

Regional Cabled Array

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OOI Hackweek 2018

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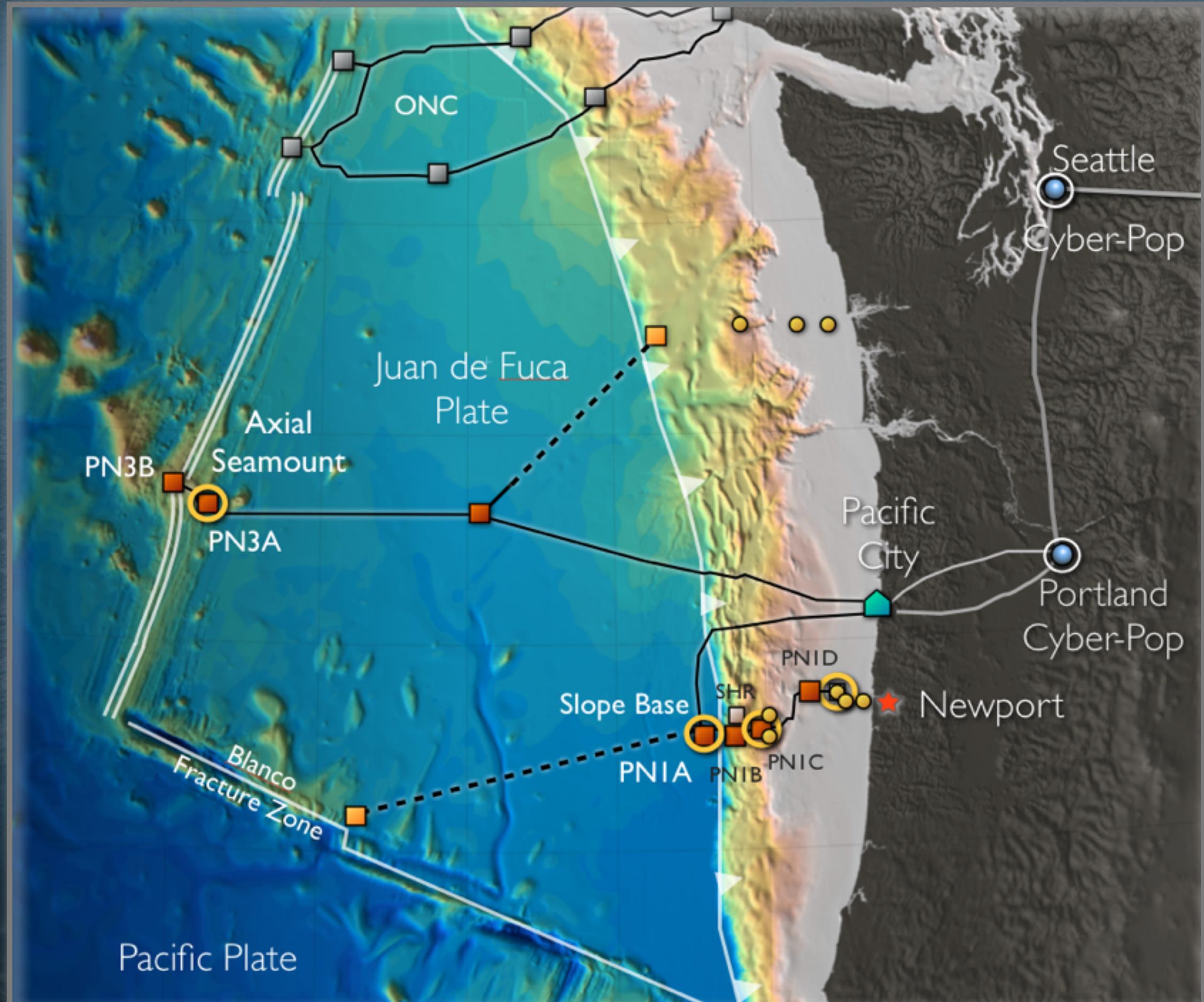
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OOI
OCEAN OBSERVATORIES INITIATIVE

NSF-OOI's Cabled Array



Built on time and under budget

Primary Infrastructure

- 900 km of high bandwidth (10 Gbs) and high power (8 kW) **primary** cables & nodes

Secondary Infrastructure

- 18 junction boxes providing 375V and 1 Gbs
- 6, up to 2700 m tall instrumented moorings with wire crawlers connected to the cable
- >140 instruments now providing 24/7 real-time data with two way communication - response capabilities
- highly expandable for science, industry, education



BRINGING POWER AND THE INTERNET INTO THE OCEAN



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Cabled Array: West Coast Perspective

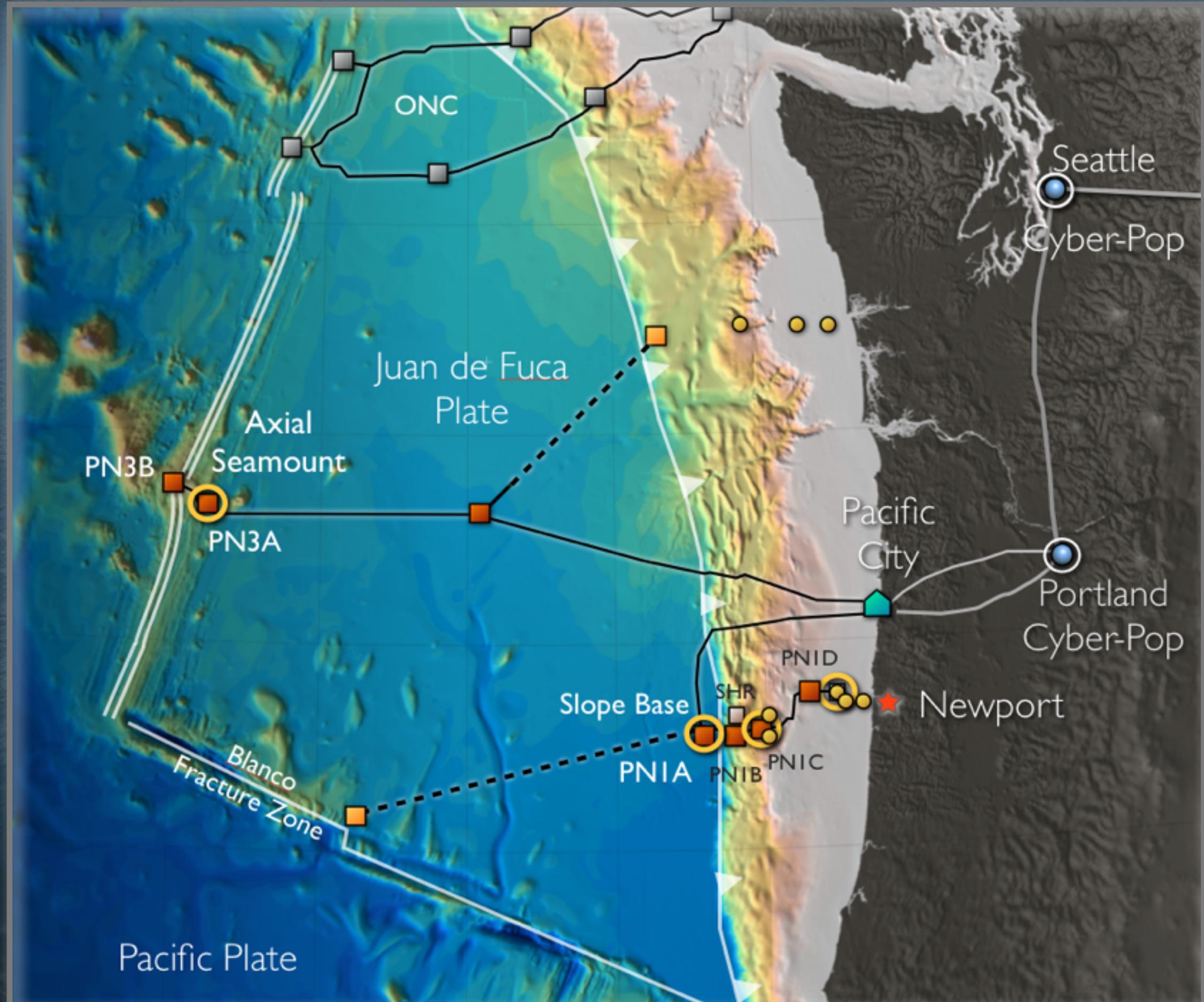


Imagine

- ▶ 525 km of high power cable stretching across Cascades, Columbia River Flood Basalts, desert
- ▶ Single nick in armor kills the system
- ▶ All installations done at night from 10,000 ft up
- ▶ Power, communications, data flow



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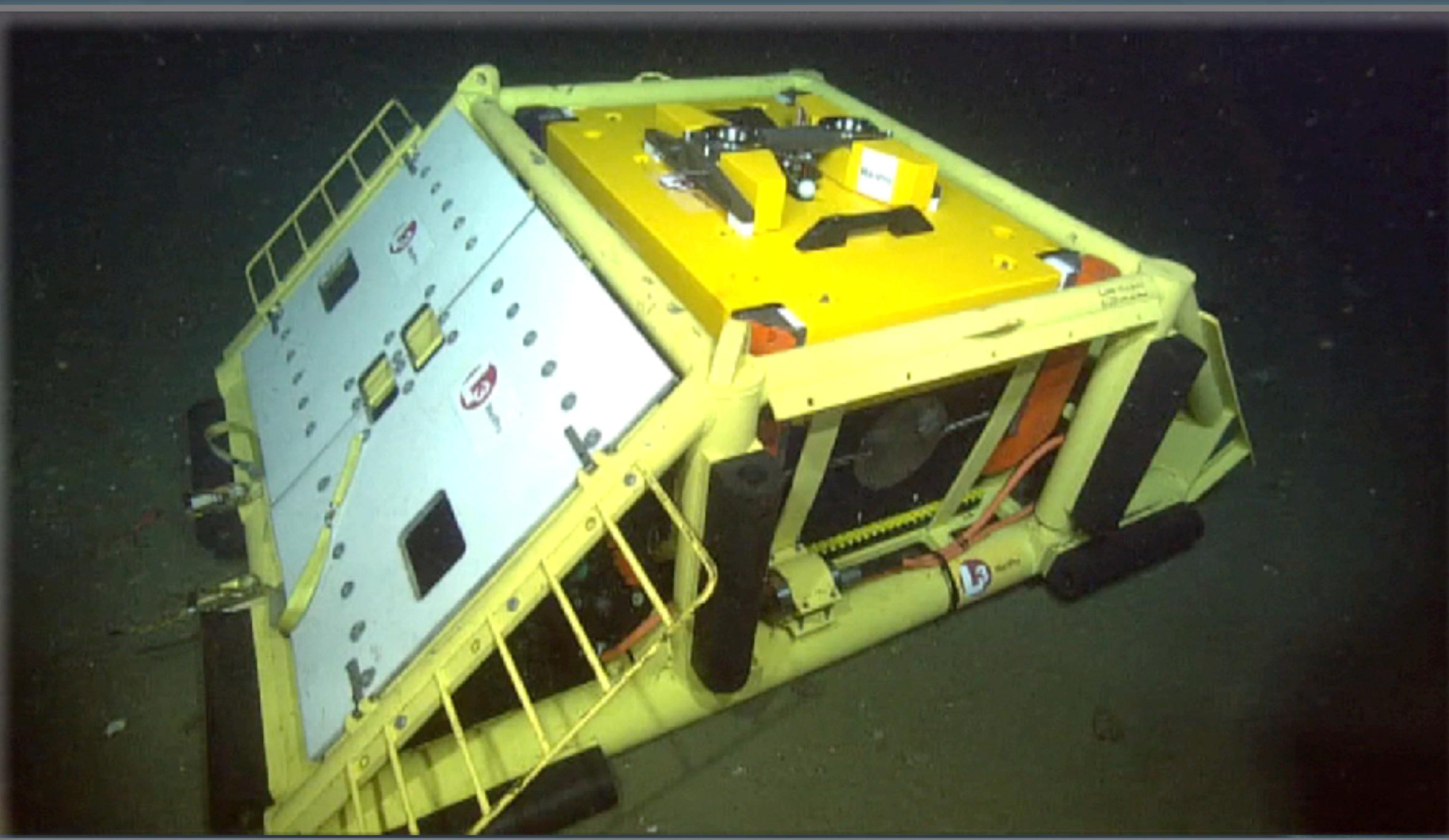
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Primary Infrastructure: L-3 Mari Pro Inc. and UW Working Together - Important Industry-Institution collaboration



