NSF-OOI Regional Cabled Array (RCA): Current Infrastructure and Data Delivery

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NSF-OOI Regional Cabled Array (RCA): Current Infrastructure and Data Delivery

» History and Overview of Ocean Observatories Initiative (OOI) Program

» RCA Infrastructure Summary

» RCA Instrument and Data Types

» OOI Data Delivery

Orest E. Kawka (University of Washington)

System of Systems

- Integrated infrastructure of science-driven platforms & sensors
- Measures physical, chemical, geological, & biological properties from seafloor to air-sea interface
- Examines processes at multiple scales:
  - From ocean basin to tidal basin
  - Short-term, stochastic events and large-scale decadal cycles
  - Within sections of wave fronts and stratified nutrient layers
- Delivers free-access data to a vast user community, much of it in real time
- Expandable architecture accommodates technical advances

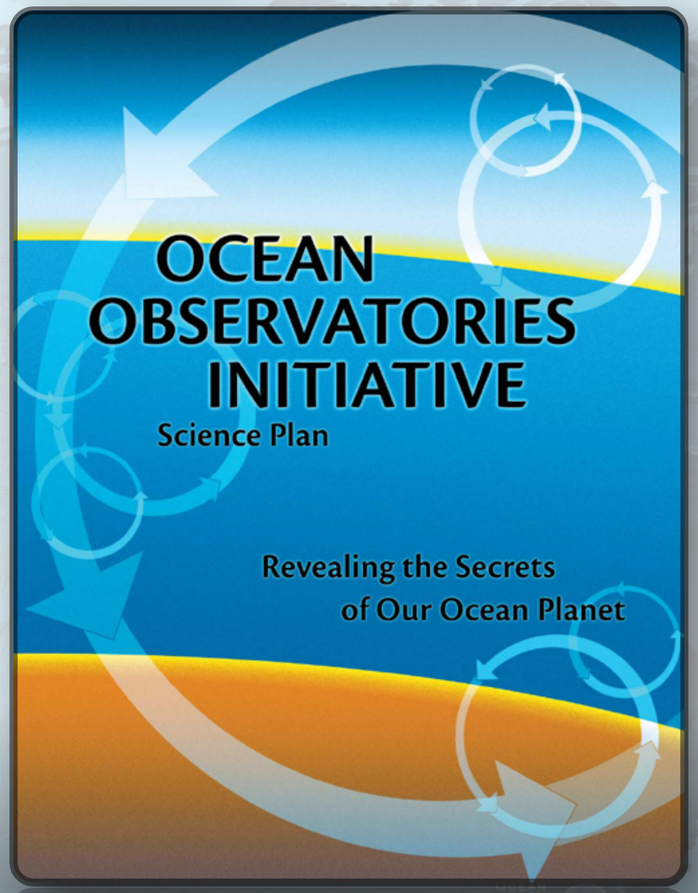
OOI Planning & History

- National Research Council committees and community workshops lead to the recommendation that the National Science Foundation (NSF) go forward with the design, construction, and operation of a sustained ocean observing infrastructure.
- Through community workshops the science requirements for the OOI were developed and the marine infrastructure was engineered to meet them.
- The infrastructure was built and implemented using instruments and platforms acquired to meet engineering requirements with flow-through to science requirements.
- Construction began in 2009 - $385M from NSF's Major Research Equipment and Facilities Construction (MREFC)
- Data began flowing 2014 with all OOI infrastructure commissioned in 2016.

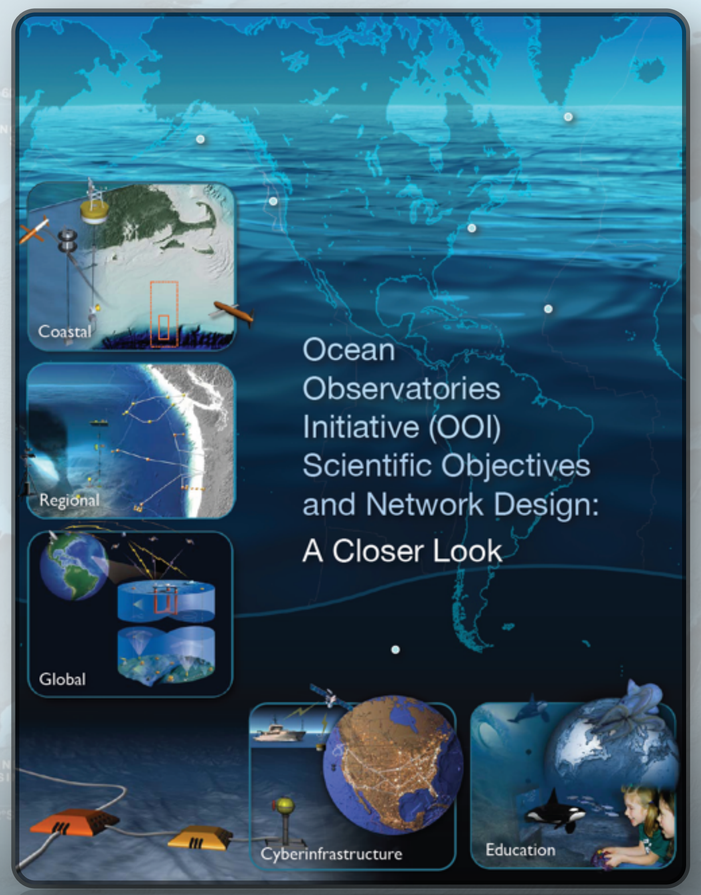
OOI Mandates

- Select critical locations, of high science impact yet data sparse due to challenging nature
- Deploy cutting edge platforms and equip with multidisciplinary sensors
- Provide as much real time data as possible
- Provide as much interactive capability as possible
- Provide additional bandwidth and carrying capacity
- Launch crucial long-term measurements that resolve high frequencies and episodic events
- Make all data available

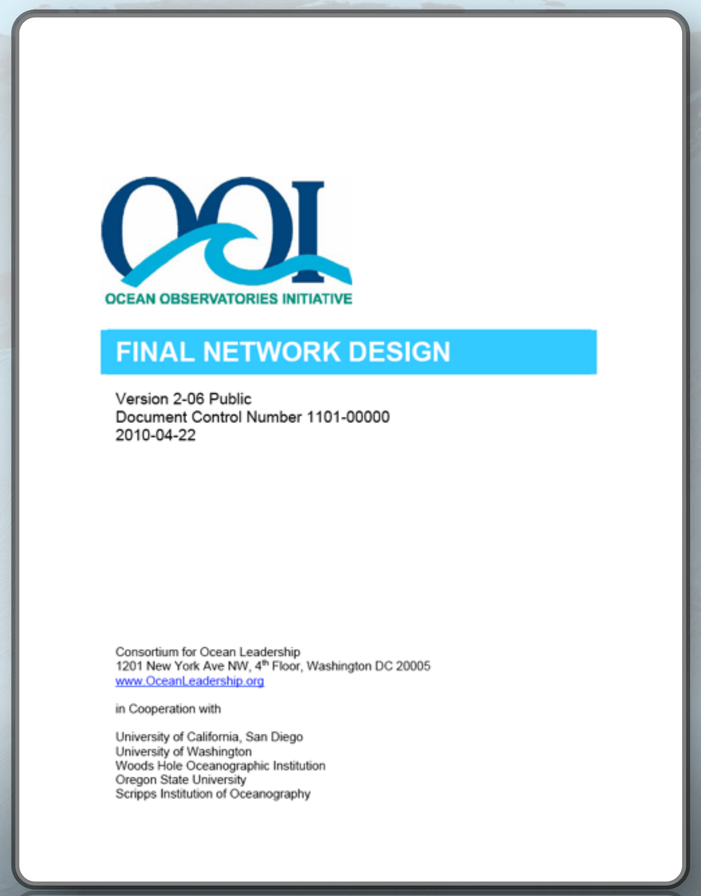
PUBLICATIONS



SCIENCE PLAN



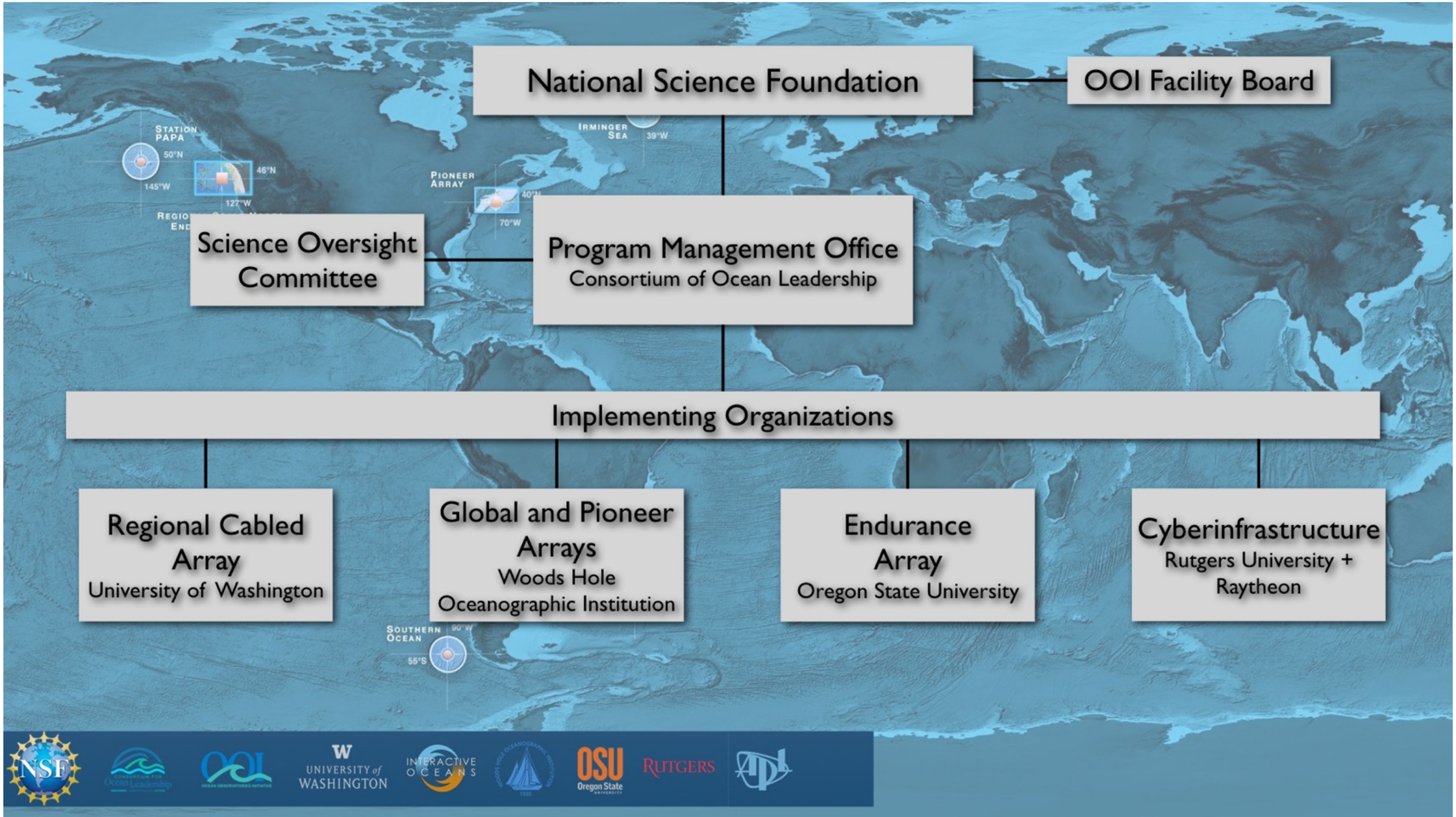
SCIENCE PROSPECTUS



FINAL DESIGN

http://www.oceanobservatories.org/publications/

Program Management



Ocean Observatories Initiative:

