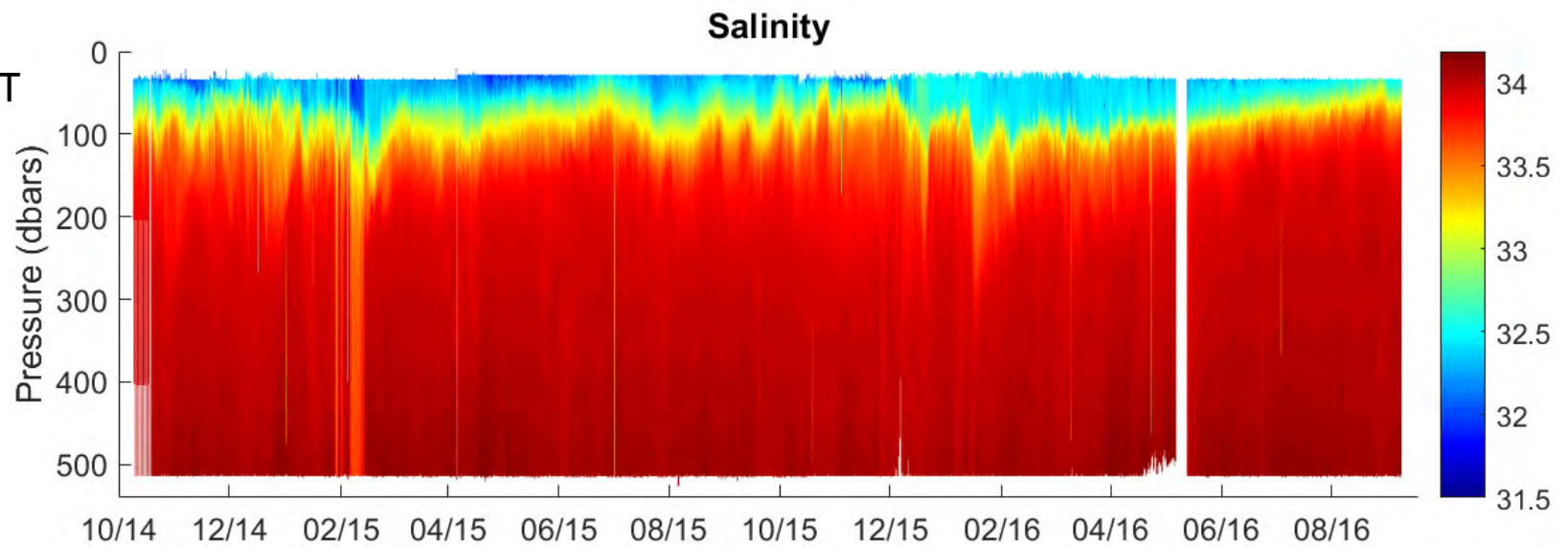
Endurance Array Platform Regular Data Collection Start Dates