7 PRIMARY NODES - Large Substations

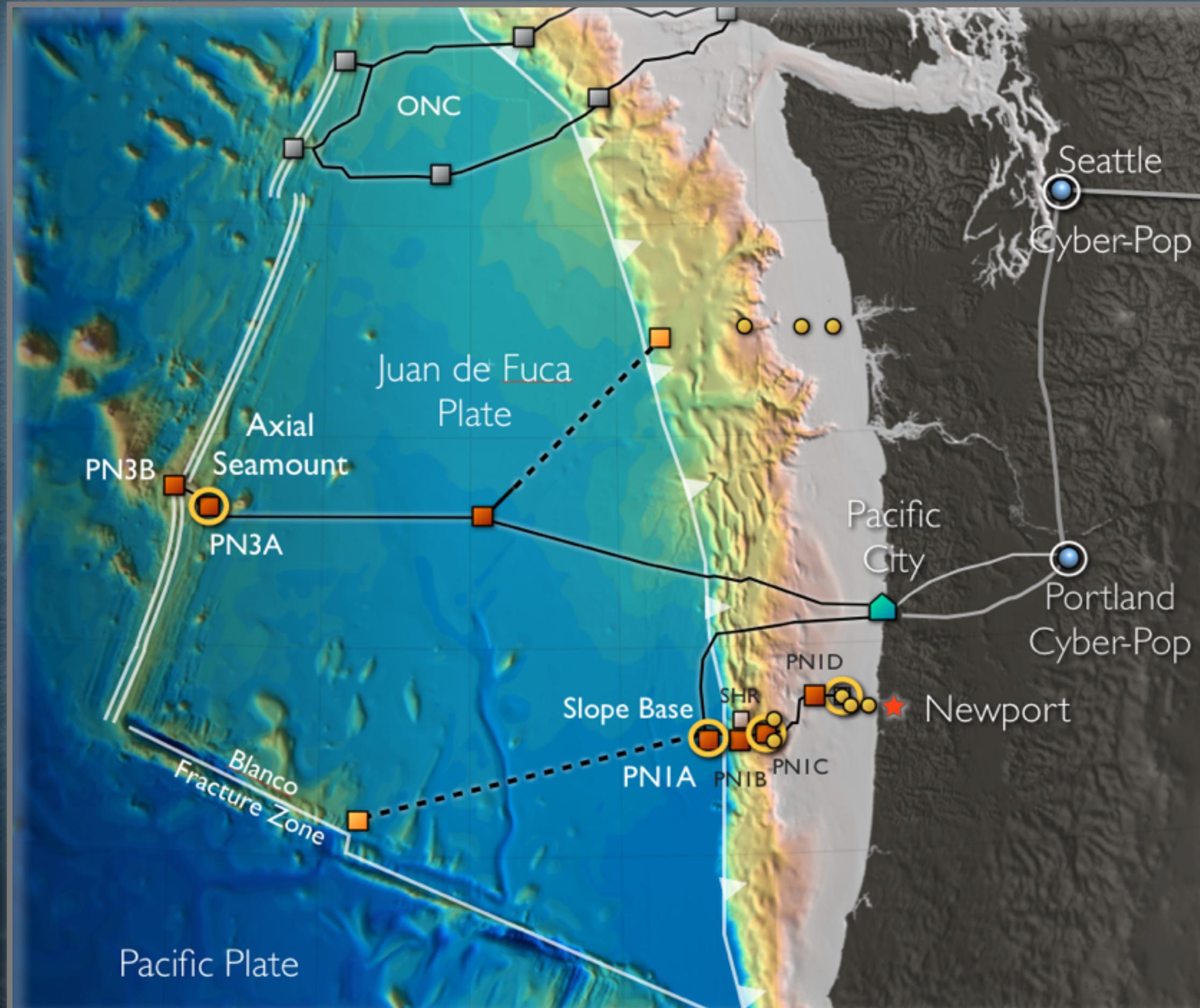
- Each Primary Node -10 GbE, 8 kW
5 Science Ports (1 GbE, 375 V)
ROV Wet mate Connectors
- 2 High Bandwidth Science Ports (10GbE, 375V)
ROV Wet mate Connectors
- 2 Backbone Expansion Ports (10kV)
- Pulse per Second Timing
- Science Interface Assembly removable by ROV

Shallow Water Node

10 km south of Southern Hydrate Ridge

Trawl resistant frame

NSF-OOI's Cabled Array



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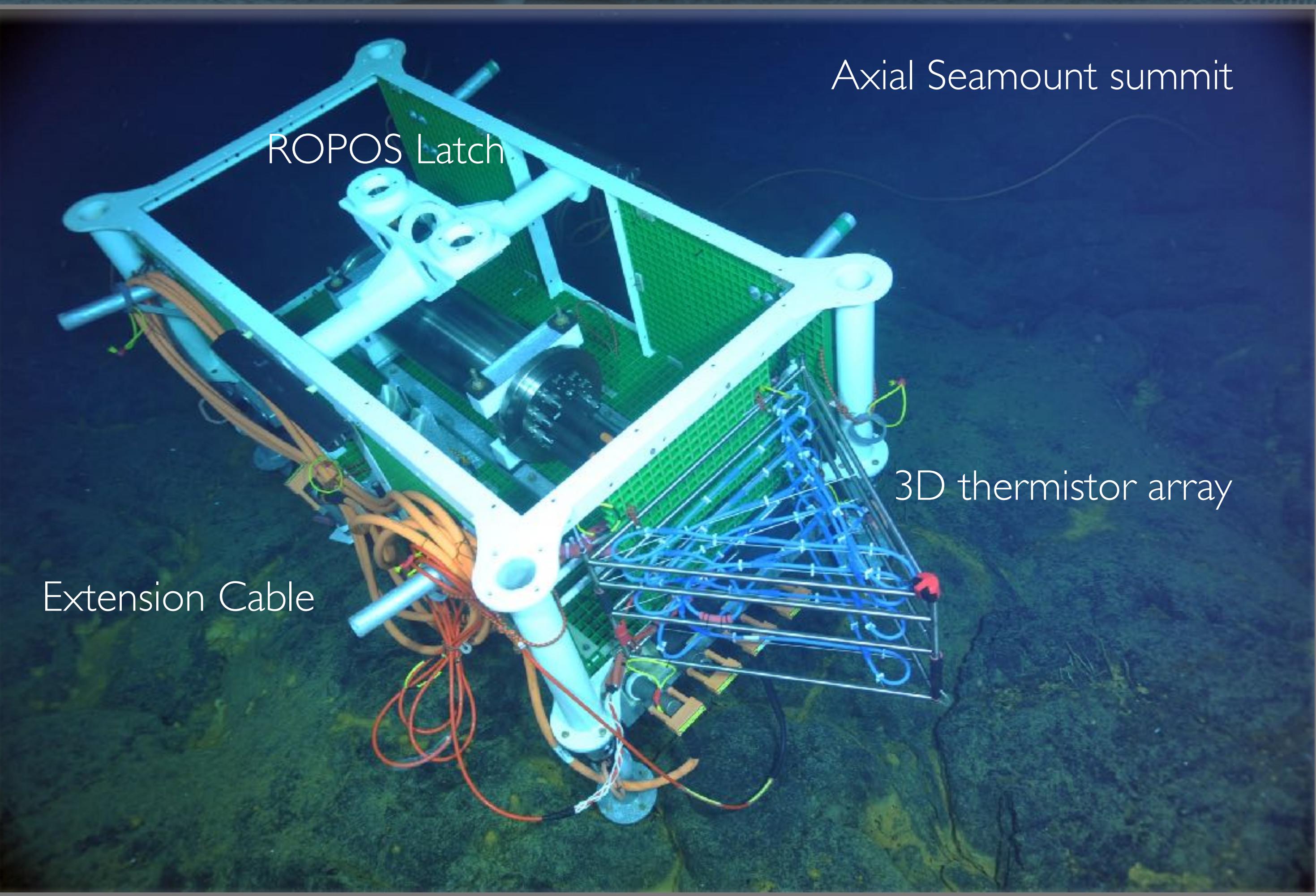
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Secondary Junction Boxes



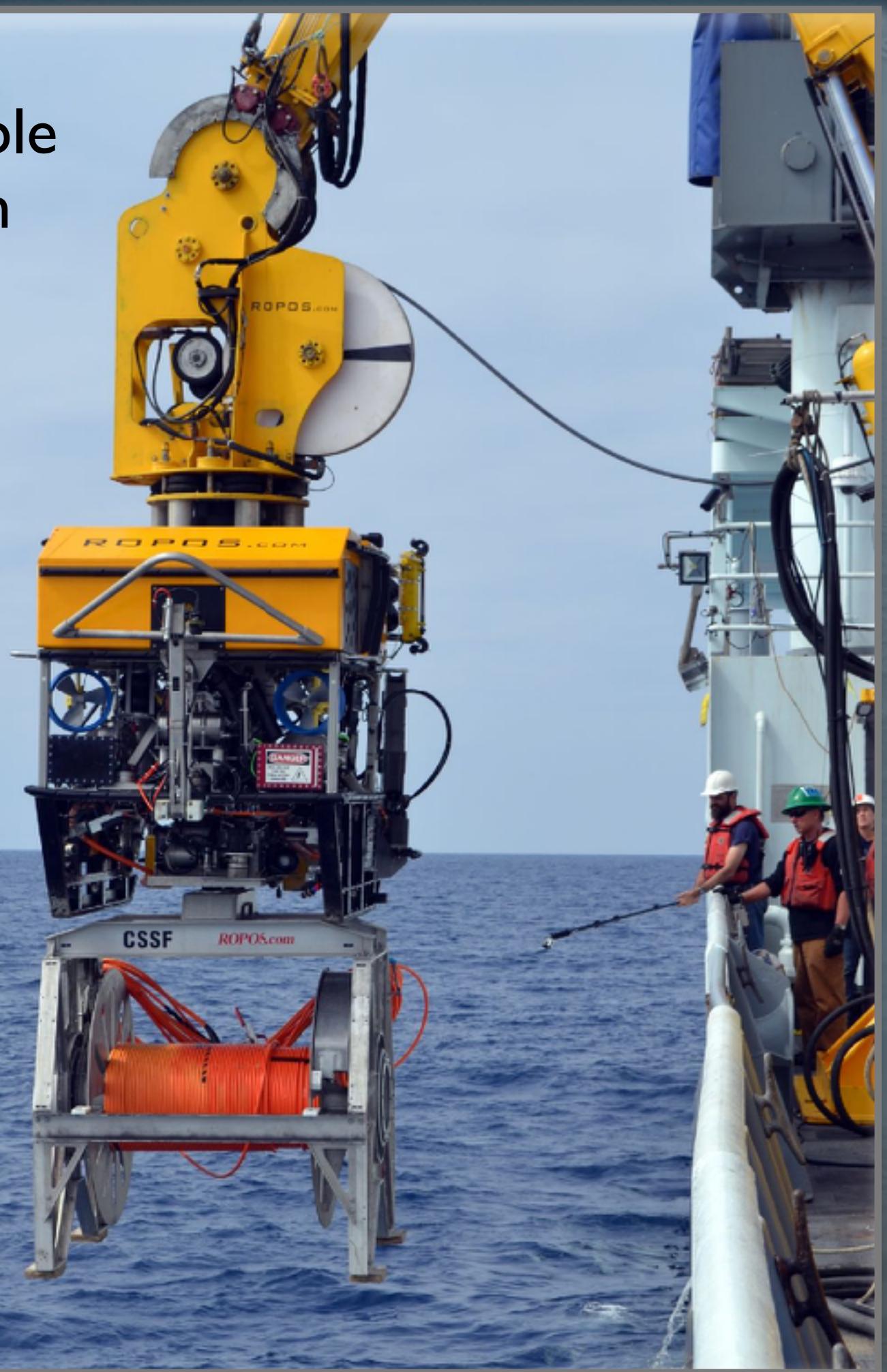
- Provides 8 configurable science ports with 1 Gbs bandwidth, up to 200W of power per port ($\pm 12/24/48$ VDC), and one expansion port 10Amp, 375VDC, 10/100BASE-T, RS232 or RS485 data links
- Extend power and bandwidth to instruments and platforms
- Setup specifically for each platform/site; can easily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