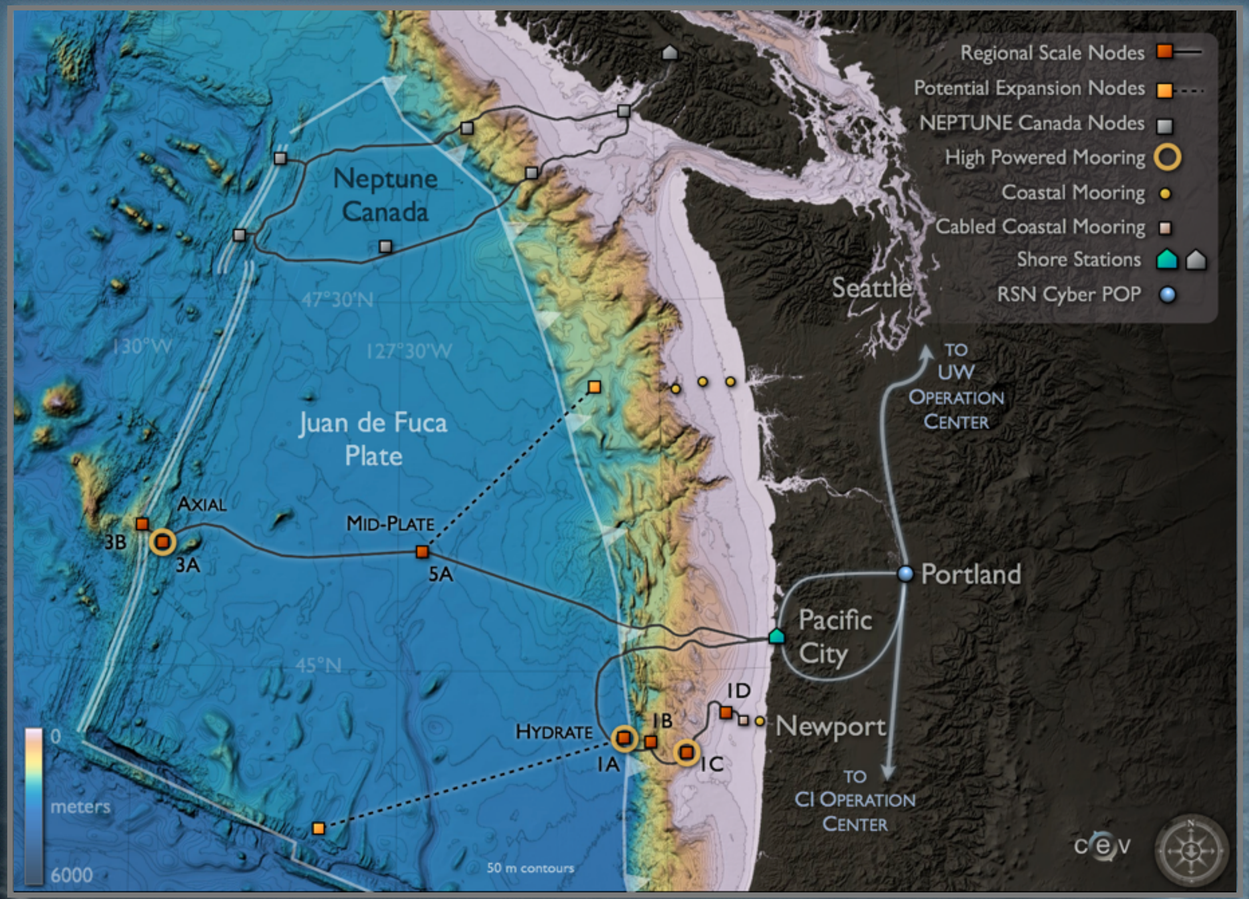
Real-time Science Exploration in a Changing Ocean from Anywhere on Earth

OOI $385M MREFC - 5.5 year build - 2014
Cabled (RCA) Component $155 MREFC

THE VISION

To launch an era of scientific discovery across and within the ocean basins, utilizing widely accessible, scalable, interactive telepresence

OOI's Regional Cabled Array (RCA)



- 900 km of high-bandwidth (10 GbE) and high-power (8 kW) Primary Cables
- 7 Primary Nodes converting 10 kV to 375 V for Secondary Infrastructure and providing 1GbE and 10GbE ports
- 18 Junction Boxes providing 1 GbE and transforming 375 V to usable 12/24/48 V
- 6, up to 2700 m tall, instrumented moorings with winched profilers (0-200 m) or wire crawlers
- up to ~140 cabled instruments (34 types) now providing 24/7 real-time data with two way communication
- highly expandable for science, industry, education

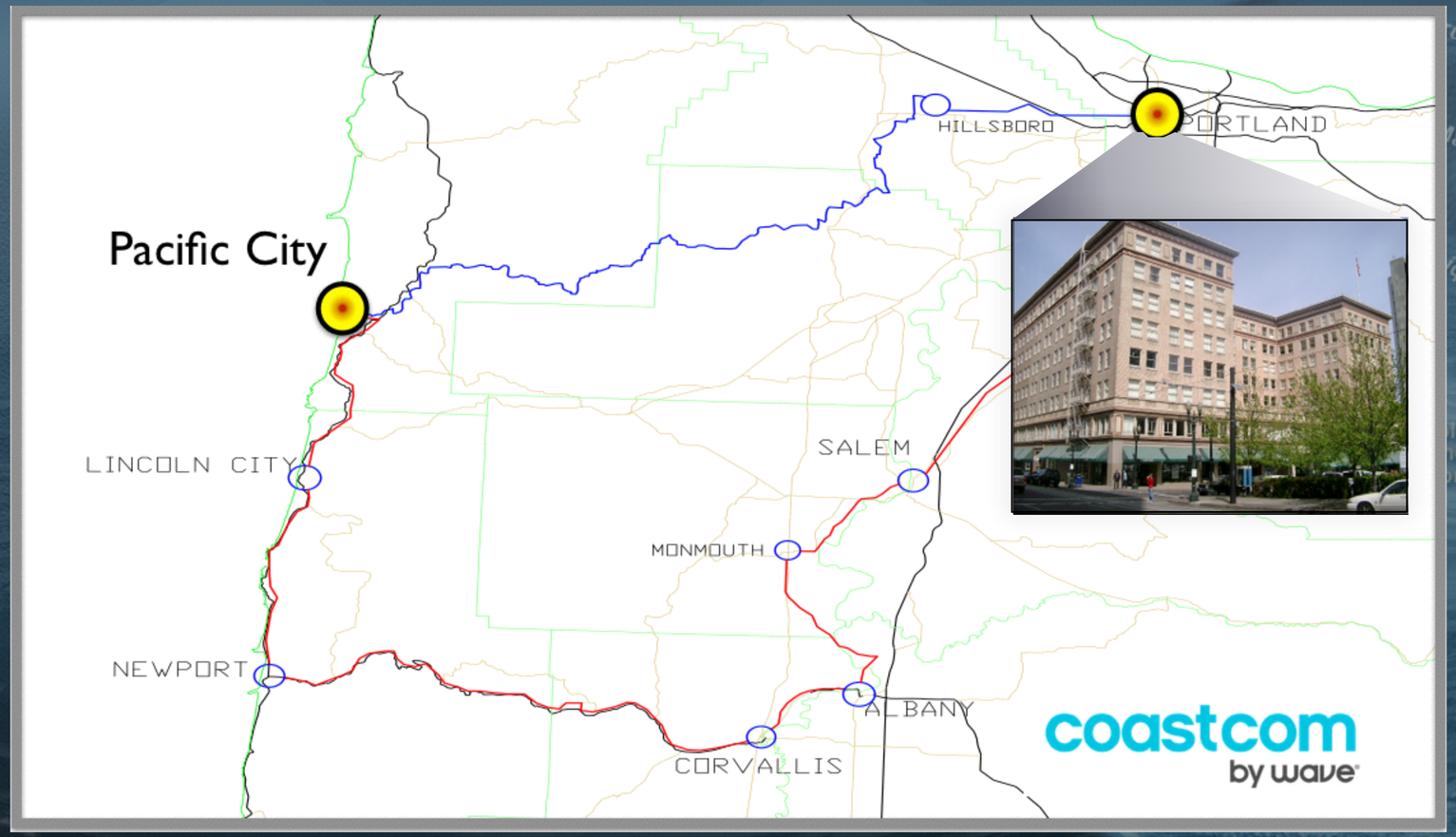
2014 - Installation of RCA Completed (83 Days)
2015 - First Annual Maintenance Cruise

Shore Station Leased from Tillamook Lightwave

10,000 gallon fuel tank provide several weeks of power should land lines fail (utilized a couple times); station behind secured gate

- Manned during working hrs, 1.5 FTE, powering up/down of Primary Infrastructure is done at Shore Station
- Provides 10 kVdc, up to 8A, 8 kW power, and 10 Gbs communication to each cable line (upgradable to 40 Gbs)
- All seismic data and hydrophone data are routed to the NAVY from a secure site in the Shore Station; returned from Johns Hopkins to Pittock
- All raw data flow both to the Pittock Exchange Building, Rutgers University, and the UW Operations Center

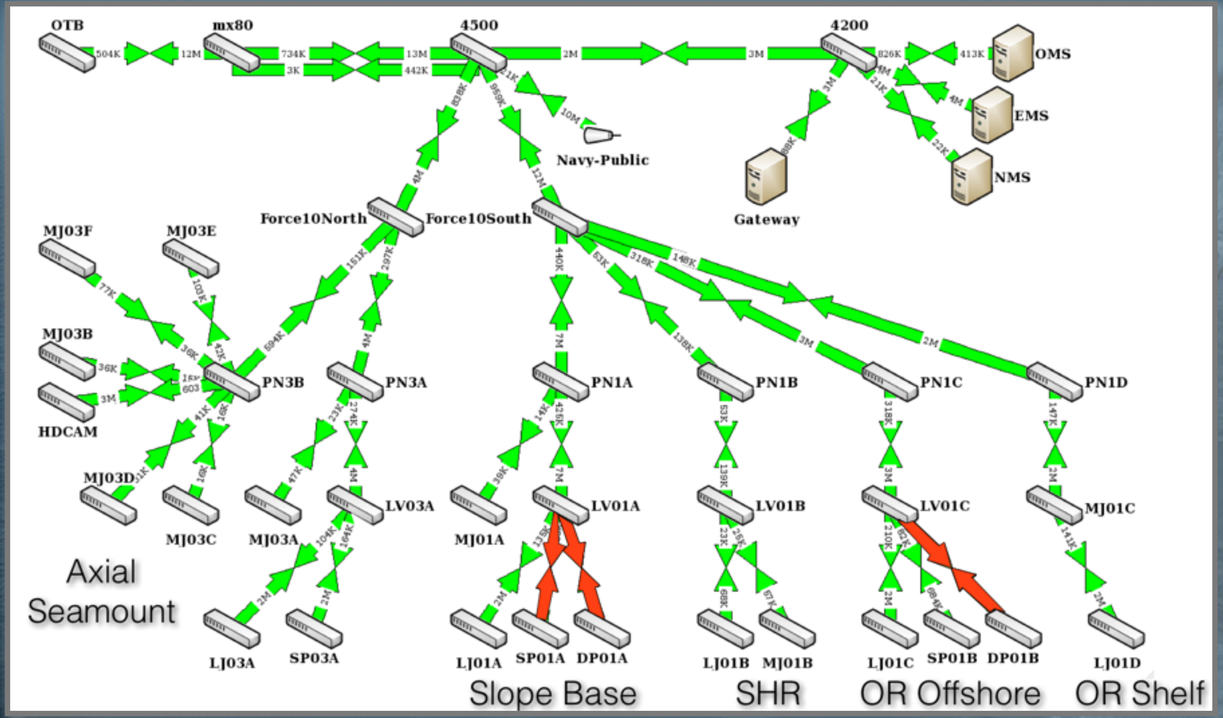
Backhaul (Portland, OR to Pacific City, OR)



- Terrestrial telecommunications fiber that connect the shore station in Pacific City, OR with the Portland Point of Presence (Cyberpop)
- Utilizes diverse routes from Pacific City to Portland, OR allowing maximum availability.