Washington Offshore Wire Following Profiler: 2 years of success

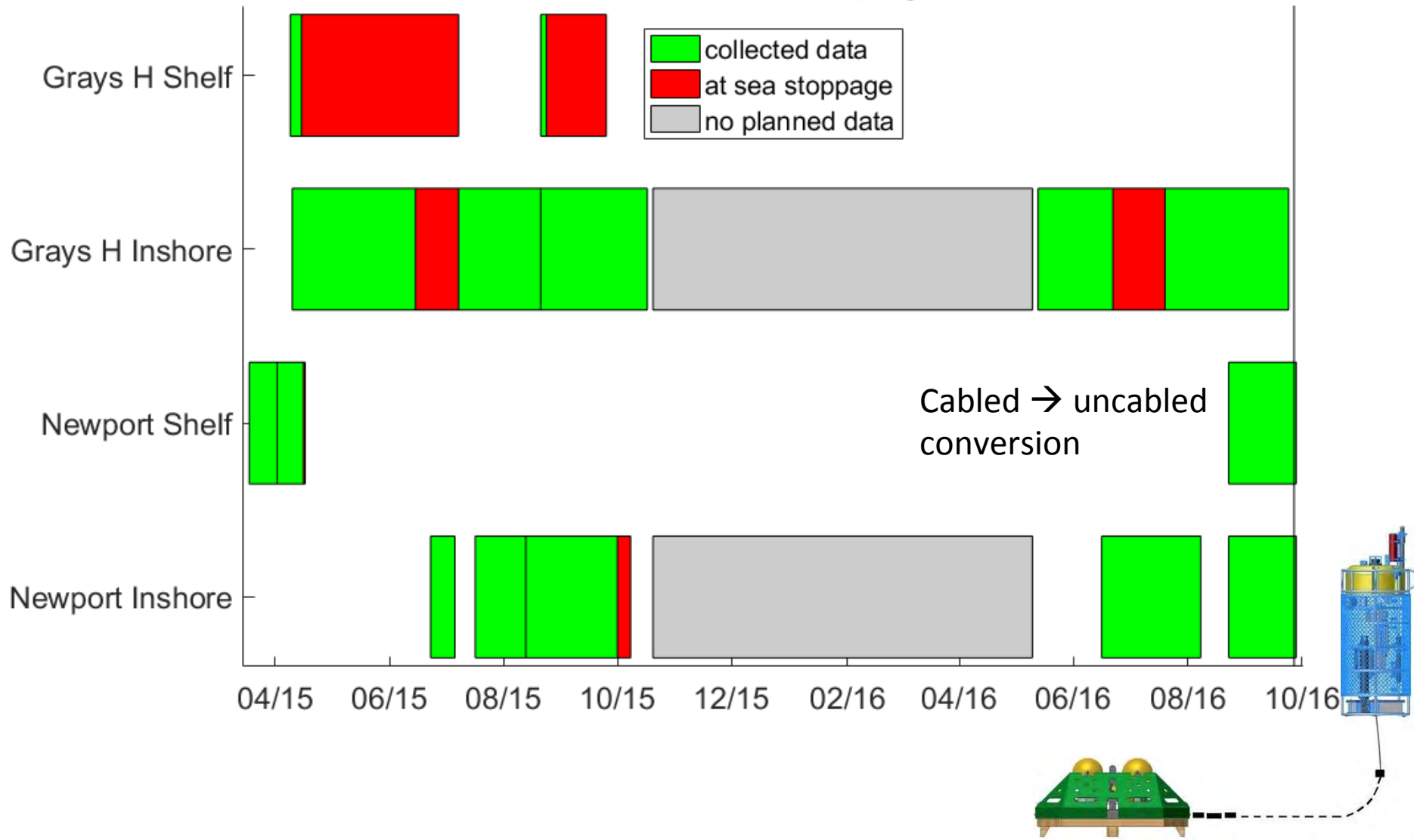


- CTD
- Oxygen
- Velocity
- PAR
- FLORT



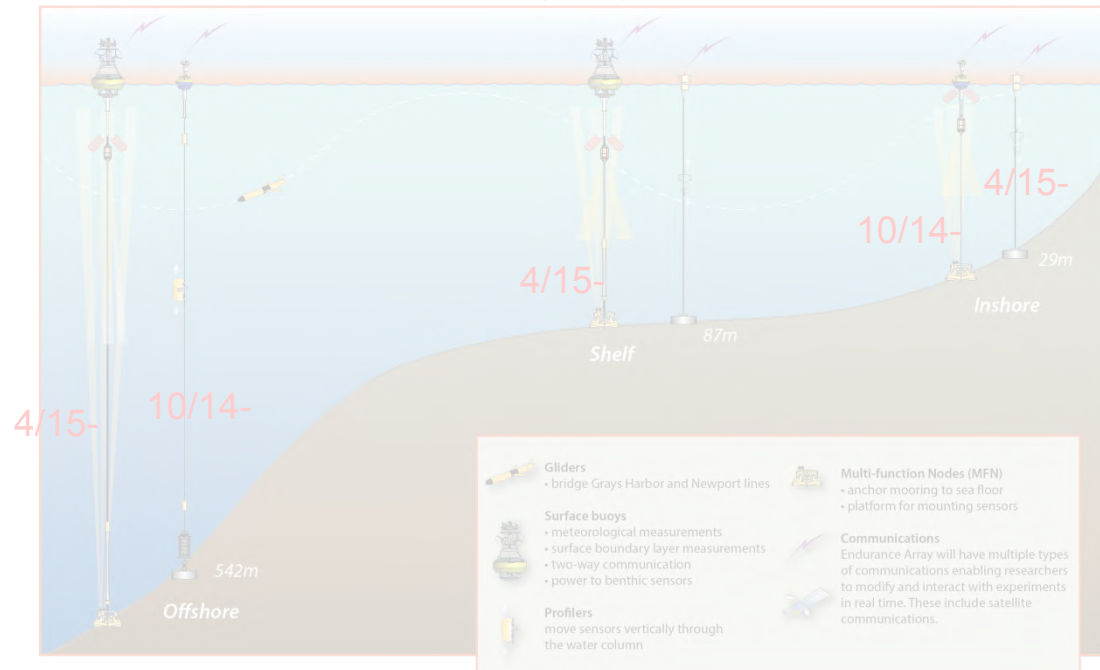
Coastal Surface Piercing Profiler

Endurance CSPP Deployments

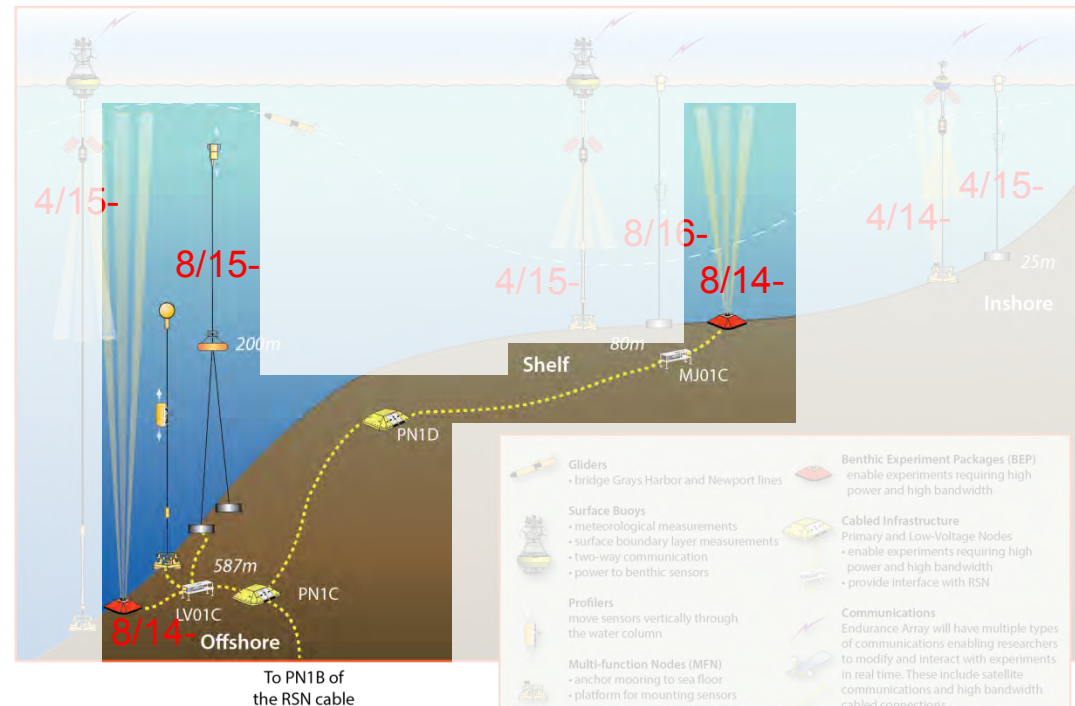


Endurance Array Platform Regular Data Collection Start Dates

Endurance Array – Grays Harbor Line



Endurance Array - Newport Hydrographic Line



- Cabled Endurance: when platforms on, instruments worked except CAMDS, sometimes ZPLSC & OPTAA
- CAMDS
 - Digital still camera
 - Kongsberg
- OPTAA
 - Optical attenuation & absorption
 - WET Labs ac-s
- ZPLSC
 - Zooplankton sonar, coastal
 - Simrad EK60

Surface Mooring Instrument Data Summary

CAMDS	Digital still camera	Very little data, software incomplete, frequent hardware failures, late procurement & poor quality
OPTAA	Optical attenuation and absorption	No battery, so turns off if mooring fails. Long service interval so often not deployed. Significant biofouling.
FDCHP	Air-sea Flux direct covariance	Frequent instrument hardware failures, late procurement
NUTNR	Dissolved nitrate	Frequent instrument hardware failures, significant biofouling