Designed and built by Applied Physics Lab,
easily modified and upgraded

18 now installed on Cabled Array - All are Operational since
installed in 2014

4TH YEAR OF OPERATIONS AND MAINTENANCE - ANNUAL

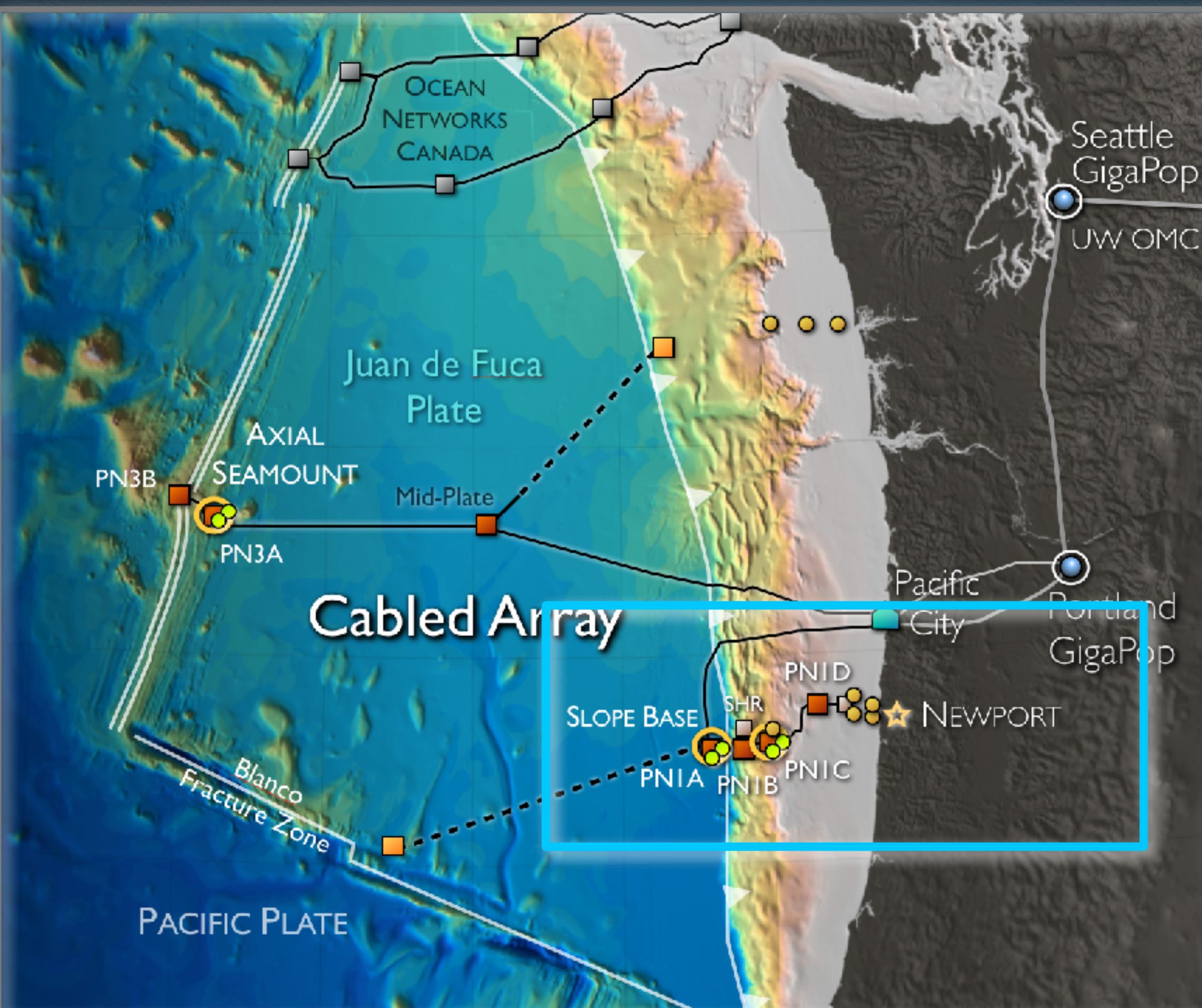
ROPOS
ROCLS - cable
laying system
4,000 lb lift
capability



- ▶ Requires “hybrid” remotely operated vehicles with heavy lift (4,000 lb) capabilities
- ▶ Requires 3 legs typically >100 instruments junction boxes
- ▶ 6 shallow profiler science “pods”
- ▶ Deep profiler moorings

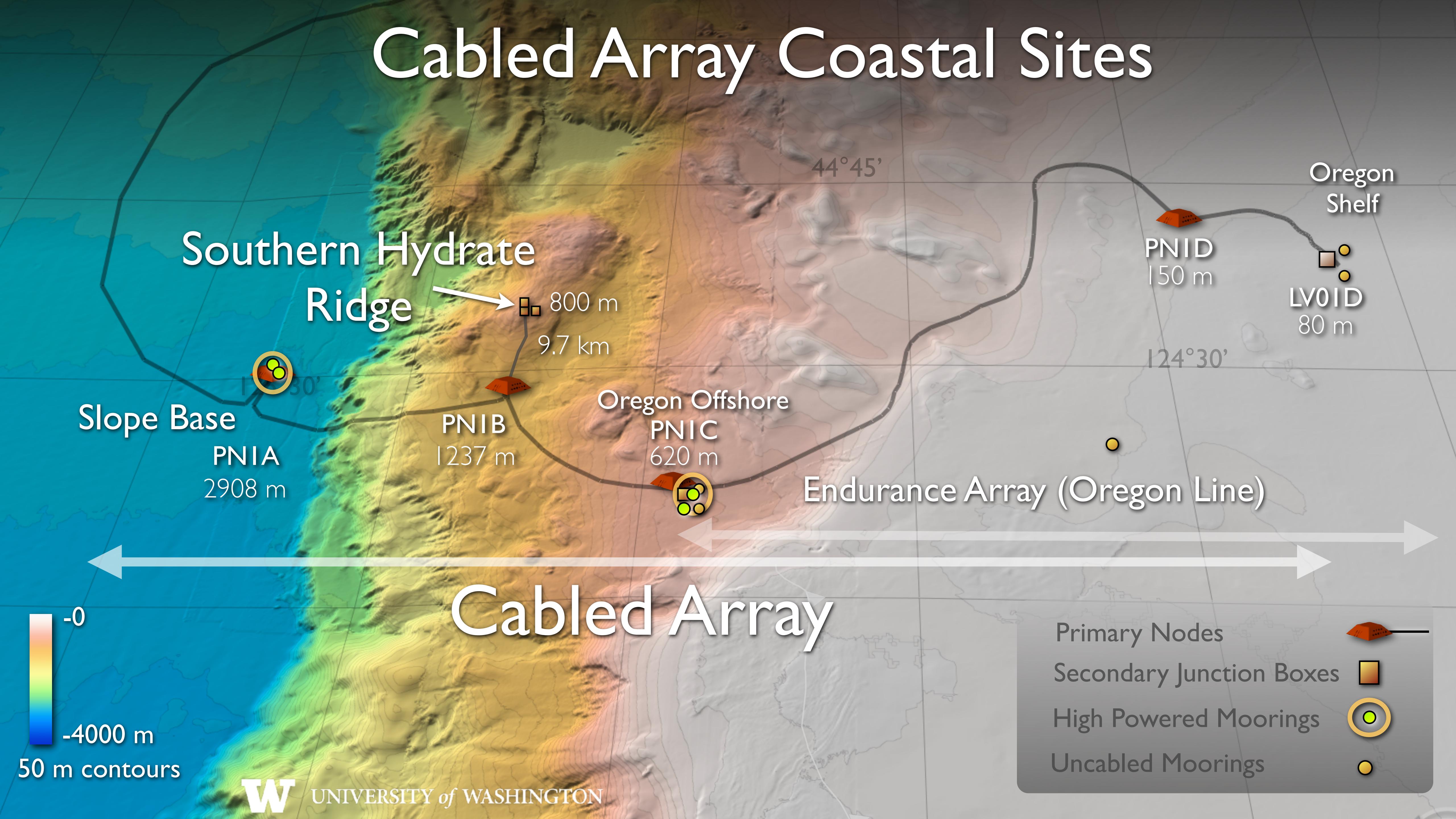
ROV ROPOS and Jason highly efficient for cabled observatory operations. Industry latch developed by ROPOS allows safe, precise deployment and recovery.

Cabled Coastal Array

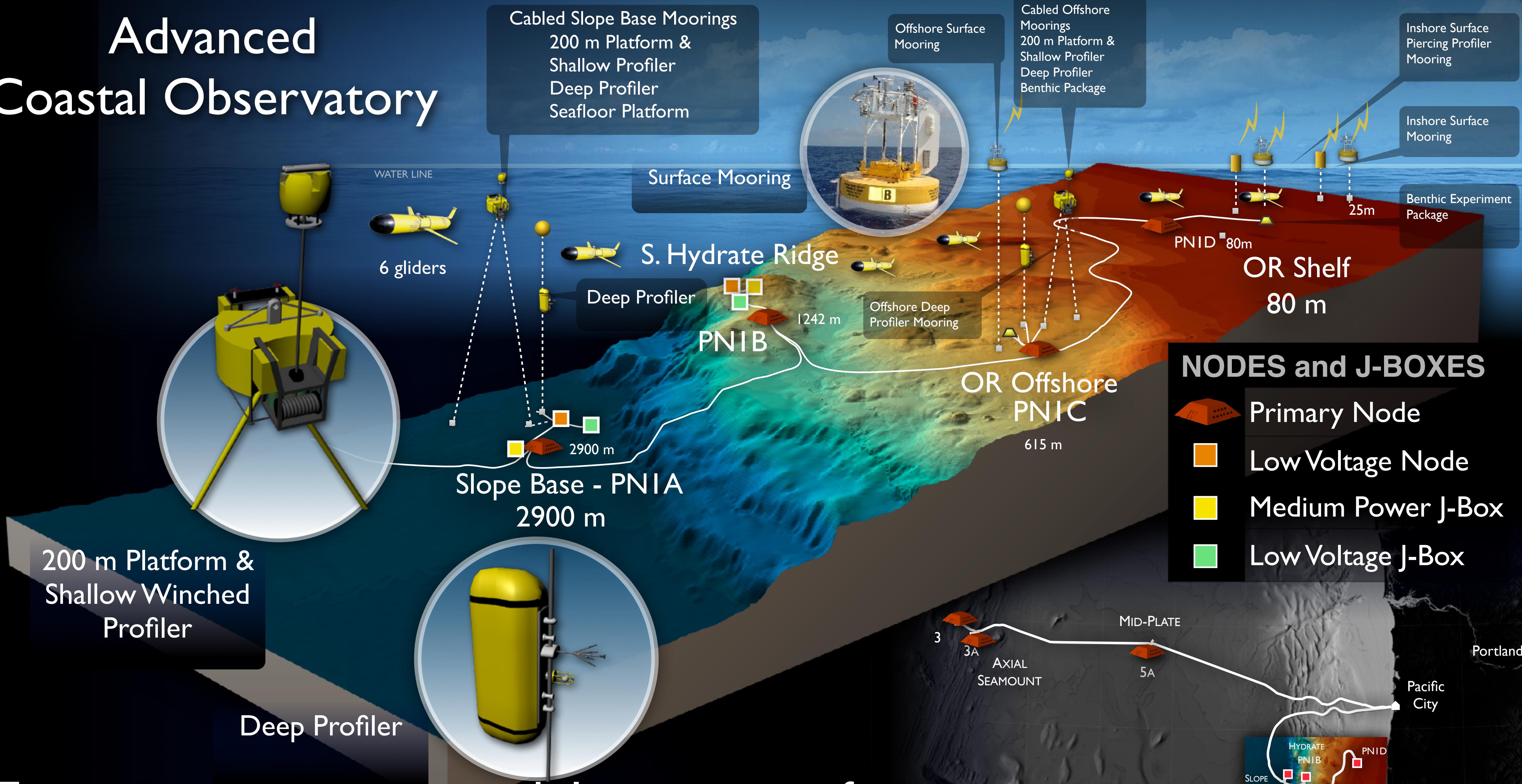


- ▶ Monitoring offshore seismic activity - Cascadia Subduction Zone
- ▶ Hypoxia events and ocean acidification
- ▶ Global biogeochemistry and carbon cycling
- ▶ Climate variability and ecosystems
- ▶ Coastal ocean dynamics and ecosystems
- ▶ Ocean circulation, mixing and ecosystems
- ▶ Methane seeps and novel microbial communities