UW Observatory Management Center

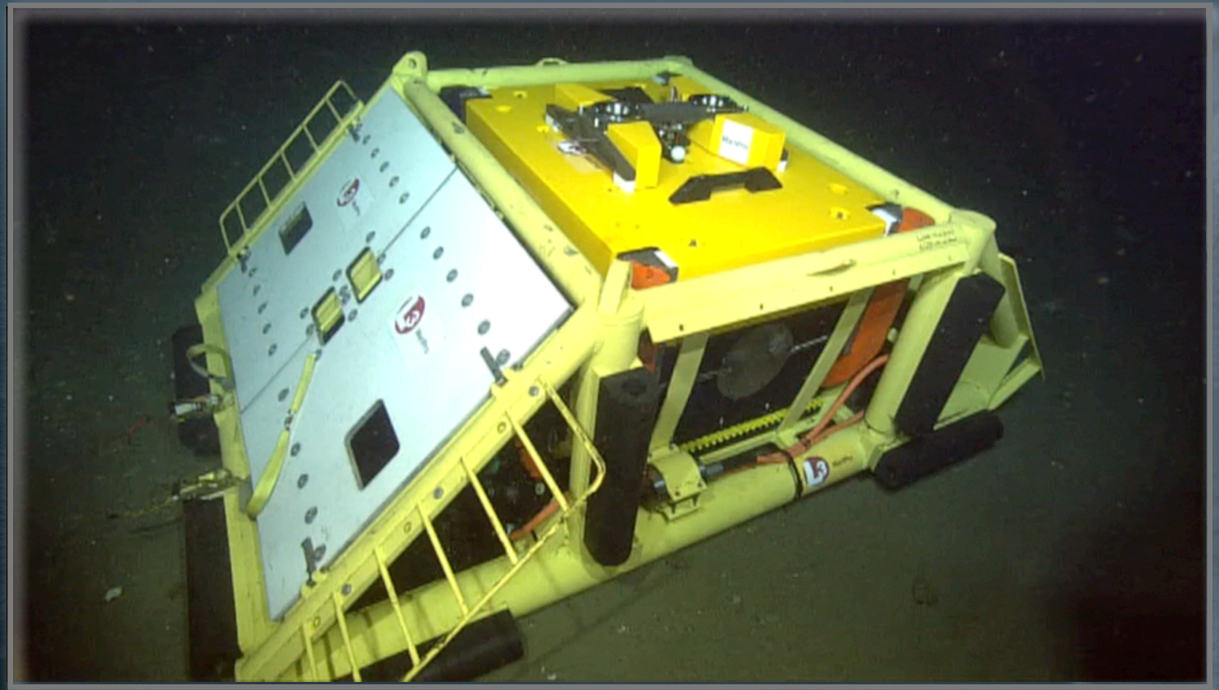
Provides Live Health Monitoring of Array



- The Observatory Management System (OMS)
  - Includes a collection of services implemented in software.
  - It is the primary control system for operation of the Cabled Array and a management system with complete observatory awareness (>1000 alerts and alarms).
  - It includes a
    - Network Management System (NMS) – L-3 MariPro; Primary Infrastructure
    - Element Management System (EMS) – Secondary Infrastructure

- Monitors the health of the networks
- Collects, stores and depicts engineering telemetry data from all network components
- Provides both a local and remote GUI for the OMS operator control
- Provides alarm capture, notification, management and propagation.

Primary Infrastructure: L-3 Mari Pro Inc. - UW Important Industry-Institution collaboration



Shallow Water Node

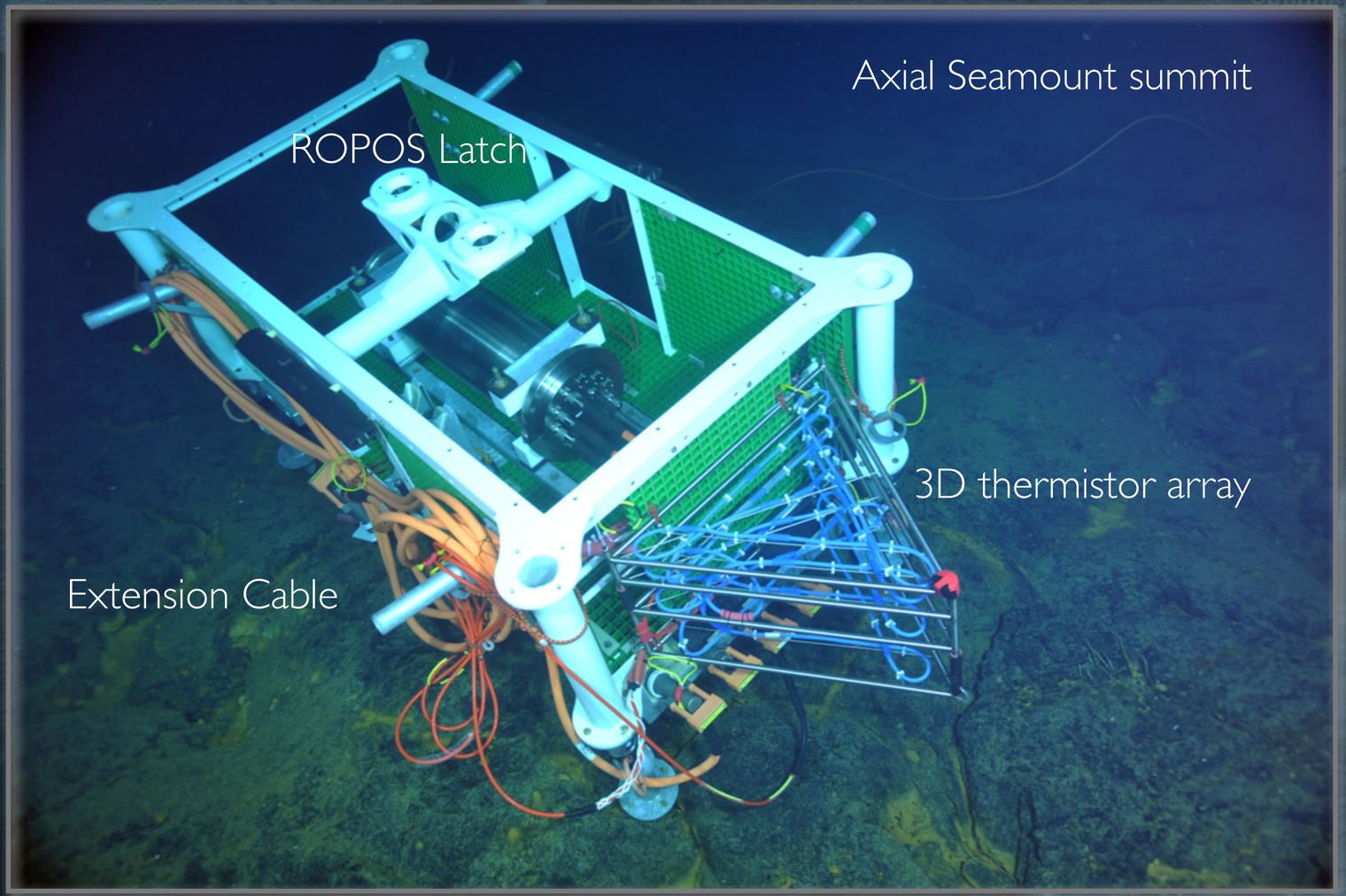
10 km south of Southern Hydrate Ridge

7 PRIMARY NODES

- Each Primary Node -10 GbE, 8 kW
  - 5 Science Ports (1 GbE, 375 V)
    - ROV Wet mate Connectors
  - 2 High Bandwidth Science Ports (10GbE, 375V)
    - ROV Wet mate Connectors
  - 2 Backbone Expansion Ports (10kV)
- Pulse per Second Timing
- Science Interface Assembly removable by ROV
- Primary cabled buried out to 1500 m water depth
- Route approved by OFCC, COL is a member

All fully operational science 2014 - virtually no issues

Secondary Junction Boxes

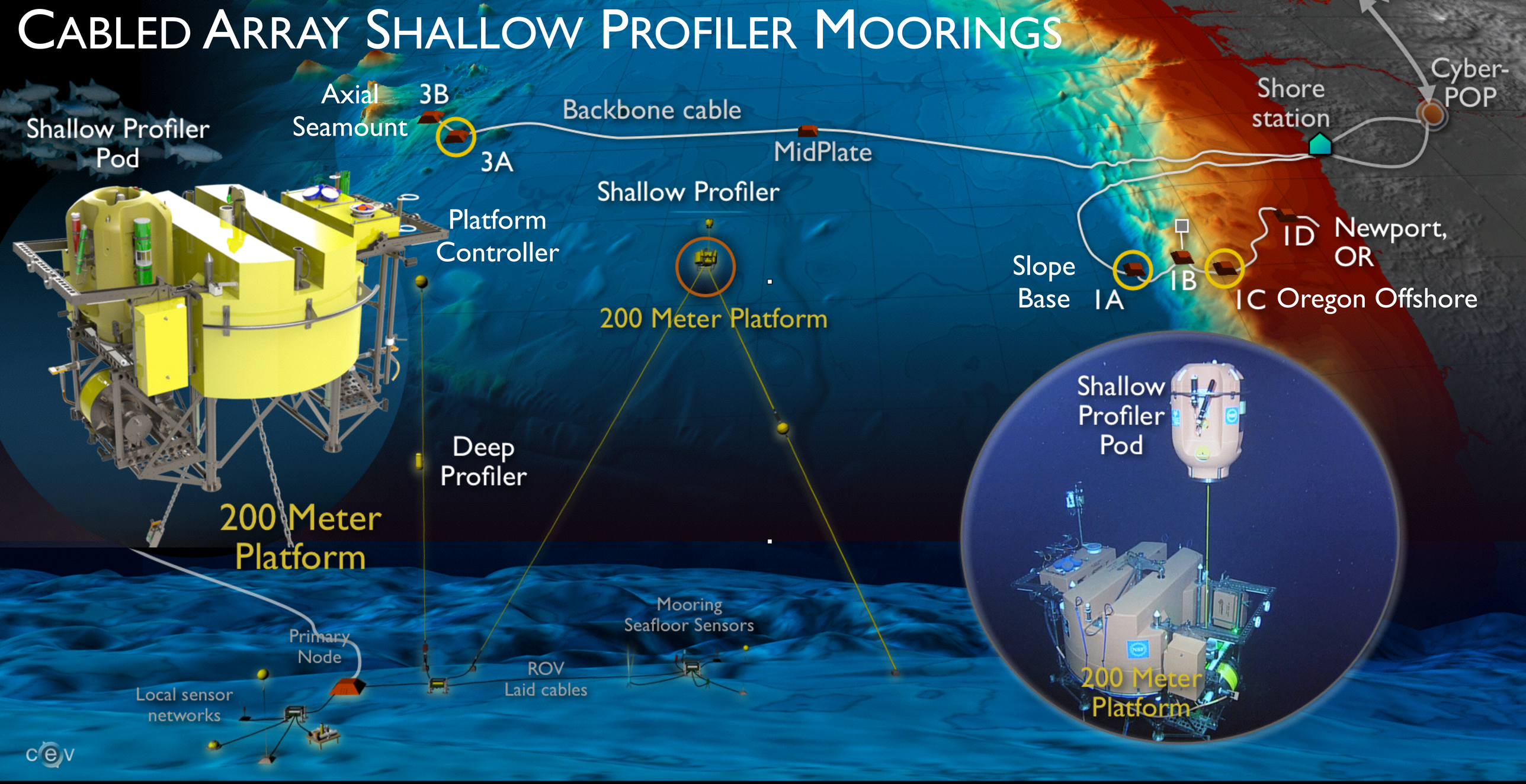


- Provides 8 configurable science ports with 1 GbE bandwidth, up to 200W of power per port (±12/24/48 VDC), and one expansion port 10Amp, 375VDC), 10/100BASE-T, RS232 or RS485 data links
- Extend power and bandwidth to instruments and platforms
- Setup specifically for each platform/site; can easily be **daisy chained** for expansion