PCO2W	Aqueous partial pressure carbon dioxide	Finicky instrument, so major setup problems, now OK
VEL3D	High-frequency 3D point velocity	Mooring software was unable to operate sensor until recently
ZPLSC	Zooplankton sonar	Late procurement, occasional hardware or configuration failure, calibration under development
PCO2A	Air and sea partial pressure carbon dioxide	Significant fouling on buoys, but now mitigated
PHSEN	pH	Finicky instrument, so some setup problems, now OK
ADCPT/S	Acoustic Doppler current profiler	Occasional instrument hardware failure or battery miscalculation
CTDBP	Conductivity, temperature, pressure	Occasional battery miscalculation Some biofouling
DOSTA	Dissolved Oxygen, stable (vs. fast DOFAST)	Significant biofouling
FLORT	Florescence (chlorophyll-a, optical backscatter, CDOM)	No battery, so turns off if mooring fails Some biofouling
METBK	Bulk meteorology (short & long wave radiation, air pressure, temperature, relative humidity, wind, rain)	Occasional instrument hardware failure
PRESF	Bottom pressure	No problems
SPKIR	Spectral irradiance	No battery, so turns off if mooring fails Some biofouling
VELPT	Mean 3D point velocity	Occasional instrument hardware failure or battery miscalculation