Cabled Array Coastal Sites



Advanced Coastal Observatory



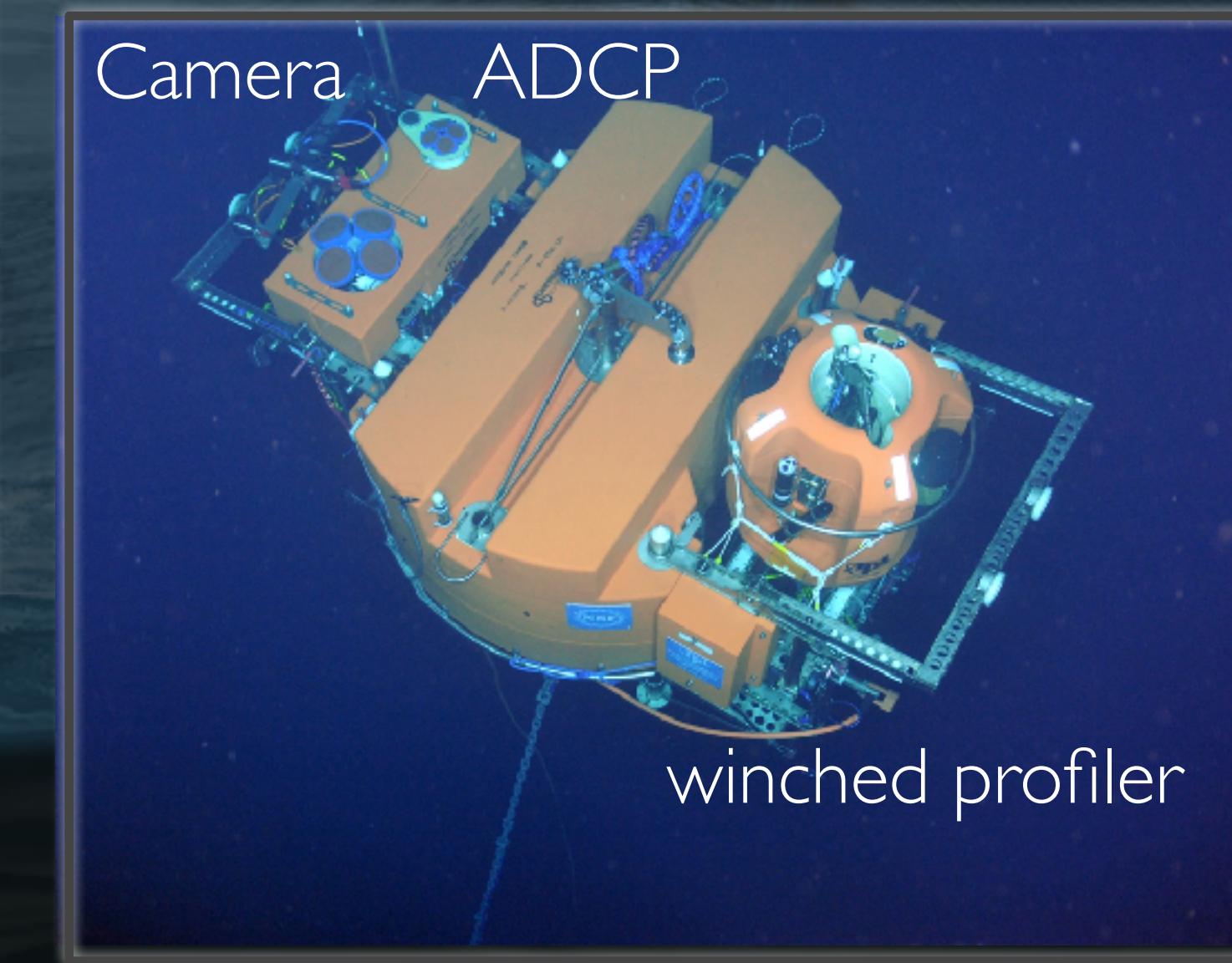
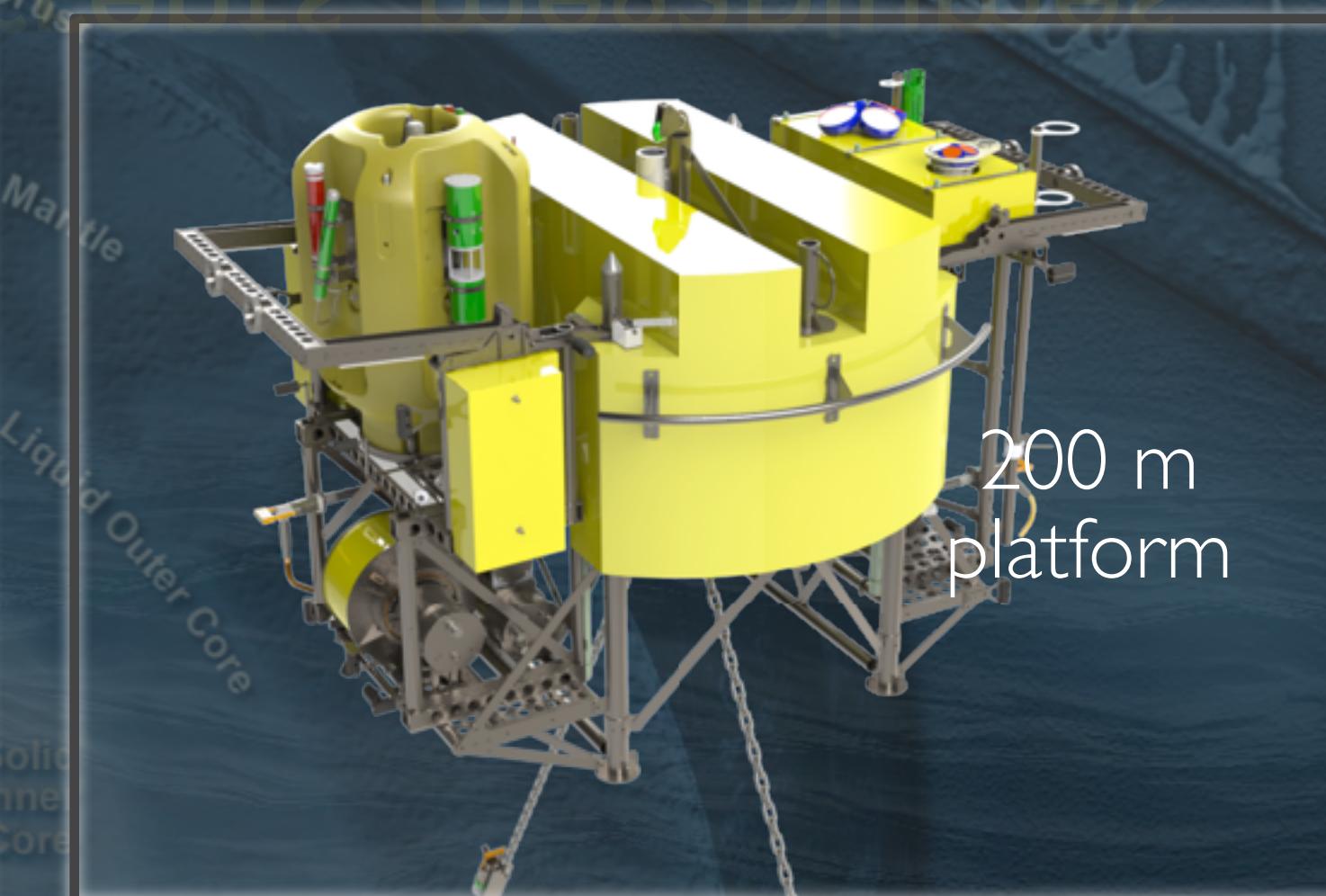
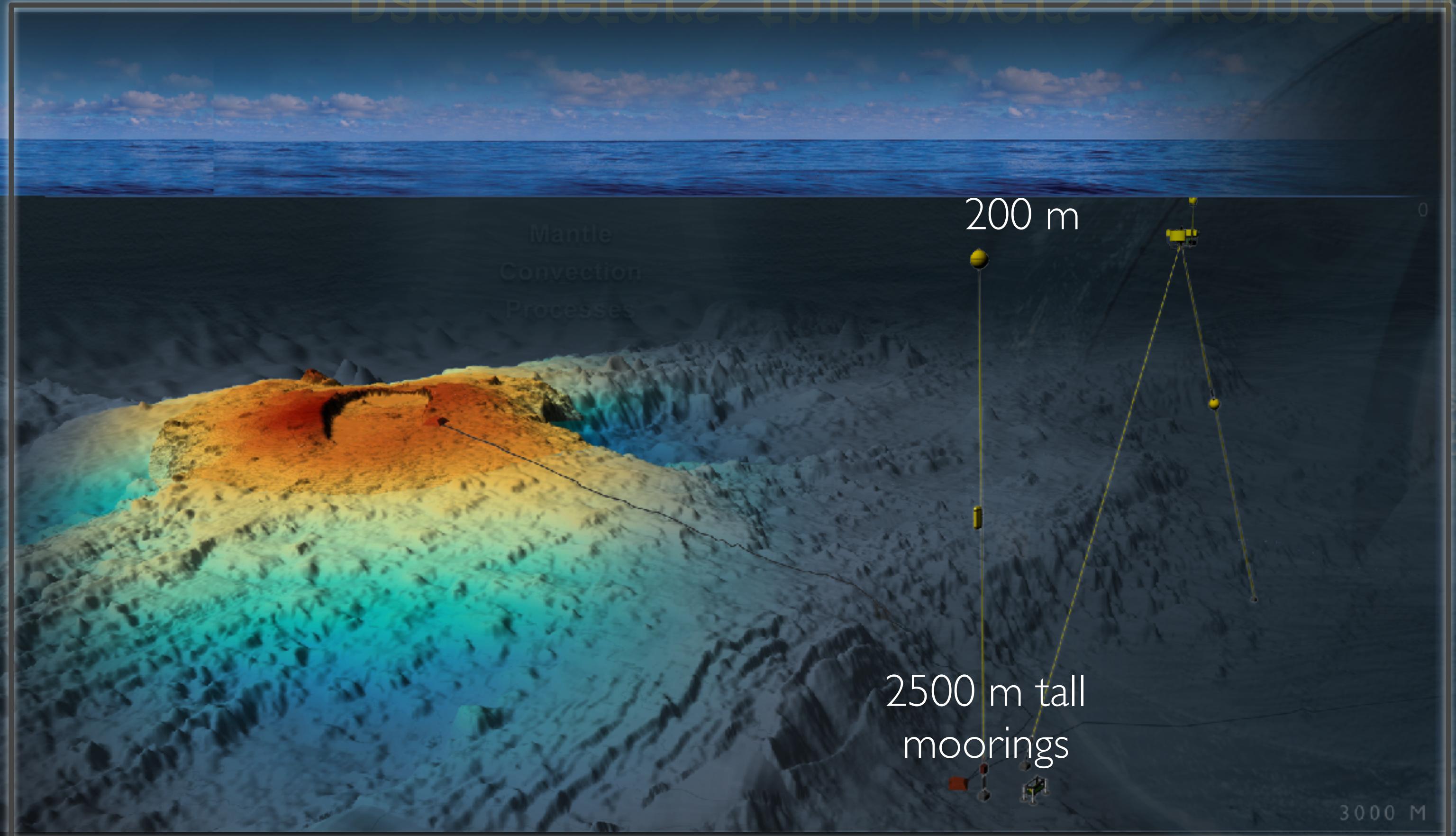
Extensive expansion capabilities, state-of-art moorings



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Advanced moorings measure in real-time ocean acidification parameters, thin layers, strong currents, megaplumes

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Instrumented wire crawlers host 18 instruments -
all streaming data live to shore

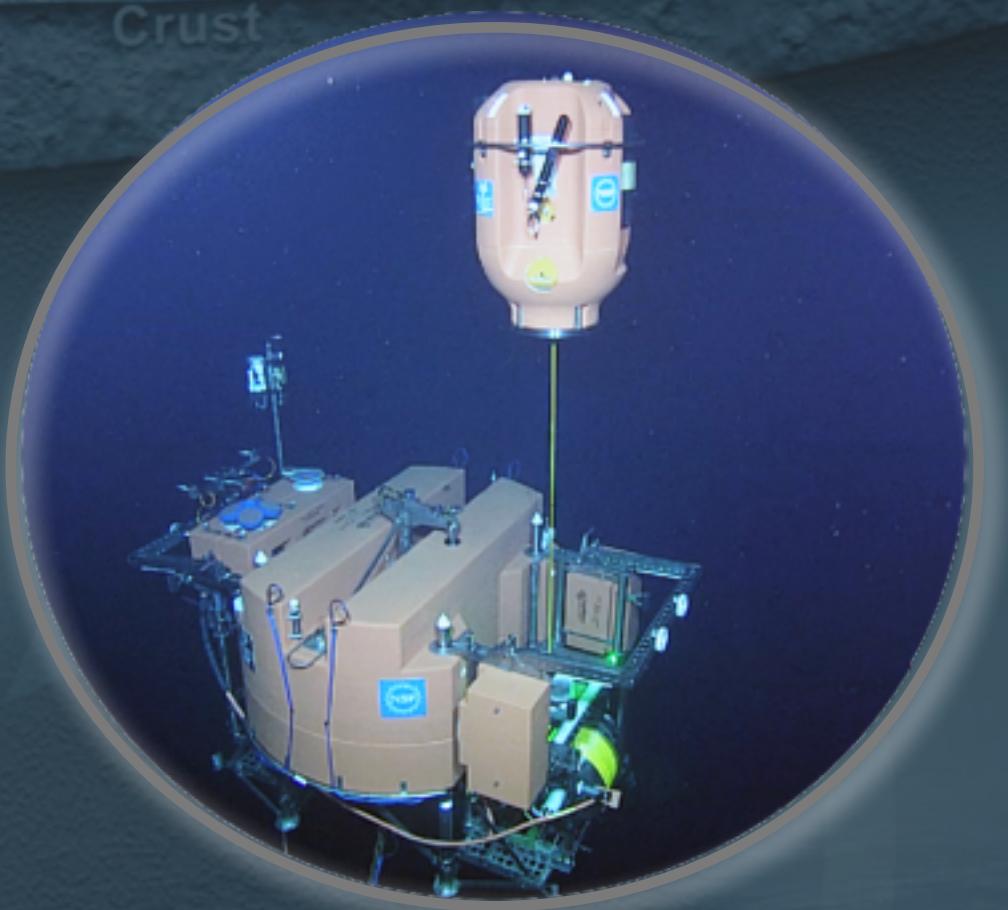
Most advanced profiler moorings - built by UW APL



Three profilers have made >27,000 profiles since 2015

- ▶ Supplied with 3 kW power, 1 Gbps communications
- ▶ Platform and Science Pod hosts 18 sensors
- ▶ Profiler makes 9 trips/day with “steps” to pause at specific depth intervals: 1.5-2.25 hrs per trip
- ▶ 2-way real-time communications allows reactive event sampling - e.g. response to thin layers, storms, megaplume formation, etc
- ▶ Each instrument sampled at 1 Hz or faster; timestamped to shore within 0.5 second