18 now installed on Cabled Array - All are Operational

Designed and built by Applied Physics Lab = easily modified and upgraded, adaptable for community experiments

Cabled Array Shallow Profiler Moorings



200 m Deep Platform: 12 ft across (7 ton) instrumented platform with up to 3 kW power & 1 Gbs bandwidth real-time two-way communications allow event response, highly expandable

SHALLOW PROFILER “SADDLE BAGS”

SHALLOW PROFILER SUBSYSTEM

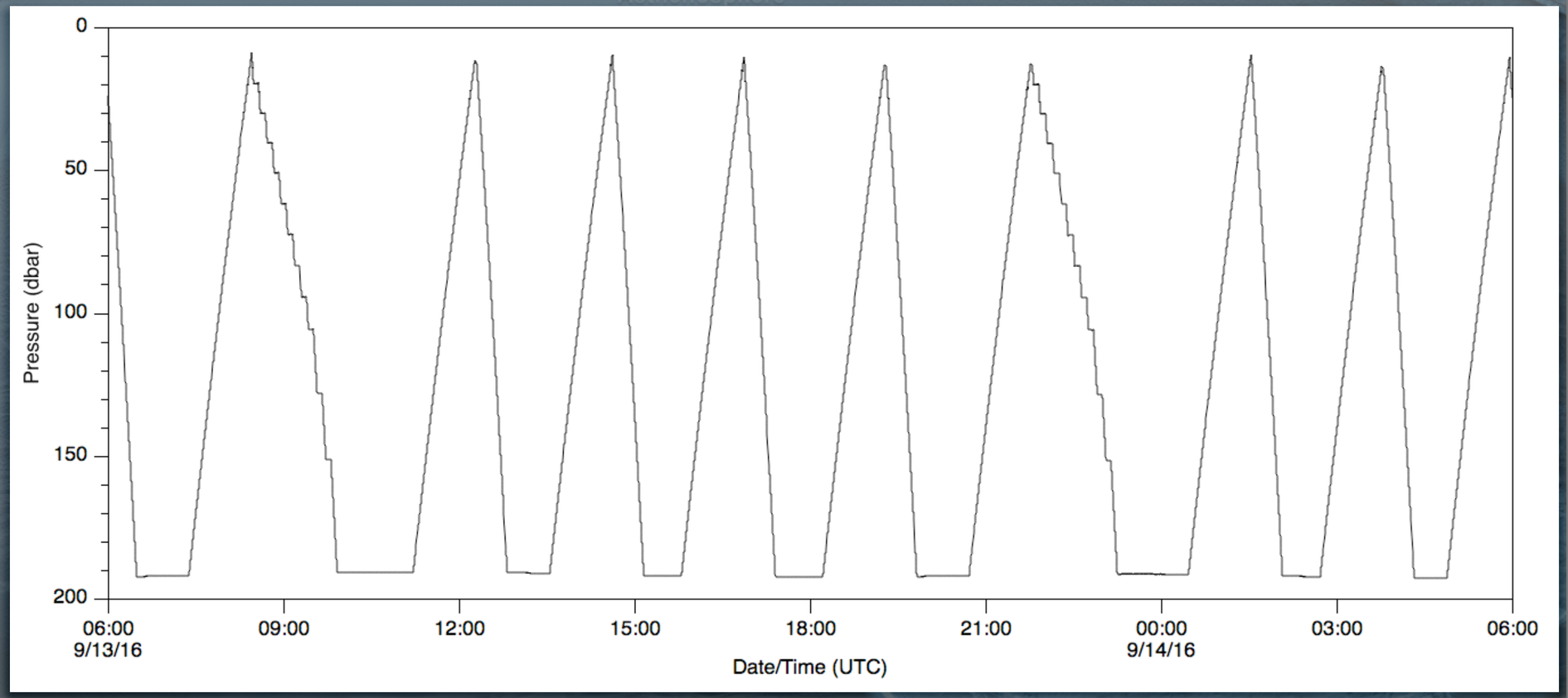
PLATFORM INTERFACE SUBSYSTEM

Shallow Profiler

Axial Base

Cabled Winched Shallow Profiler

Axial Base, Slope Base, EA Offshore (600 m)



Nominal Profiling Depths:
5 – 200 m below surface

9 Total profiles per day
"Clean" water on upcast

High resolution profiling
Upcast: 5 cm sec^{-1}
Downcast: 10 cm sec^{-1}

2x Day Stepped Descents
5 min hold at steps
Local noon/midnight

All Profiles - Continuous Operation:

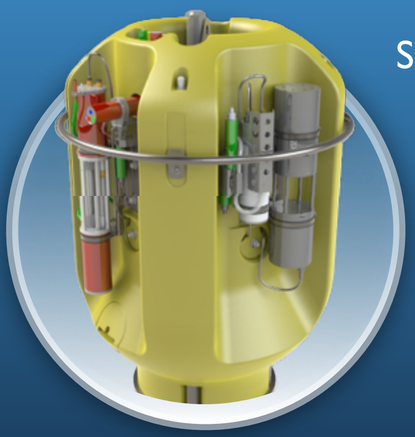
CTD and O_2
PAR
Spectral Irradiance
Fluorometer
Current Meter

Stepped Profiles:

Upcast-
Optical Attenuation
Nitrate (2 m resolution)

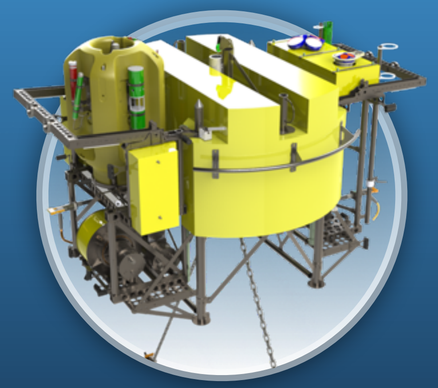
Downcast 10/20 m resolution-
pH (reagent-based)
pCO_2 (reagent-based)

Cabled Array Water-Column Mooring Instruments
Axial Base, Slope Base, Oregon Offshore



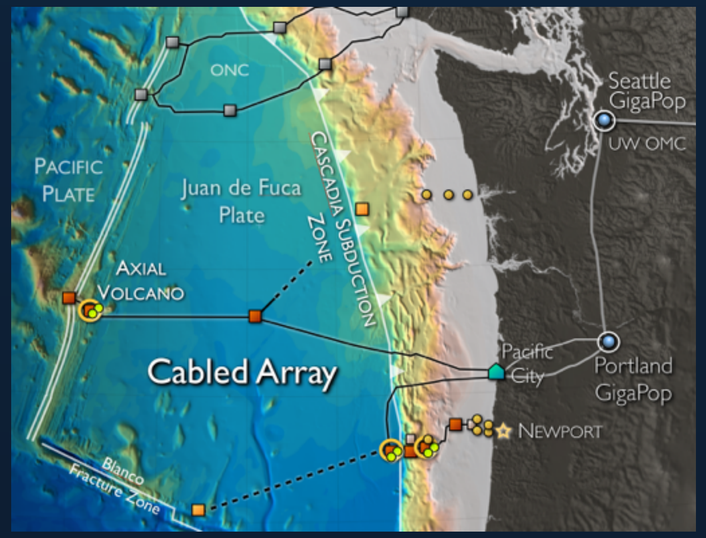
Shallow Profiler (5-200m) :

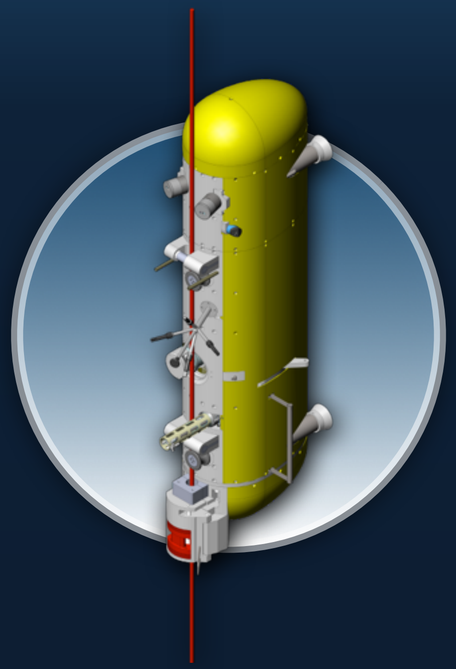
- Fluorometers
- Seawater CO_2 Partial Pressure
- Photosynthetically Active Radiation
- Spectral Irradiance
- 3-D Single Point Current Meter
- Conductivity, Temperature, Pressure
- Dissolved Oxygen
- Nitrate
- Seawater pH
- Spectrophotometer



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

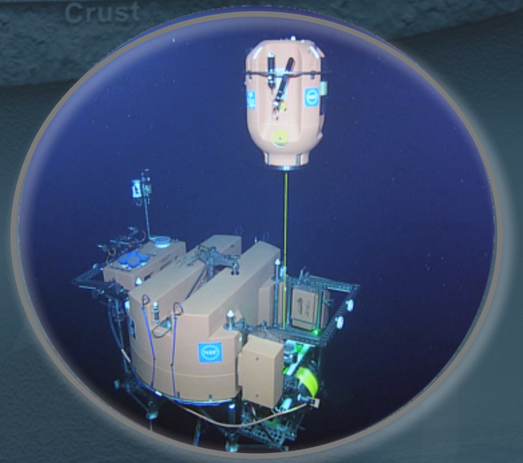




Deep Profiler (Max Depth Excursion Site-Dependent):

- Conductivity, Temperature, Pressure
- Dissolved Oxygen
- Spectrophotometer
- Fluorometers
- 3-D Single Point Current Meter