Buoy sensors covered
(PCO2A, METBK-CT)

Biofouling



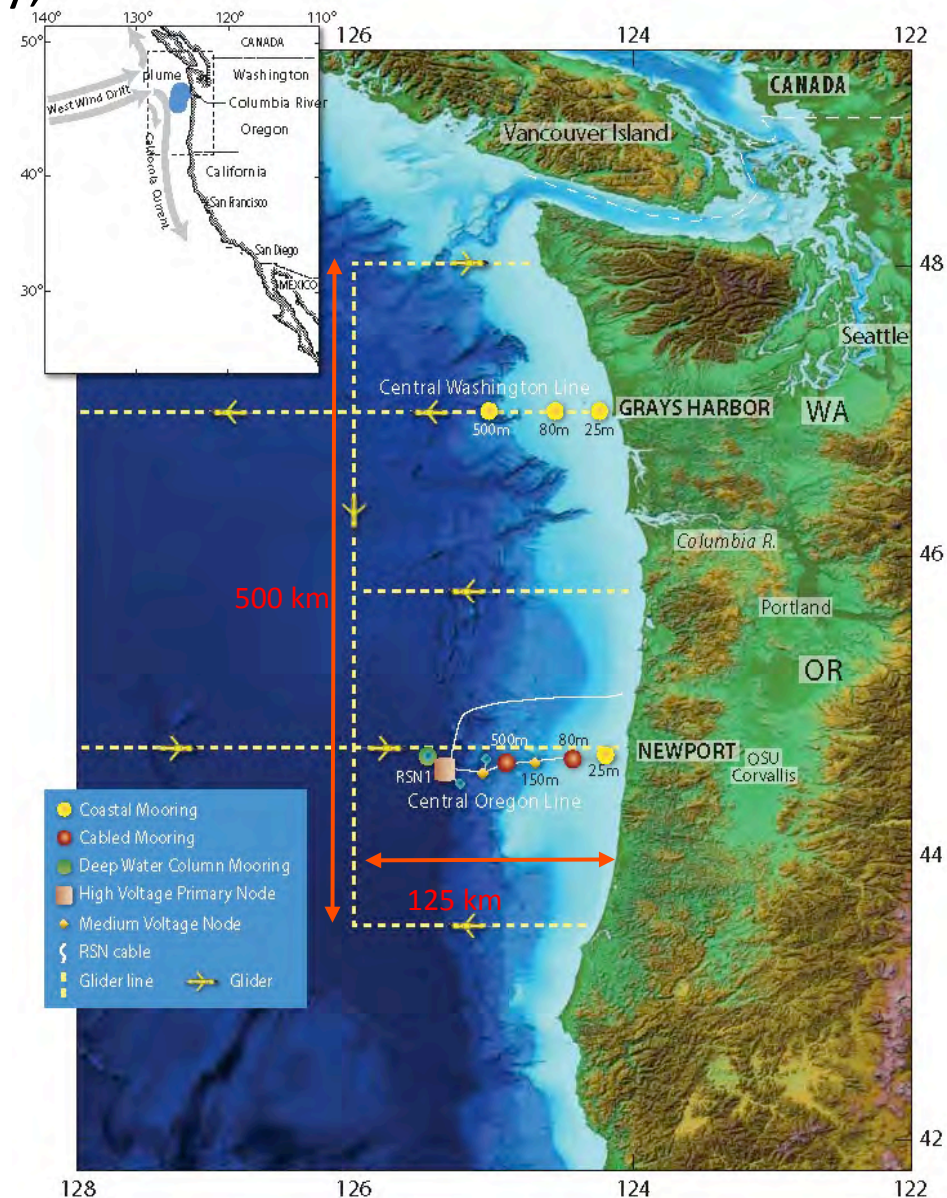
CSPP painting shows mitigation
measures can work

Endurance Array Summary

operate, maintain, deliver data, improve, make efficient, collaborate,
work transparently, share ...

Opportunities

- Use data
- Add instruments
- Change sampling
- Ancillary projects
- Join a cruise
- Talk with us



Subsurface Instruments have often become autonomous

- Stretch hoses
 - WA Shelf & Offshore surface moorings hoses send power and data
 - Inshore mooring and WFP hoses send data
 - Revised hoses succeeded on latest Pioneer deployment
- Mooring Electronics
 - Custom & complex, so many failure points—better each time
 - Long build & service intervals—being fixed
 - Connectors on all subsea controllers upgraded to titanium

Endurance Array – Grays Harbor Line



Endurance Array - Newport Hydrographic Line