Providing unparalleled “imaging” of shallow oceanographic processes

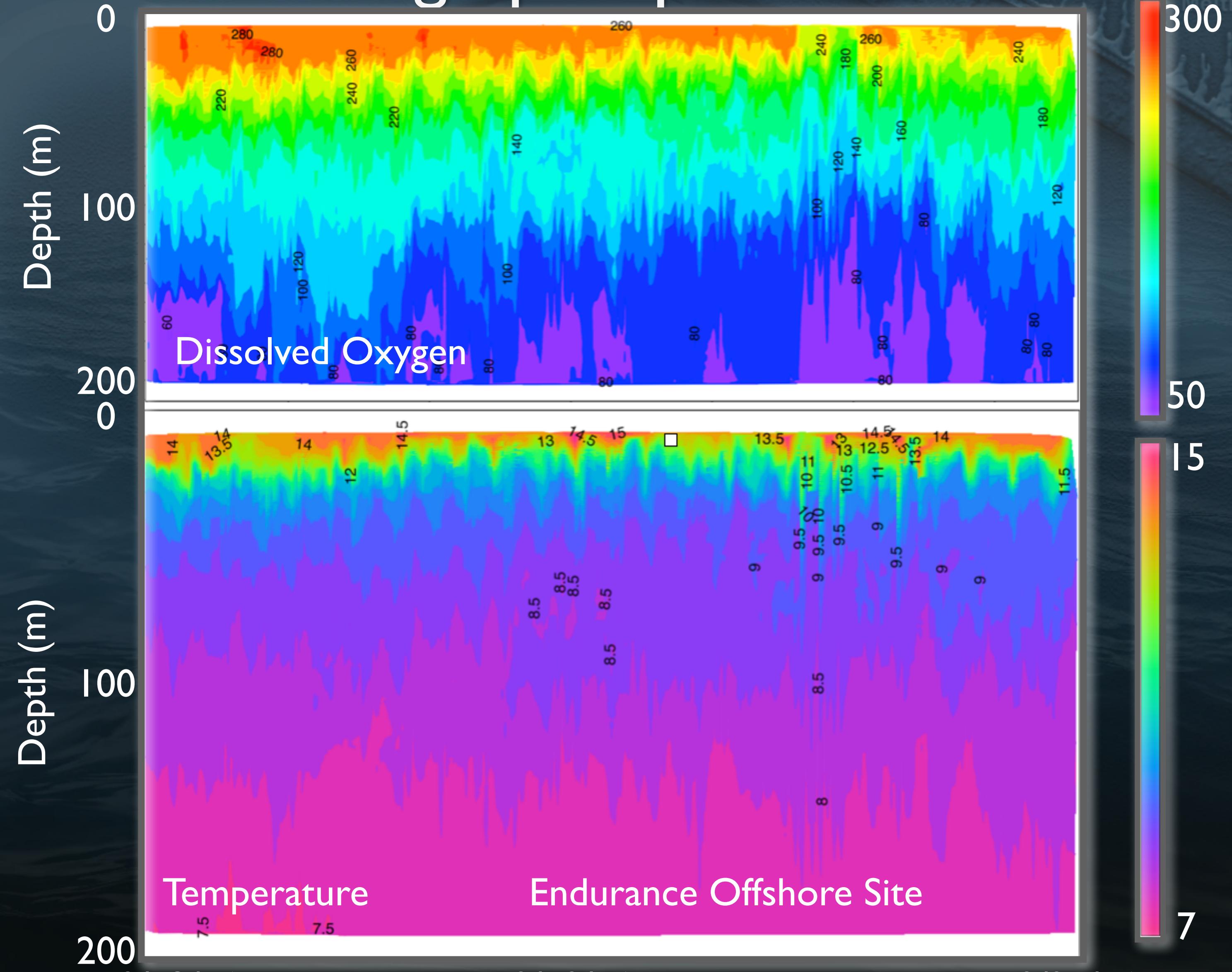


Platform Interface Controller
(stationary science pod)

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

Winched Shallow Profiler

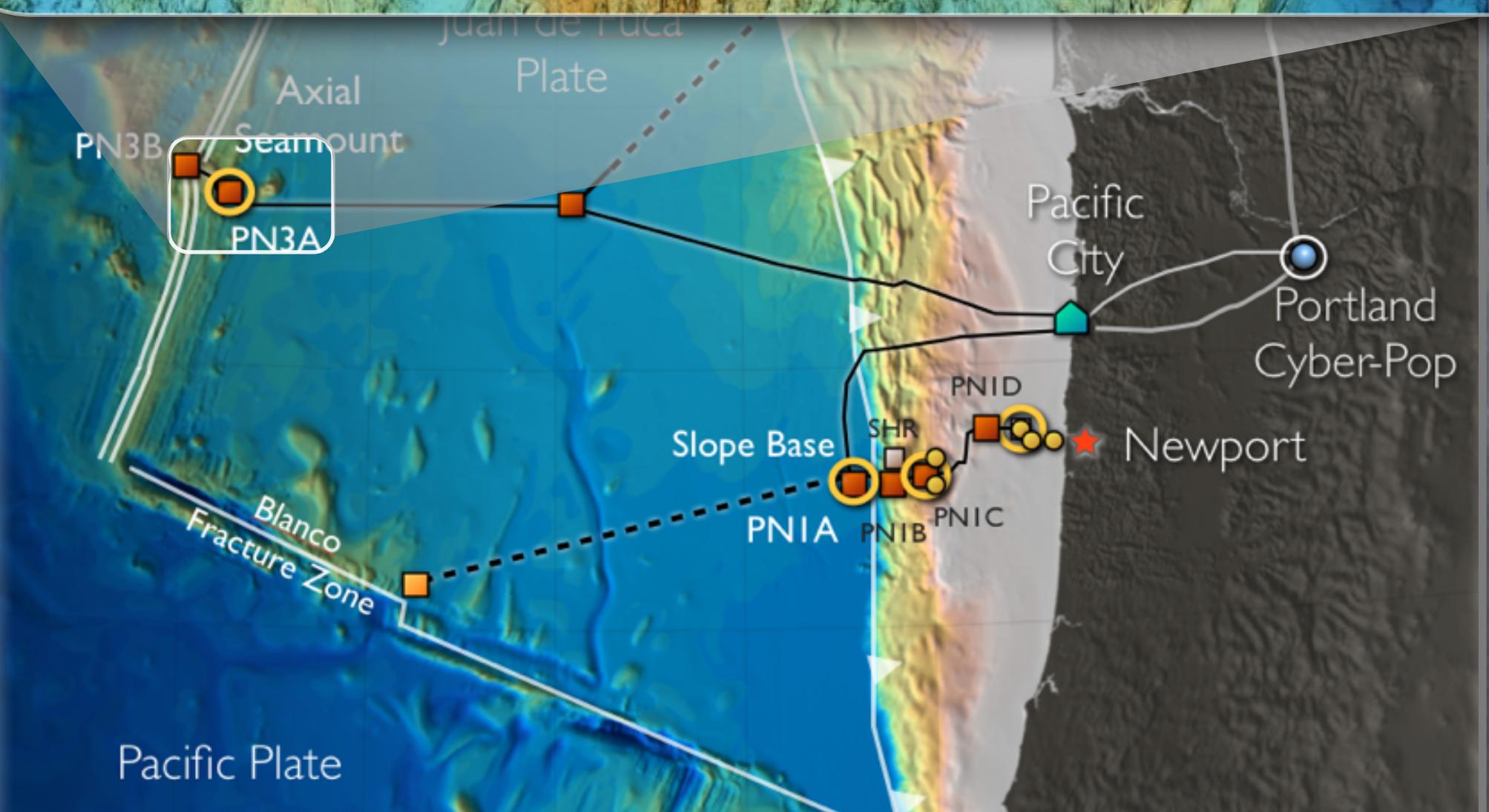
pH
3W fluorometer
CTD-dissolved oxygen
PCO₂
nitrate
Spectral irradiance
PAR
current meter+ temperature



Axial Seamount

The most advanced submarine
volcanic observatory in World's
Oceans

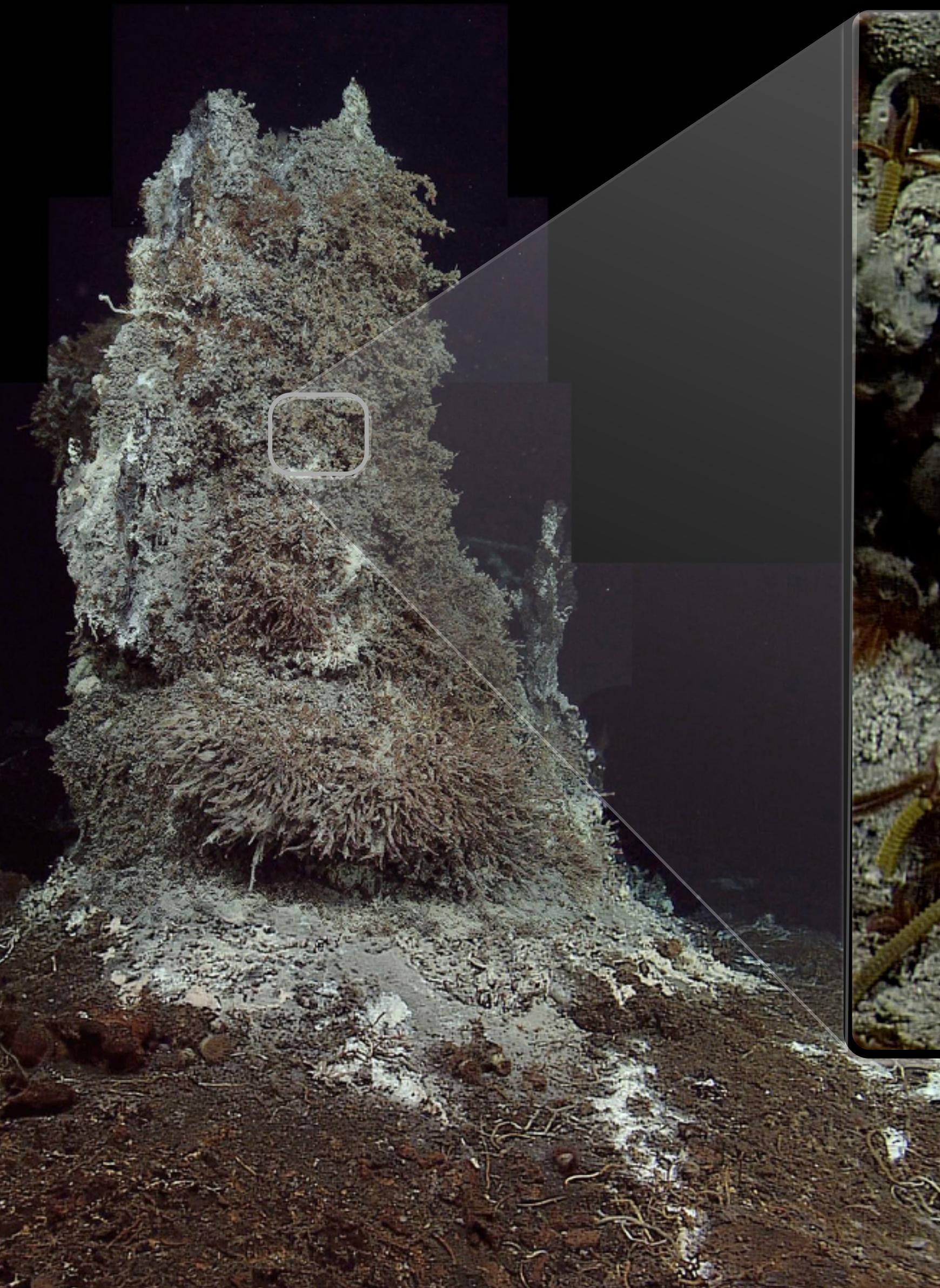
Axial Seamount



- ▶ 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 hydroshere, linkages among seismic, chemical and biological processes and how they change with time?