Since 2015, the three shallow profilers have completed >10,000 profiles

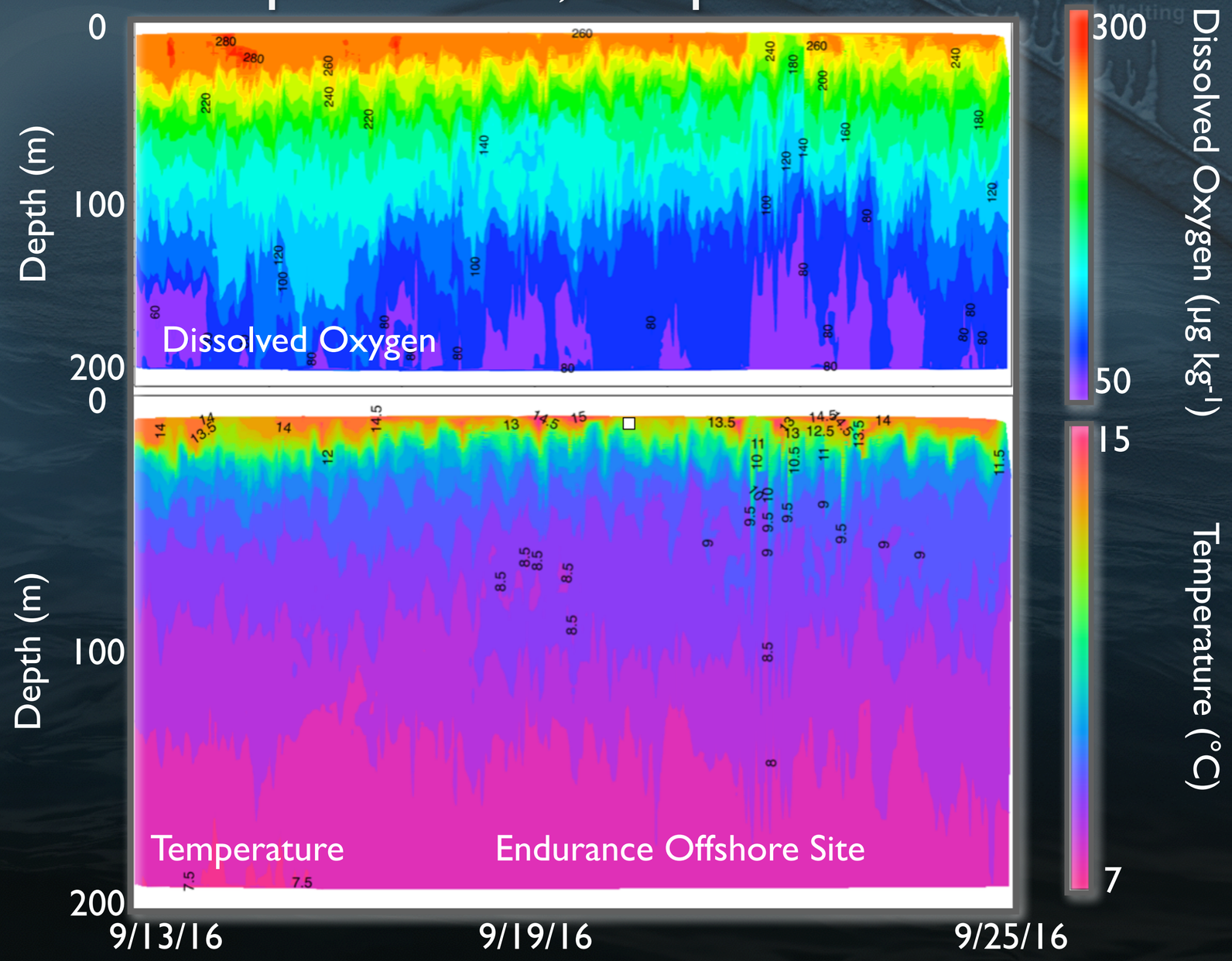


Platform Interface Controller
(stationary science pod)

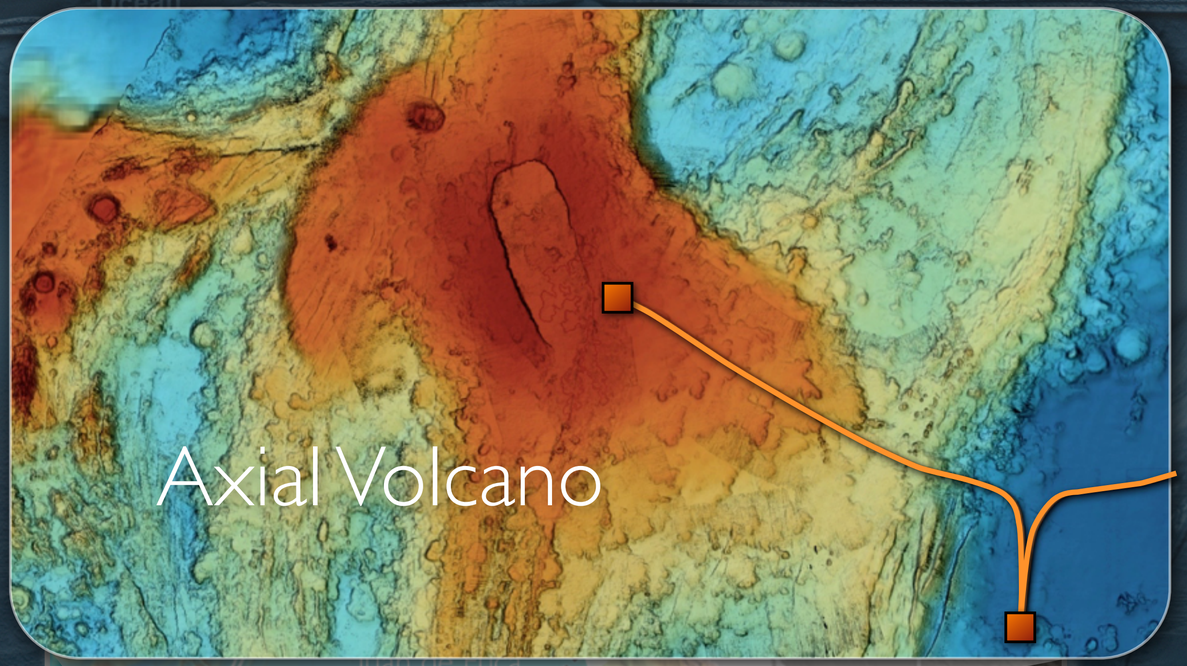
- pH
- broadband hydrophone
- fluormeter
- CTD-dissolved oxygen
- 5-beam ADCP
- 150 kHz ADCP
- Digital still camera

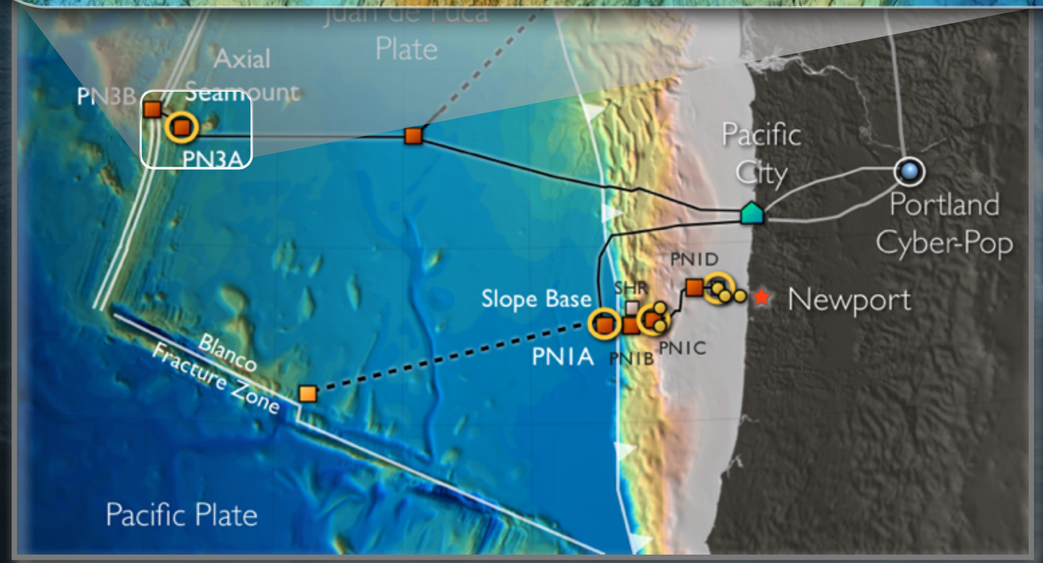
Winched Shallow Profiler

- pH
- 3W fluorometer
- CTD-dissolved oxygen
- PCO2
- nitrate
- Spectral irradiance
- PAR
- current meter+ temperature



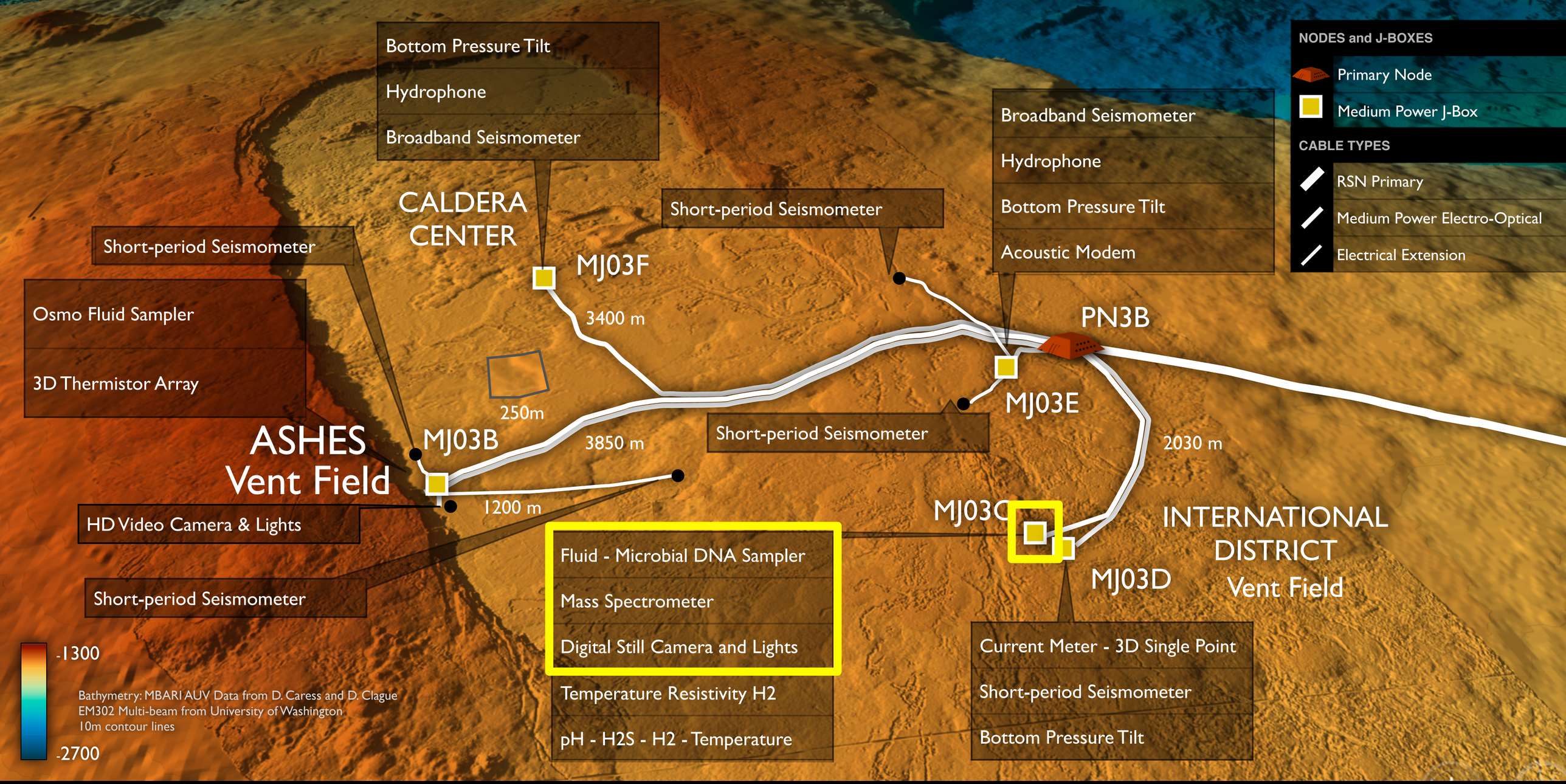
Axial Seamount
The most advanced submarine volcanic observatory in World's Oceans