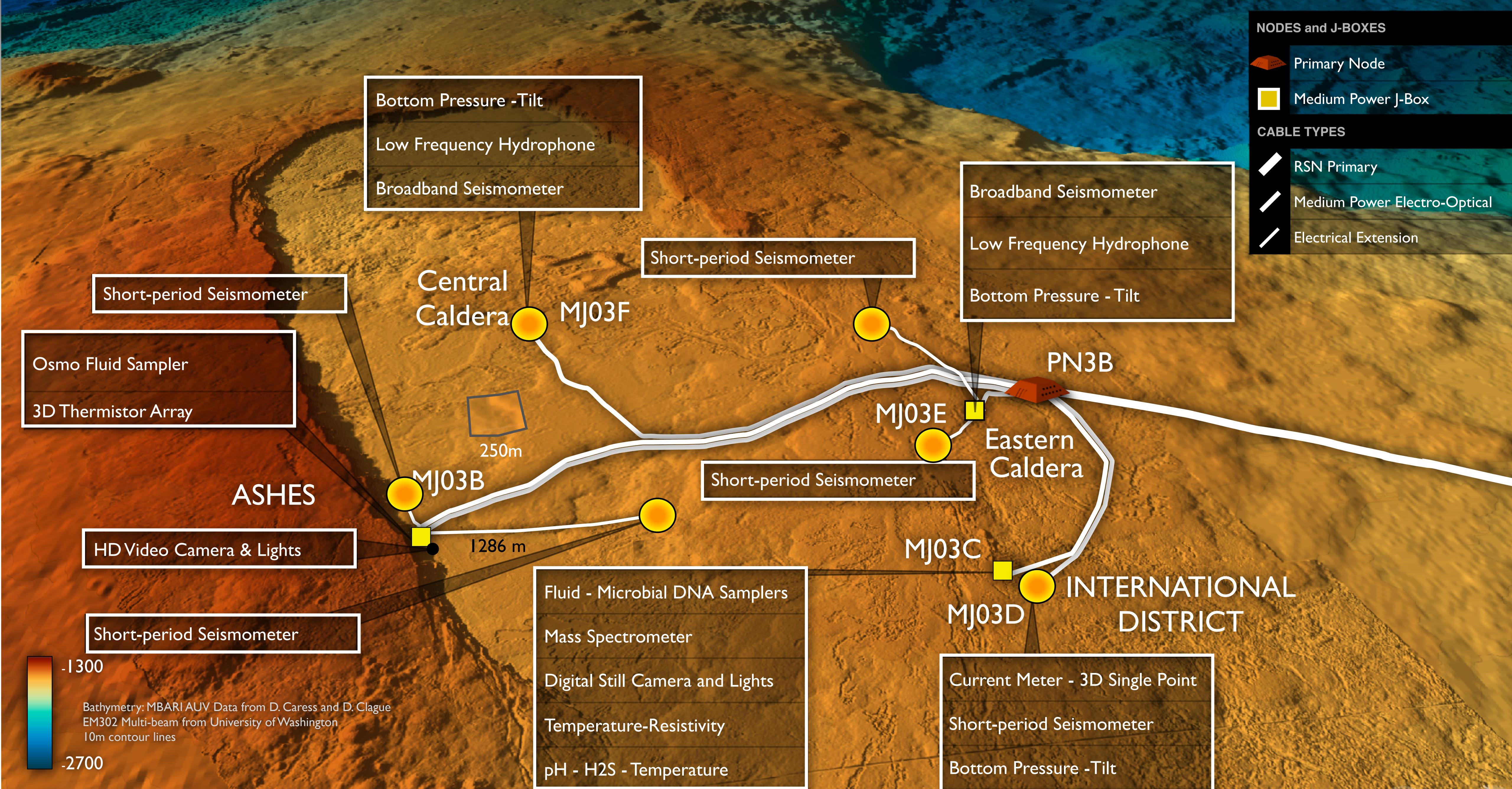
Erupted in 1998, 2011,
and April 24, 2015

How does life respond to diking-eruptive events and evolve?



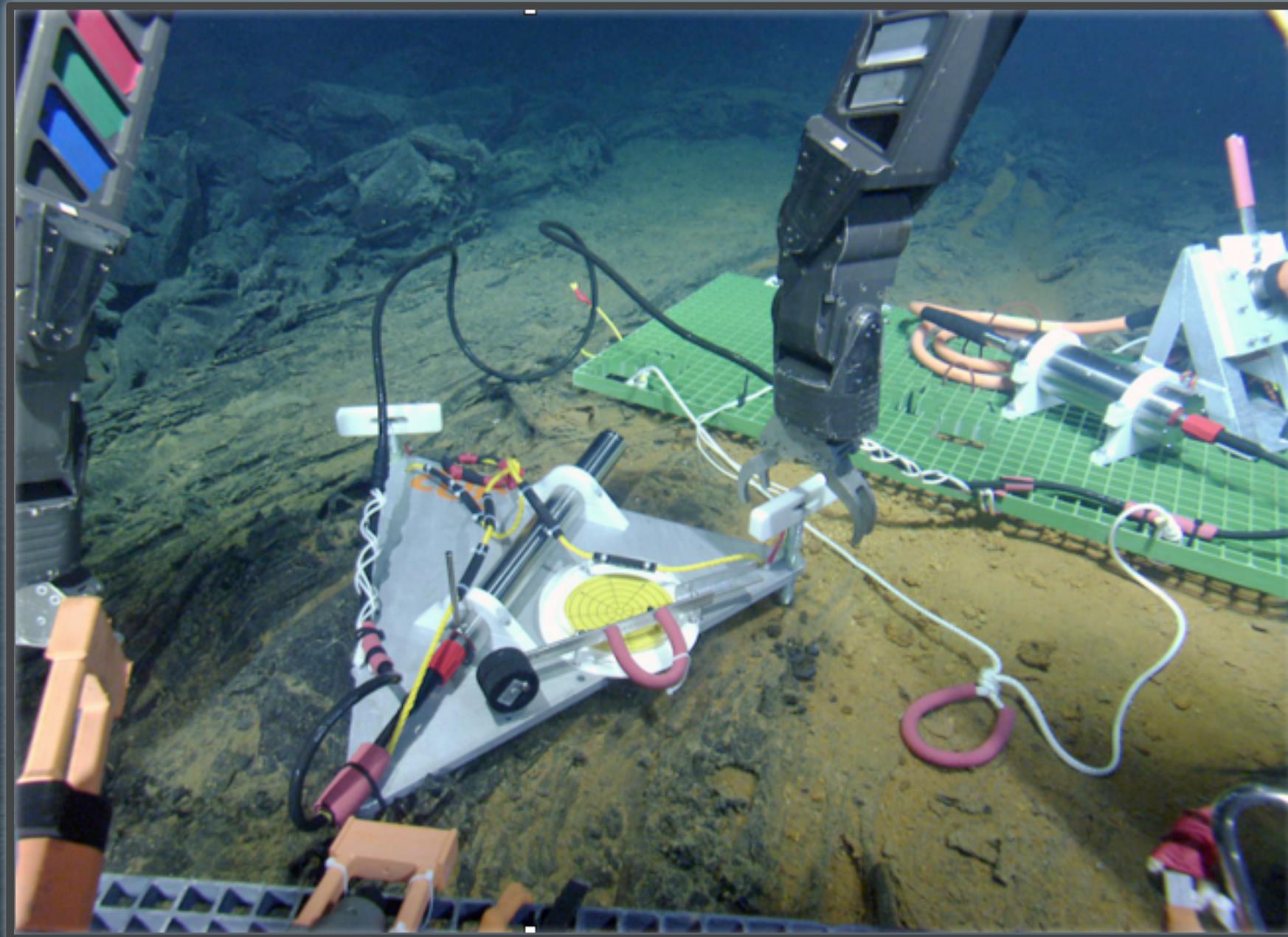
Palm worms, limpets, scale worms

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

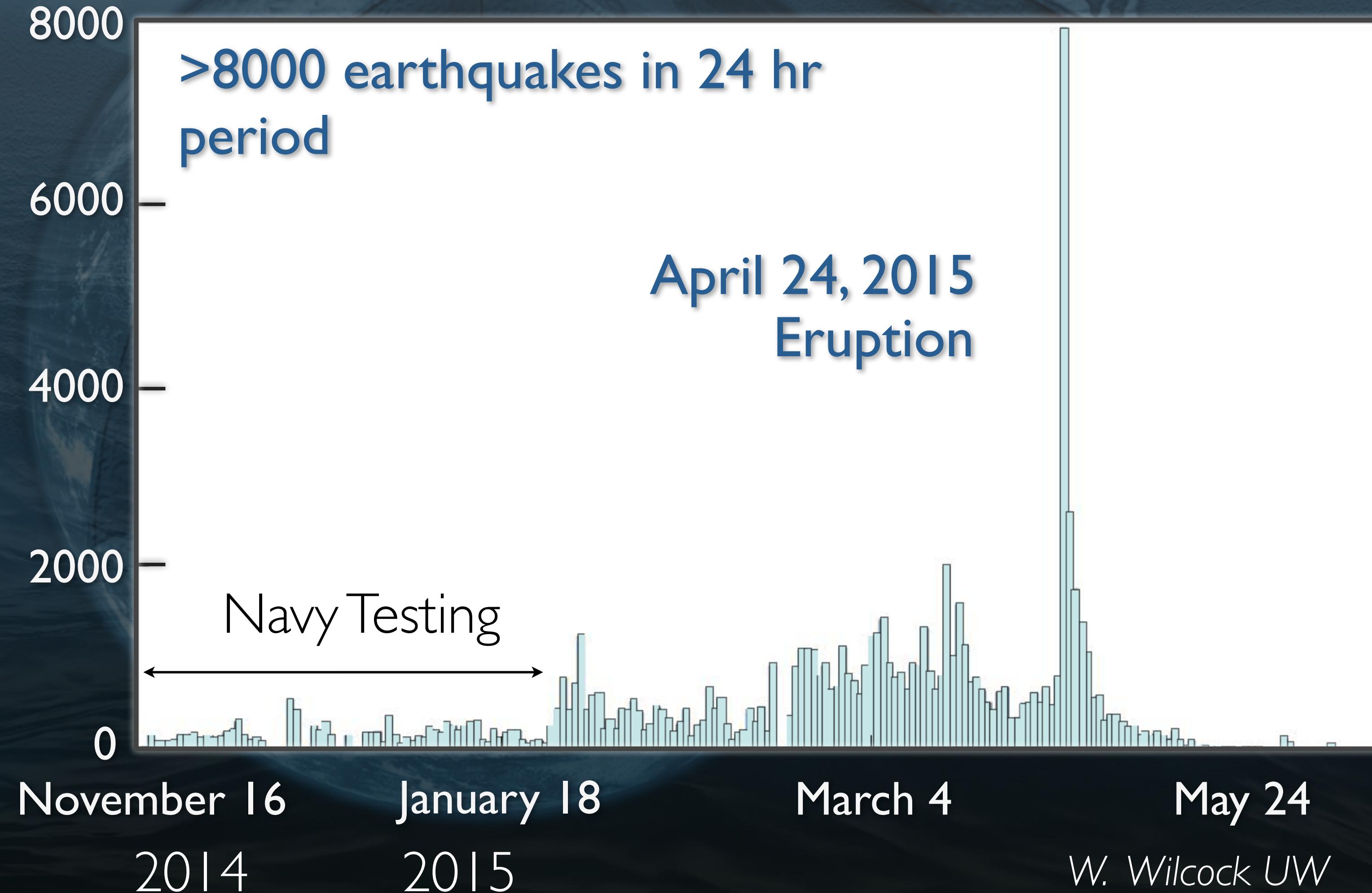


MEASURING THE HEART BEAT OF AN UNDER WATER VOLCANO 24/7

Measuring the heart beat of an active volcano in real-time



Array of seismometers on summit - > 200 repeat users now downloading data from IRIS (~4.1 TB)



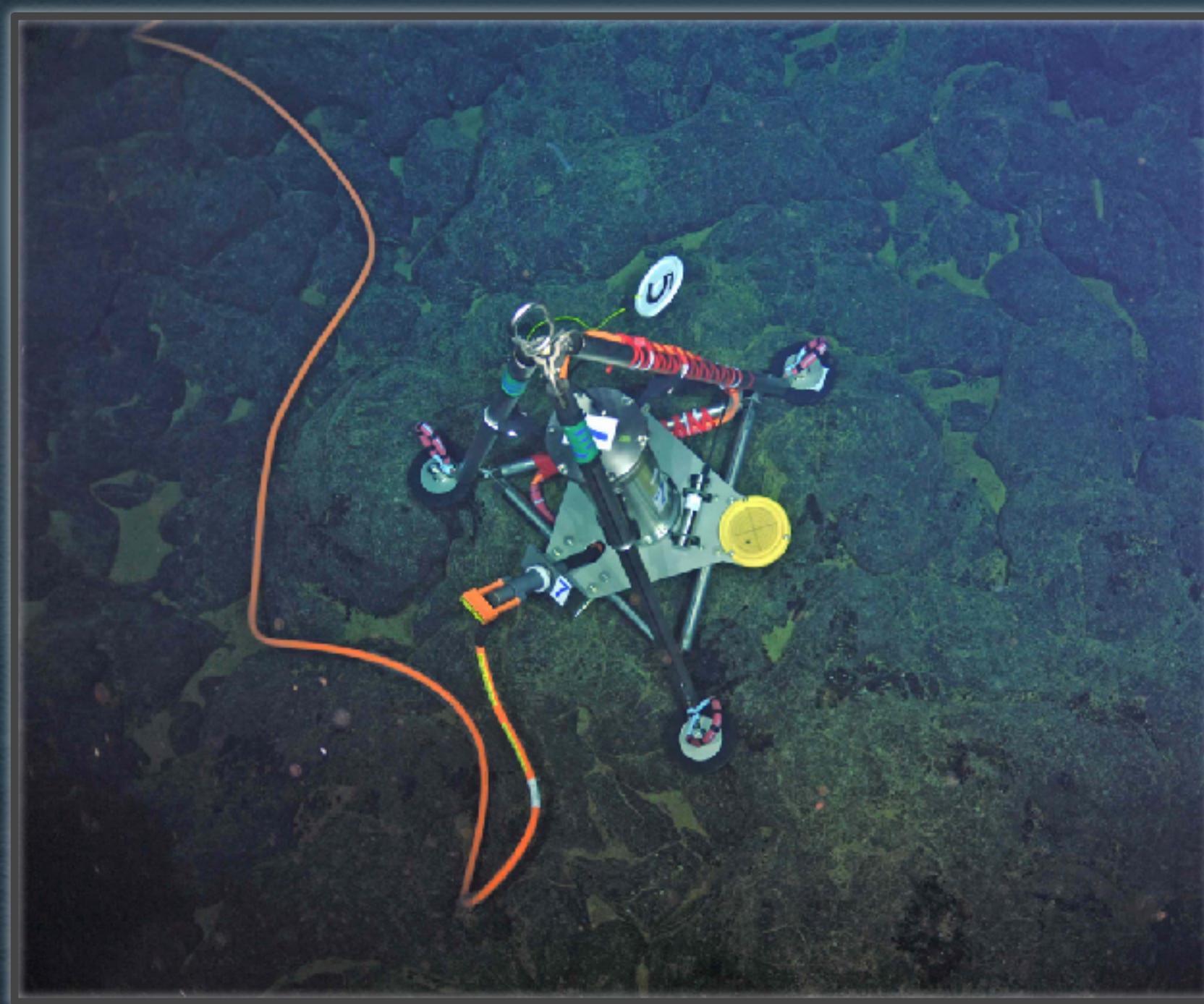
Real-time insights into an underwater volcano 1500 m down,
>300 miles offshore, tracking melt migration, eruptions, and whales