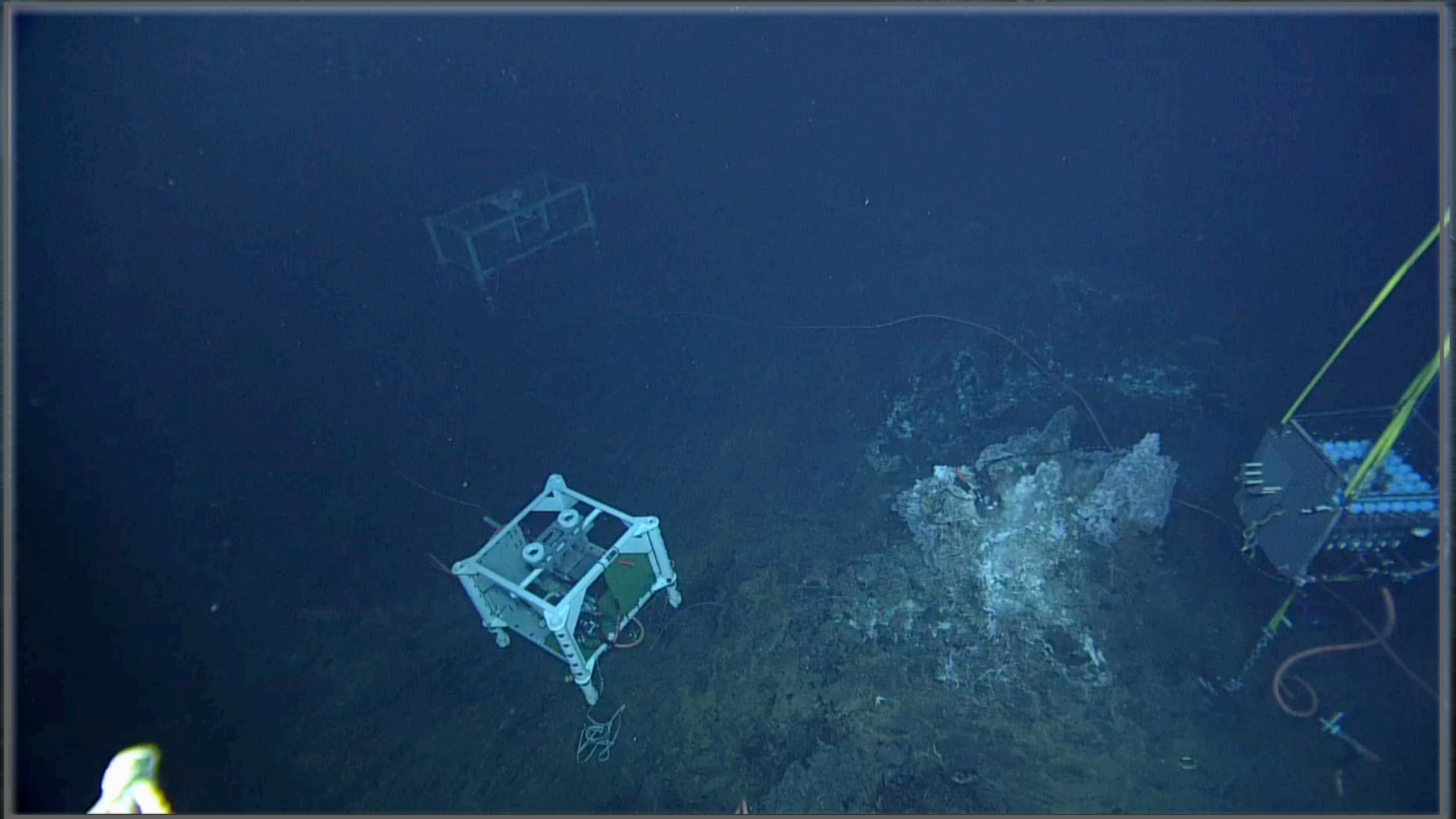
- The largest and most magmatically active volcano off the OR-WA coast
- What is the life evolution of underwater volcanoes, flux of heat, chemicals and biological material from the seafloor to the hydrosphere, linkages among seismic, chemical and biological processes and how to they change with time?

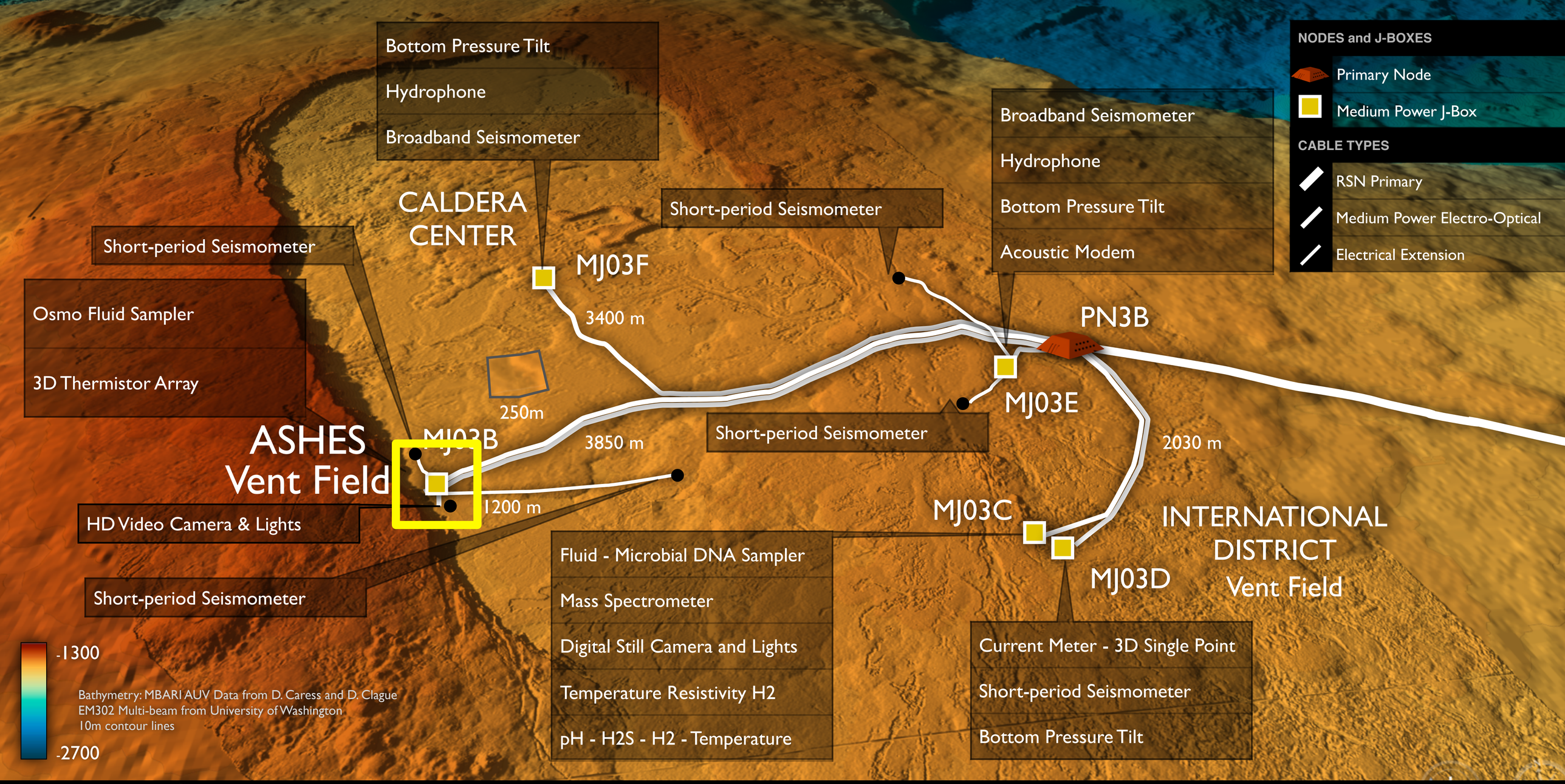
Erupted in 1998, 2011, and April 24, 2015



AXIAL CALDERA: Cabled instruments allow co-measure earthquakes, changes in vent fluid temperature-chemistry, seafloor inflation and deflation, and microbial and macrofauna communities

International District -El Gordo





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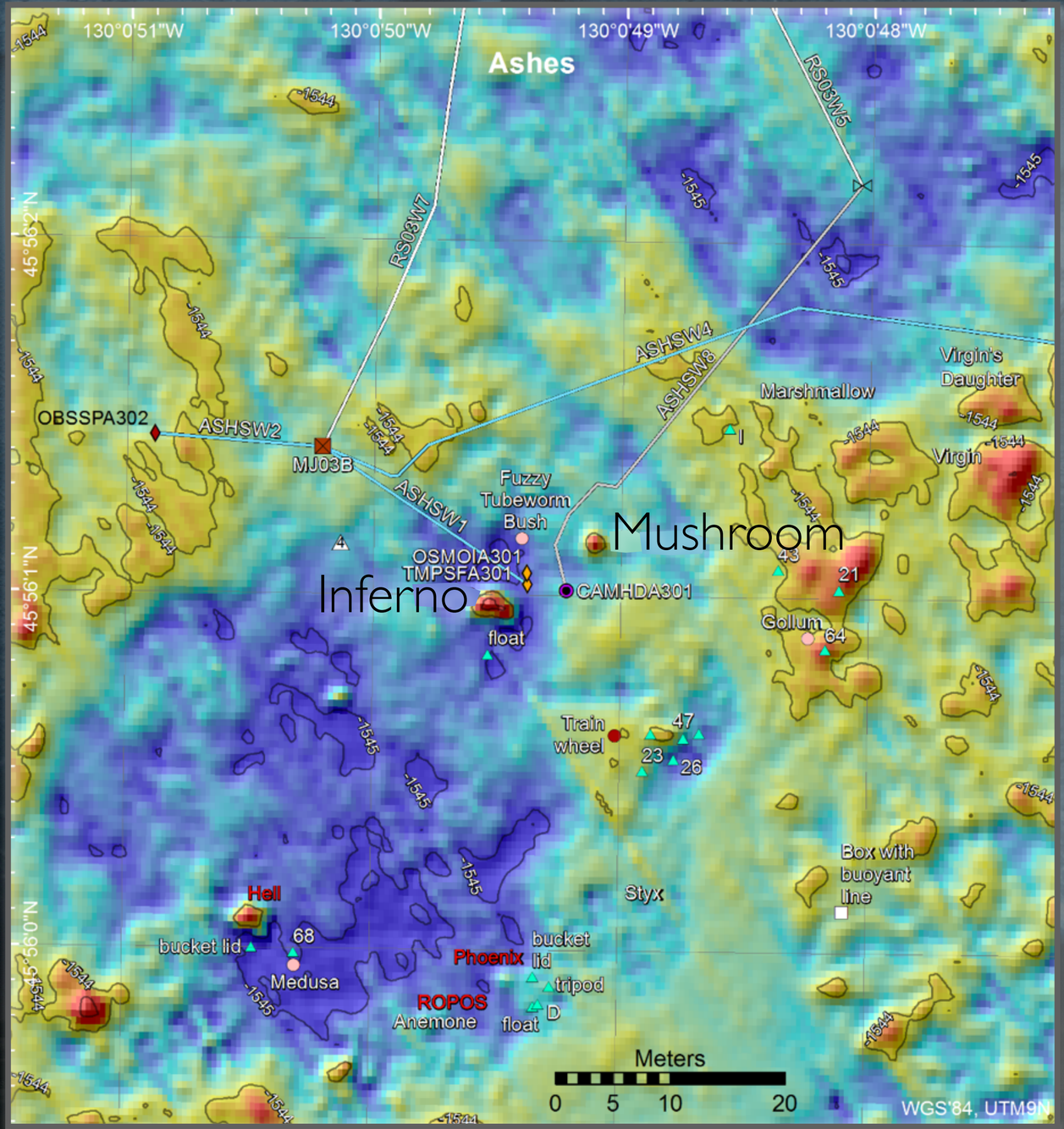
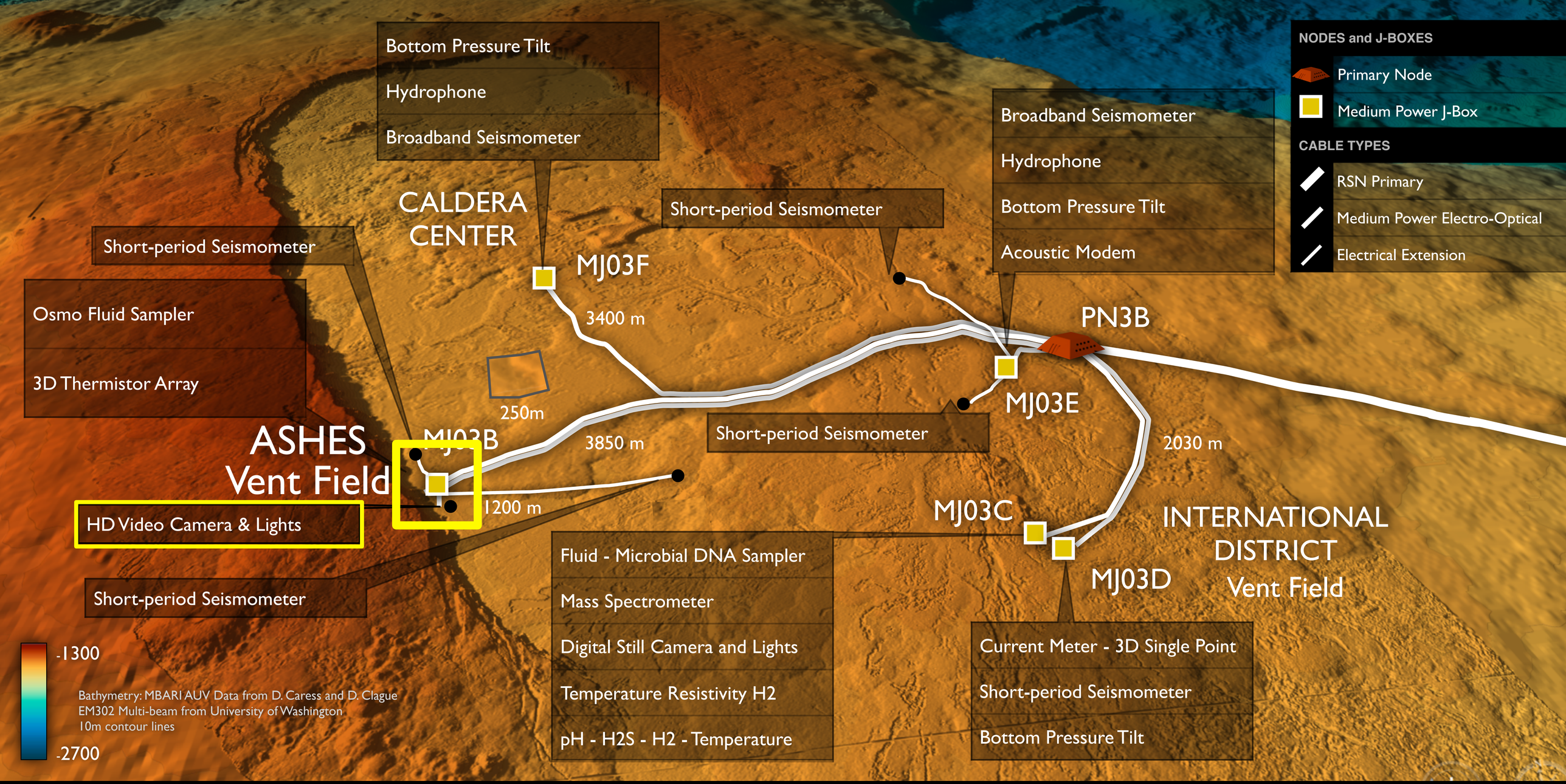
ASHES Hydrothermal Field



- How do hydrothermal systems evolve (edifices, biological communities, chemistry)?
- What are the linkages among geological, biological and chemical processes?
- How do hydrothermal systems respond to seismic events?
- What is the nature of the subseafloor plumbing system?
  - 2 short-period seismometers
  - 3D thermistor array
  - HD camera
  - Osmo fluid sampler



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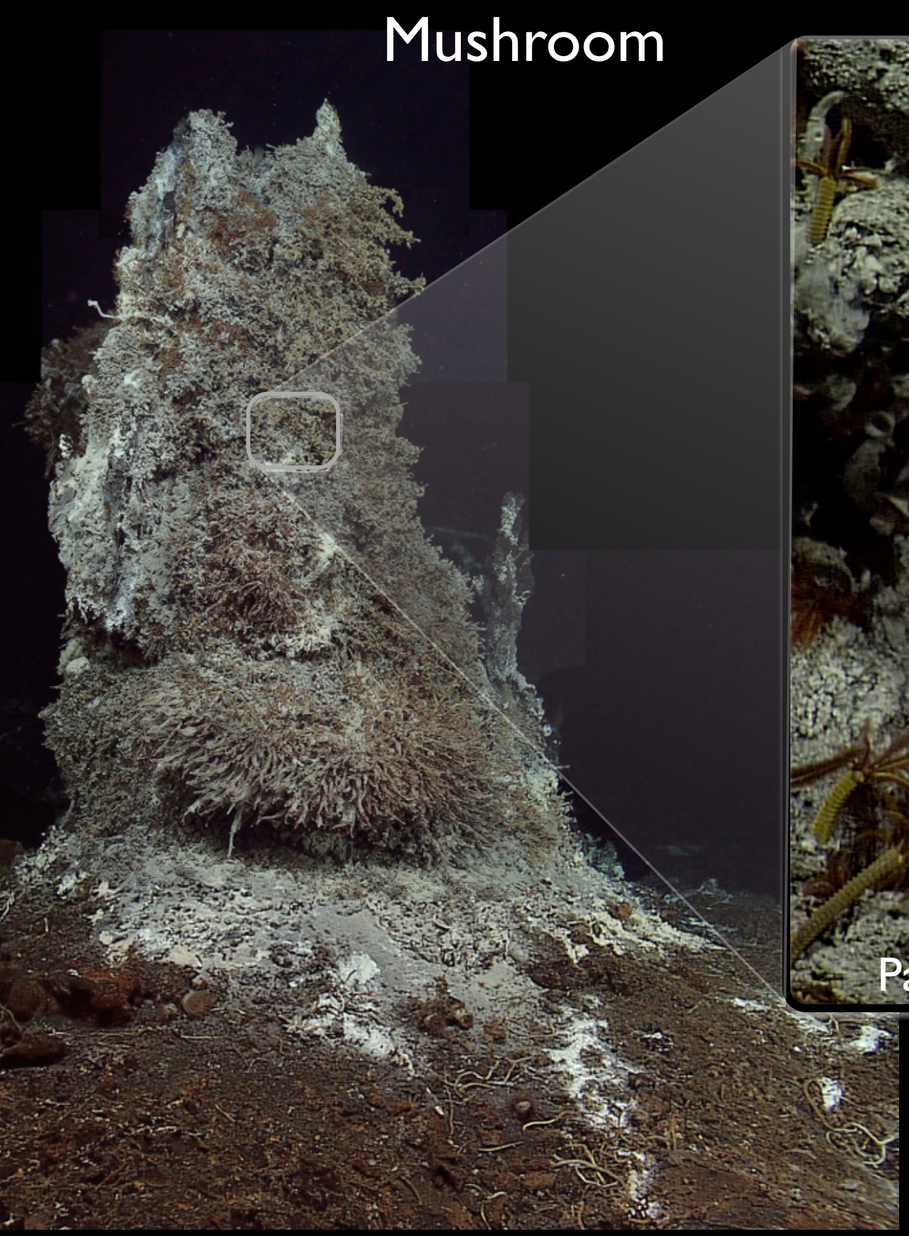


Live streaming of HD imagery from >300 miles offshore, 5000 feet beneath the surface

INTERACTIVE OCEANS

Cabled Array Seafloor Instruments

Axial Caldera and/or Hydrate Ridge Summit:

- Seafloor Pressure
- Broadband Ocean-Bottom Seismometer
- Short-Period Ocean-Bottom Seismometer
- High-Definition Video Camera
- Digital Still Camera
- Bottom Pressure and Tilt Instrument
- Thermistor Array
- Osmotic Sampler
- Dissolved Gas Mass Spectrometer
- Temperature-Resistivity Probe
- H_2, H_2S, pH, High-Temp Probe
- Remote Access Fluid and DNA Sampler
- Benthic Flow Meter
- Current Meter

Mooring (Axial and Slope Bases and Oregon Offshore):

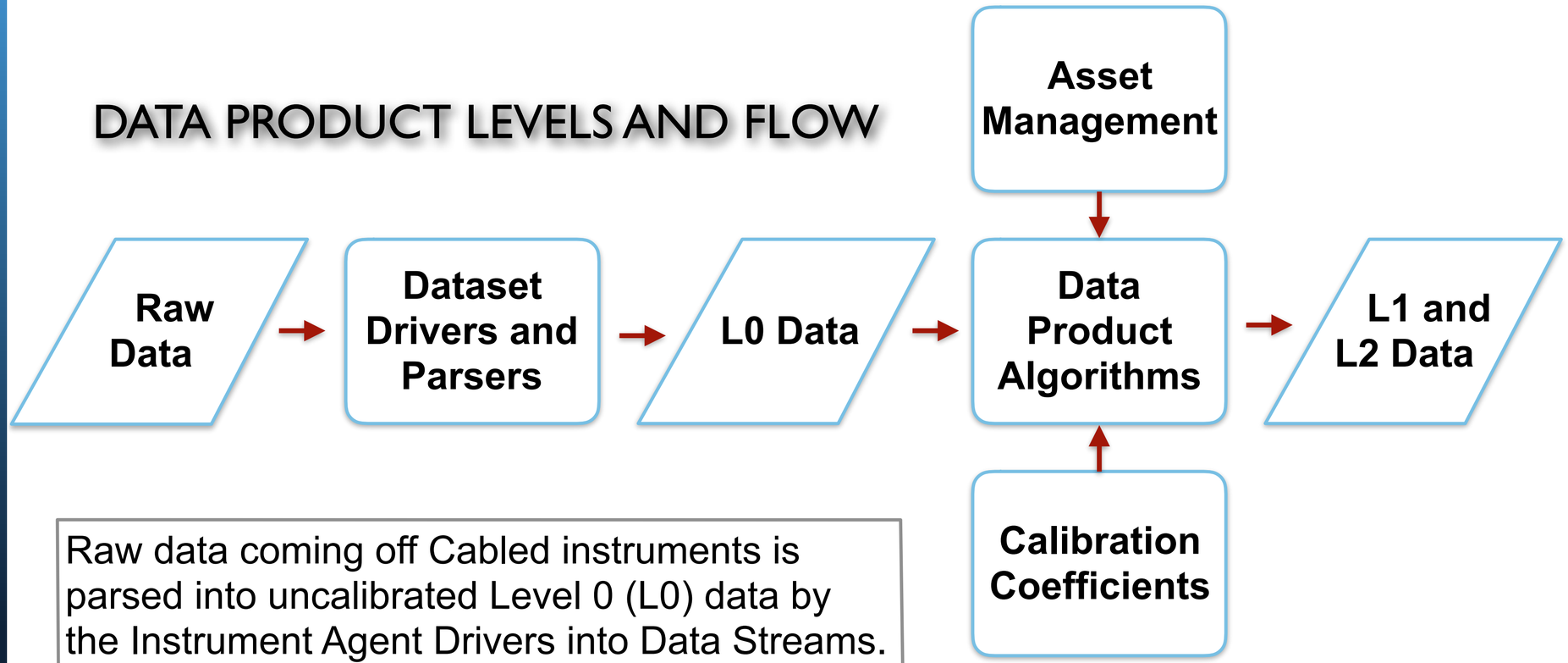
- Seafloor Pressure
- Broadband Hydrophone
- Broadband Ocean-Bottom Seismometer
- Acoustic Doppler Current Profiler (150 kHz)
- Conductivity-Temperature-Depth
- Dissolved Oxygen Sensors
- Optical Attenuation Sensor

Benthic Experiment Packages* (Oregon Offshore and Shelf):

- Broadband Hydrophone
- Acoustic Doppler Current Profiler (75 or 300 kHz)
- Conductivity-Temperature-Depth
- Dissolved Oxygen Sensors
- Optical Attenuation Sensor
- Turbulent Flow Current Meter
- pH and CO_2 Sensors
- Digital Still Camera
- Zooplankton Sonar