Ocean
Crust

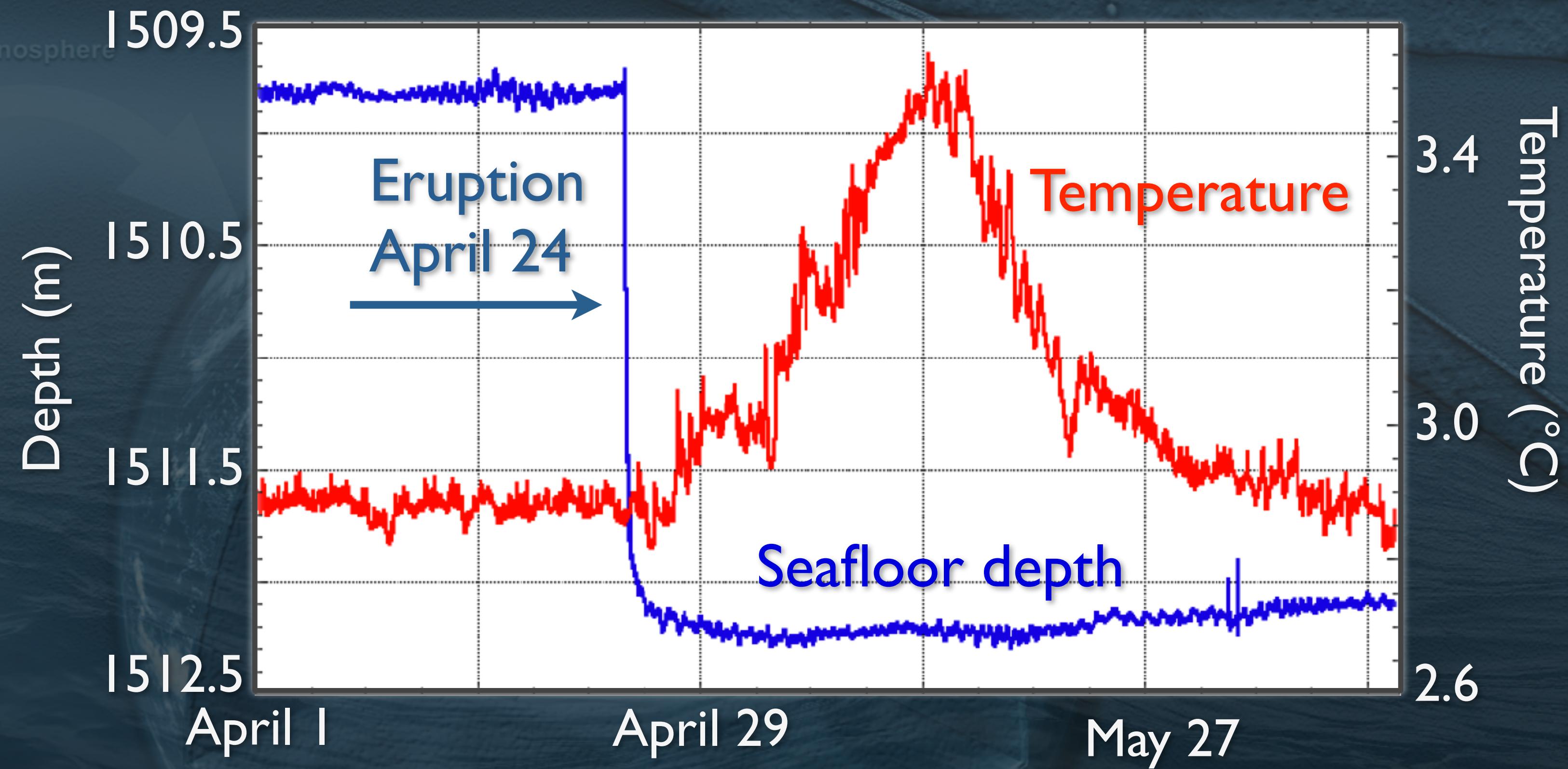
Lithosphere

Continental Crust

Seafloor inflation and deflation



Bottom pressure –
tilt instrument



- Streaming data to shore showed the seafloor fell 2.4 m (7.9 ft) - and is now inflating again

- Water temperatures across the volcano's summit were elevated for several weeks - data are on IRIS