*shared with Endurance Array

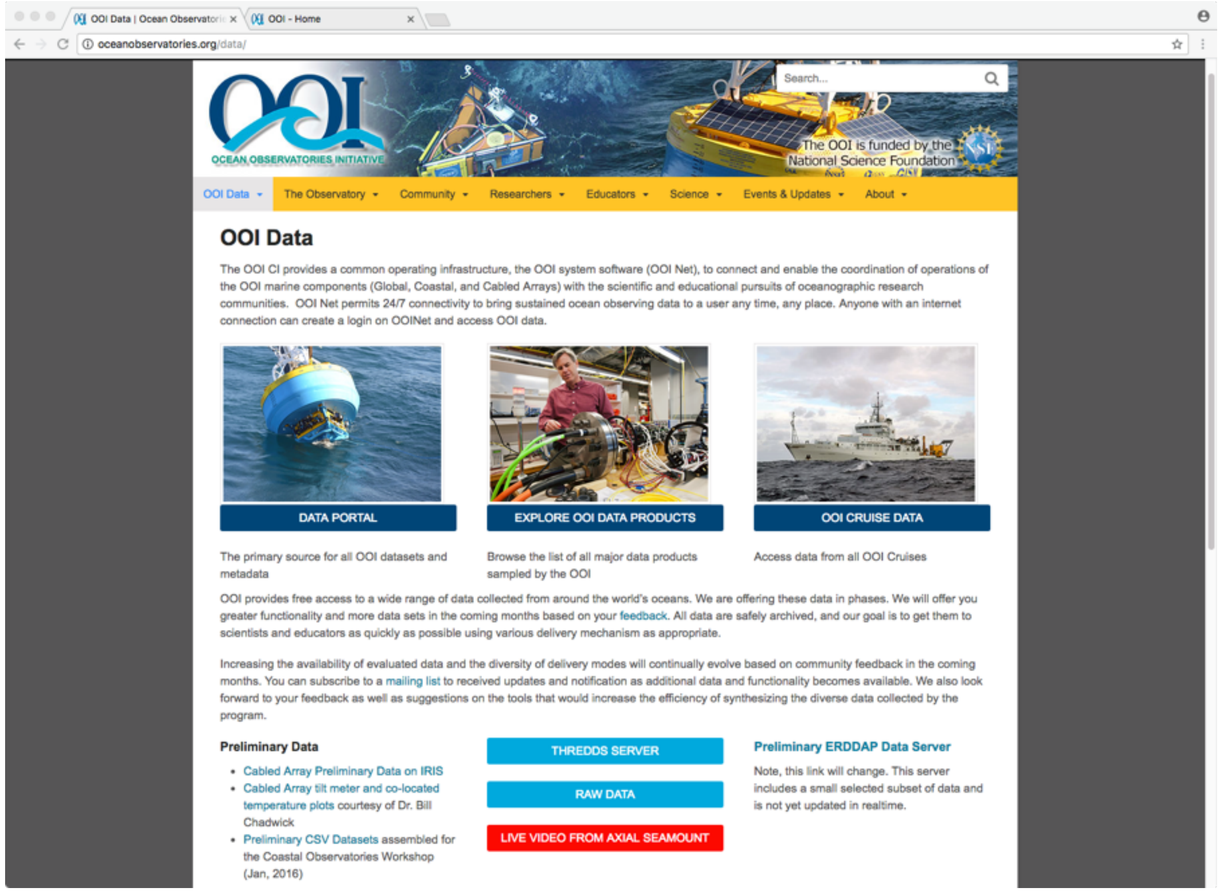
DATA PRODUCT LEVELS AND FLOW



Raw data coming off Cabled instruments is parsed into uncalibrated Level 0 (L0) data by the Instrument Agent Drivers into Data Streams. L0 data is then run through a Data Product Algorithm (DPA), which applies Calibration Coefficients and creates Level 1 (L1) Data Products. For some instruments, a Level 2 (L2) Data Product is created by using L0 and L1 data as inputs to the DPA. This final collection of L0, L1 and L2 data, known as the Data Stream, contains all data products expected from the instrument. More information about specific Data Products can be found at oceanobservatories.org/data-products/

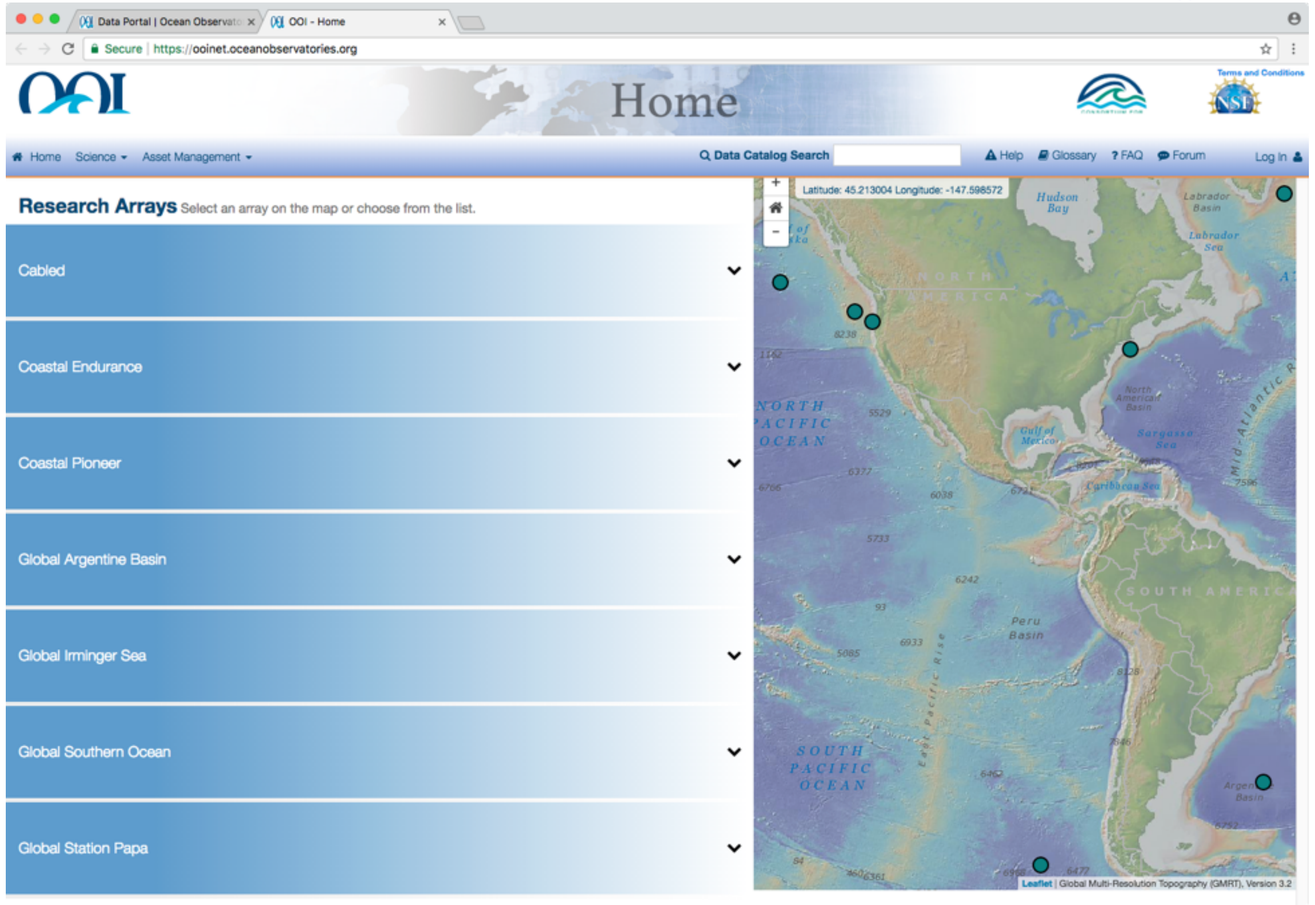
Data Access Points

Access Points - oceanobservatories.org



- THREDDS/NetCDF files/ERDDAP
- Raw Data
- Cruise Data
- High Volume Data (HYDBB, CAMHD)
- Seismometer Data (IRIS)

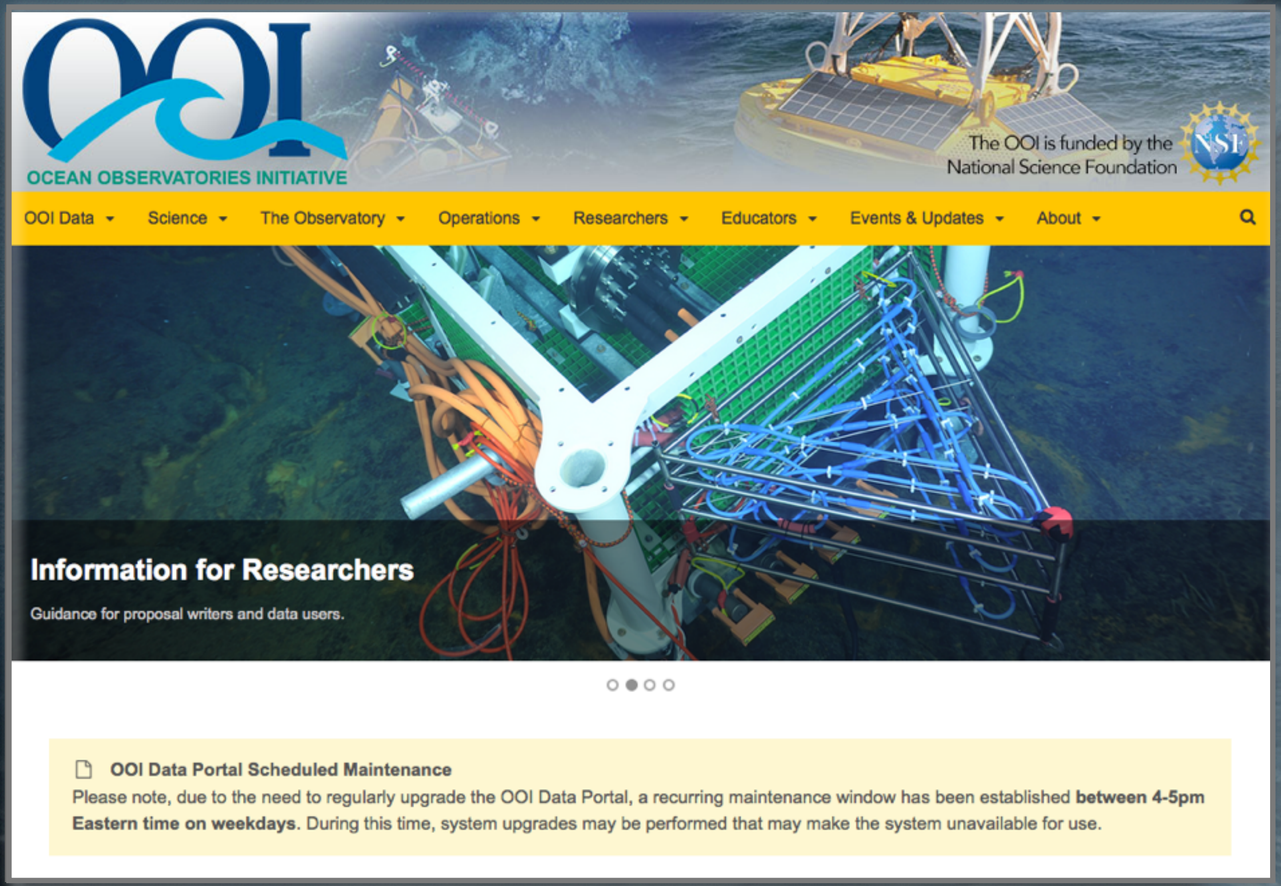
OOI Data Portal – ooinet.oceanobservatories.org



- Streaming data from cabled assets; including live video
- Plotting
- Asynchronous downloads
- Metadata/Asset Management
- Quality Control, Annotation of data

Program information and OOI Data Portal

UW Cruise and education site Sigificant video and still imagery



ooinet.oceanobservatories.org

interactiveoceans.washington.edu

NSF now accepting proposals for adding sensors onto the network