Axial Central Caldera Low Frequency Hydrophone (200 Hz) Speed x5

Mark Stoermer

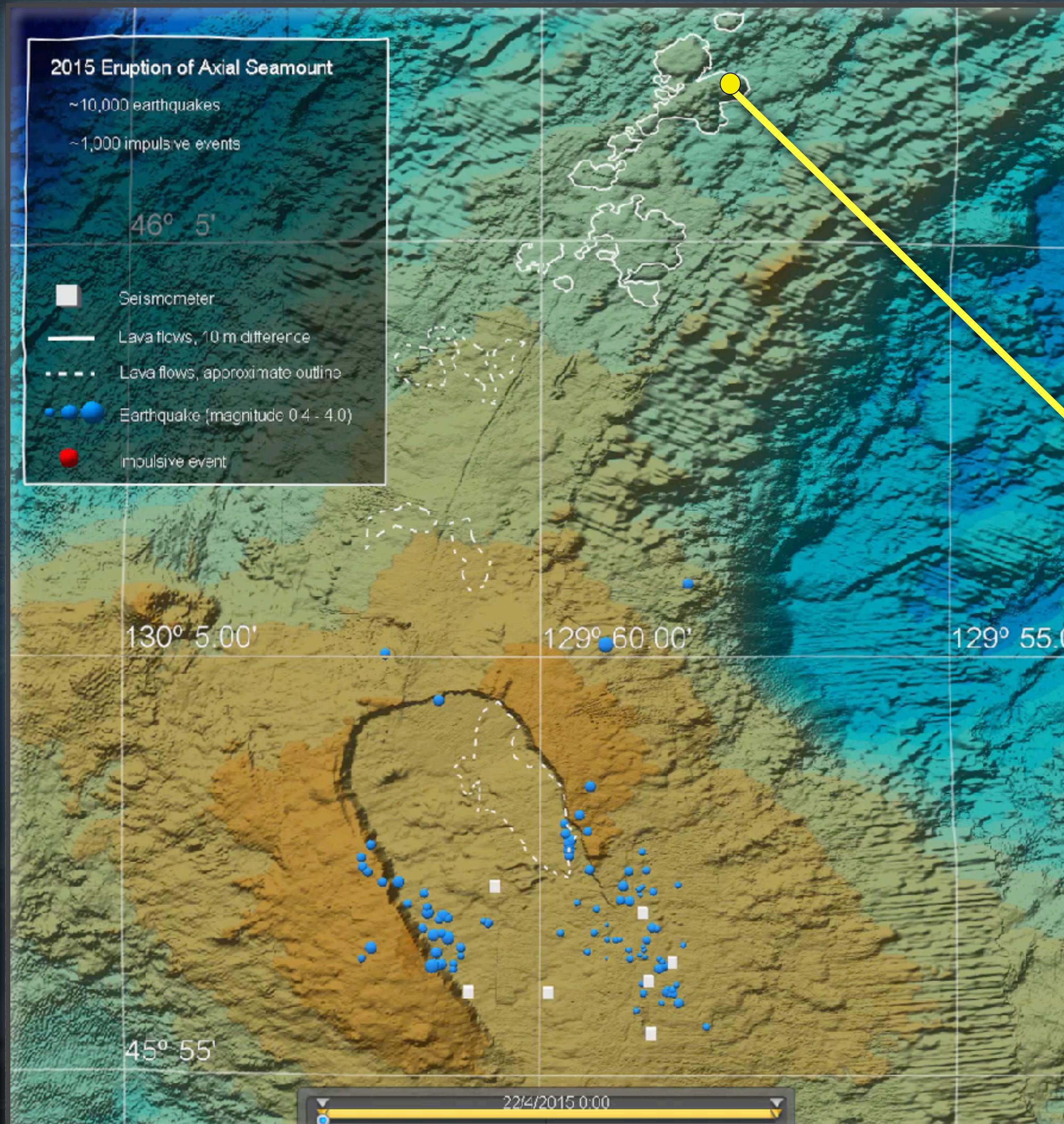
Crust

Lithosphere

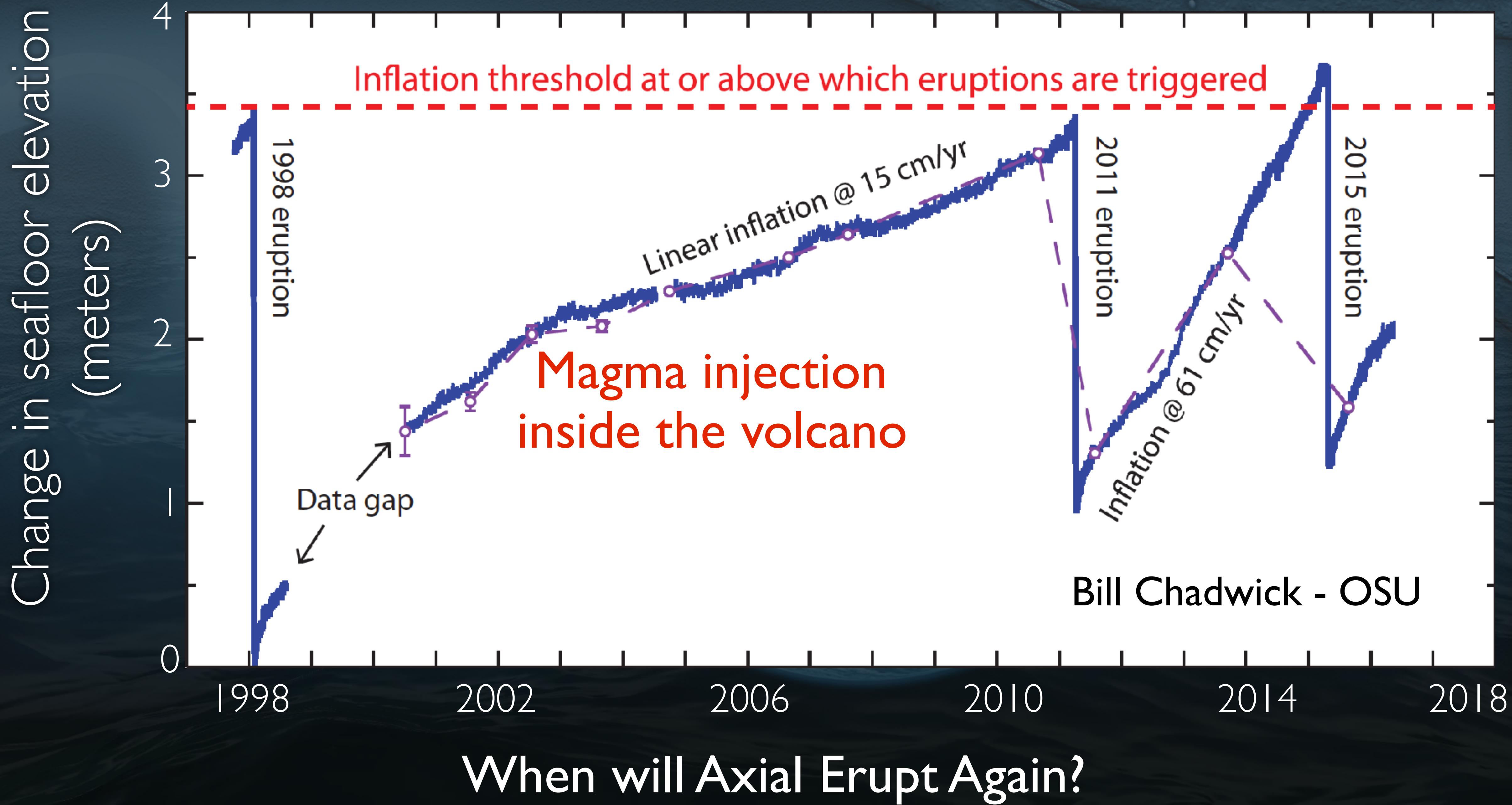
Continental Crust

● Earthquakes

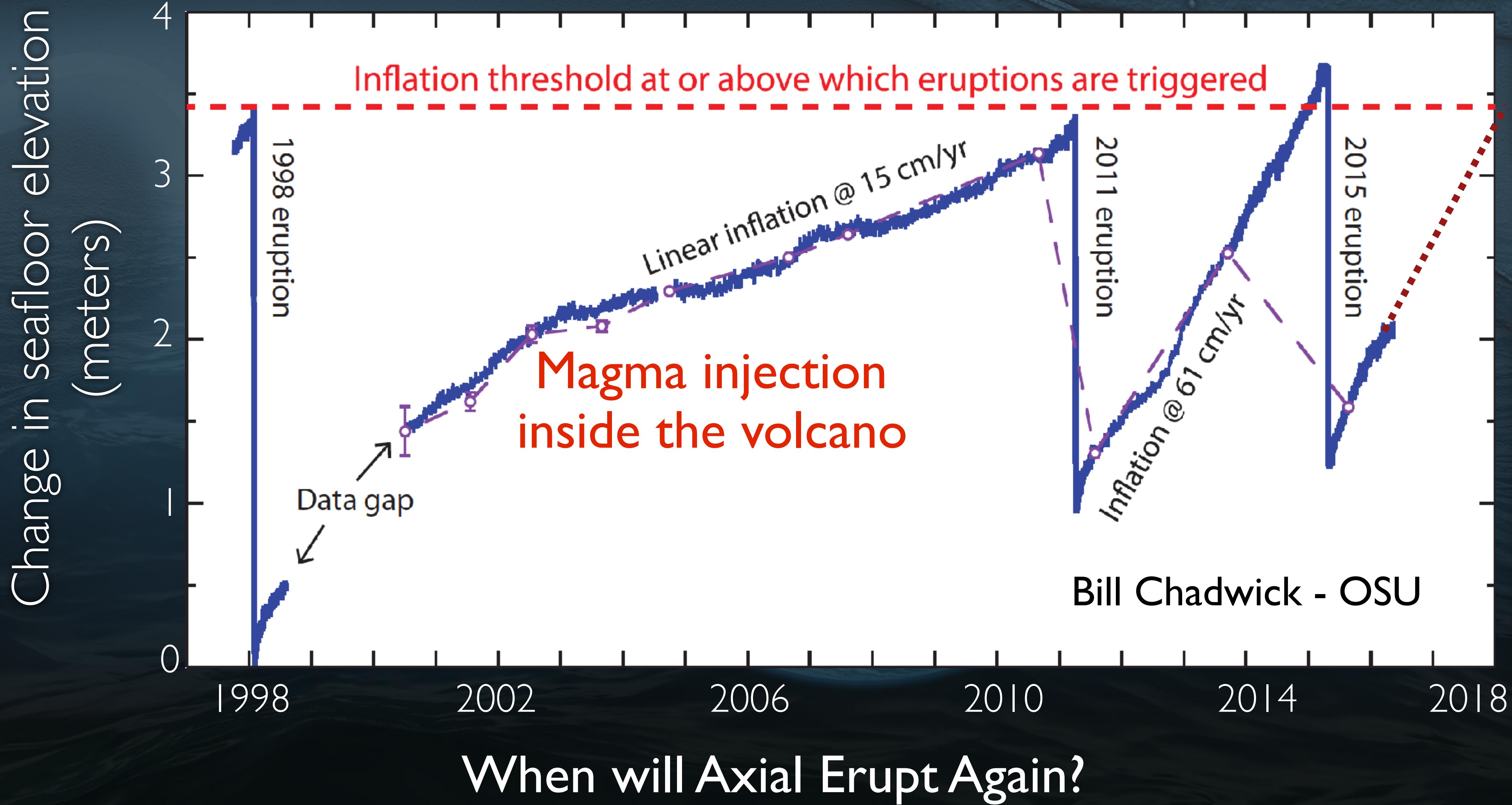
● Explosions (Wilcock et al., 2016)



First place where an eruption may be predicted!



First place where an eruption may be predicted!



Outside Funding - Instrumentation

W.Wilcock (UW 2) - Flipping Tiltmeter 2017; AOA Pressure sensor 2018

M. Zumberge & G. Sasagawa (UCSD-SIO) — Self Calibrating Pressure Sensor

K. Bemis (Rutgers) - COVIS Vent Emission Imager

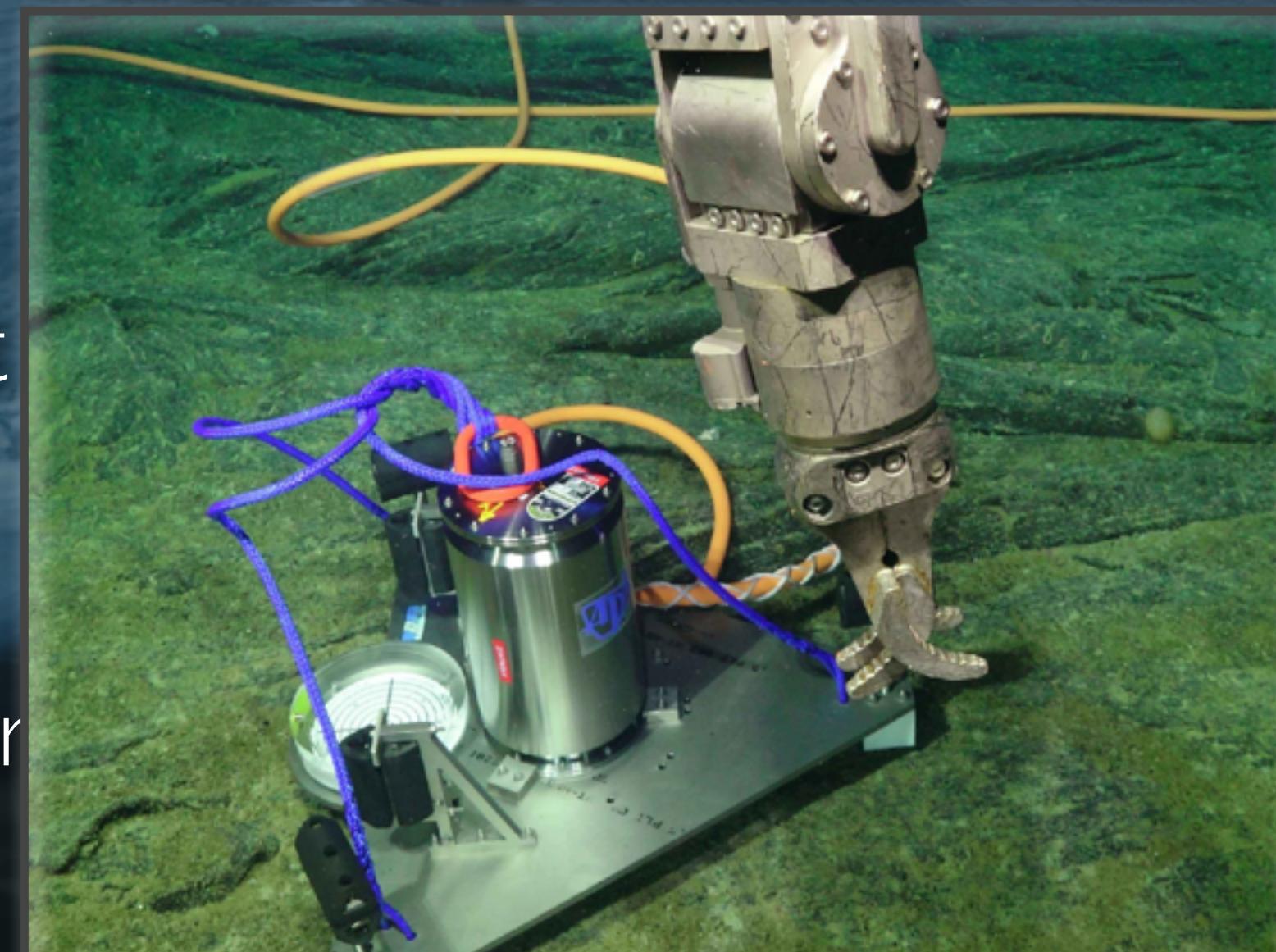
Office of Navy Research

J. Breedlove (Creare Inc) and D. Dyer (UW-APL) Energy Extraction Vents

C. Reimers (OSU) - Benthic Observer

NASA Exobiology: J. Sobron (SETI Institute) In situ Vent Analyses Divebot for Exobiology Research (INVADER).

Bremen University - MARUM: G. Bohrmann & Y. Mar Quantifying Gas Emission at Southern Hydrate Ridge



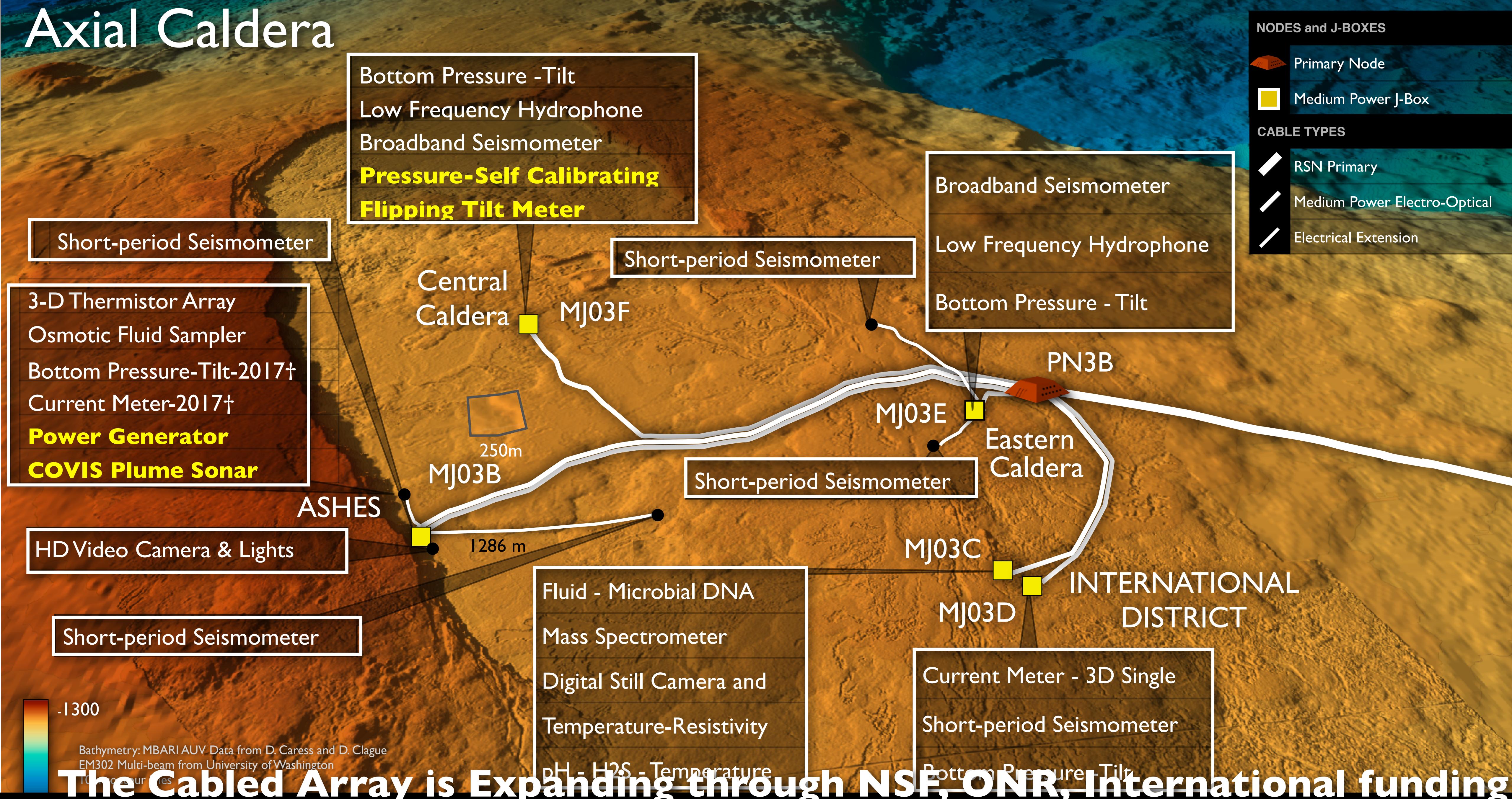
Axial Caldera

NODES and J-BOXES

- Primary Node
- Medium Power J-Box

CABLE TYPES

- RSN Primary
- Medium Power Electro-Optical
- Electrical Extension



The Cabled Array is Expanding through NSF, ONR, International funding

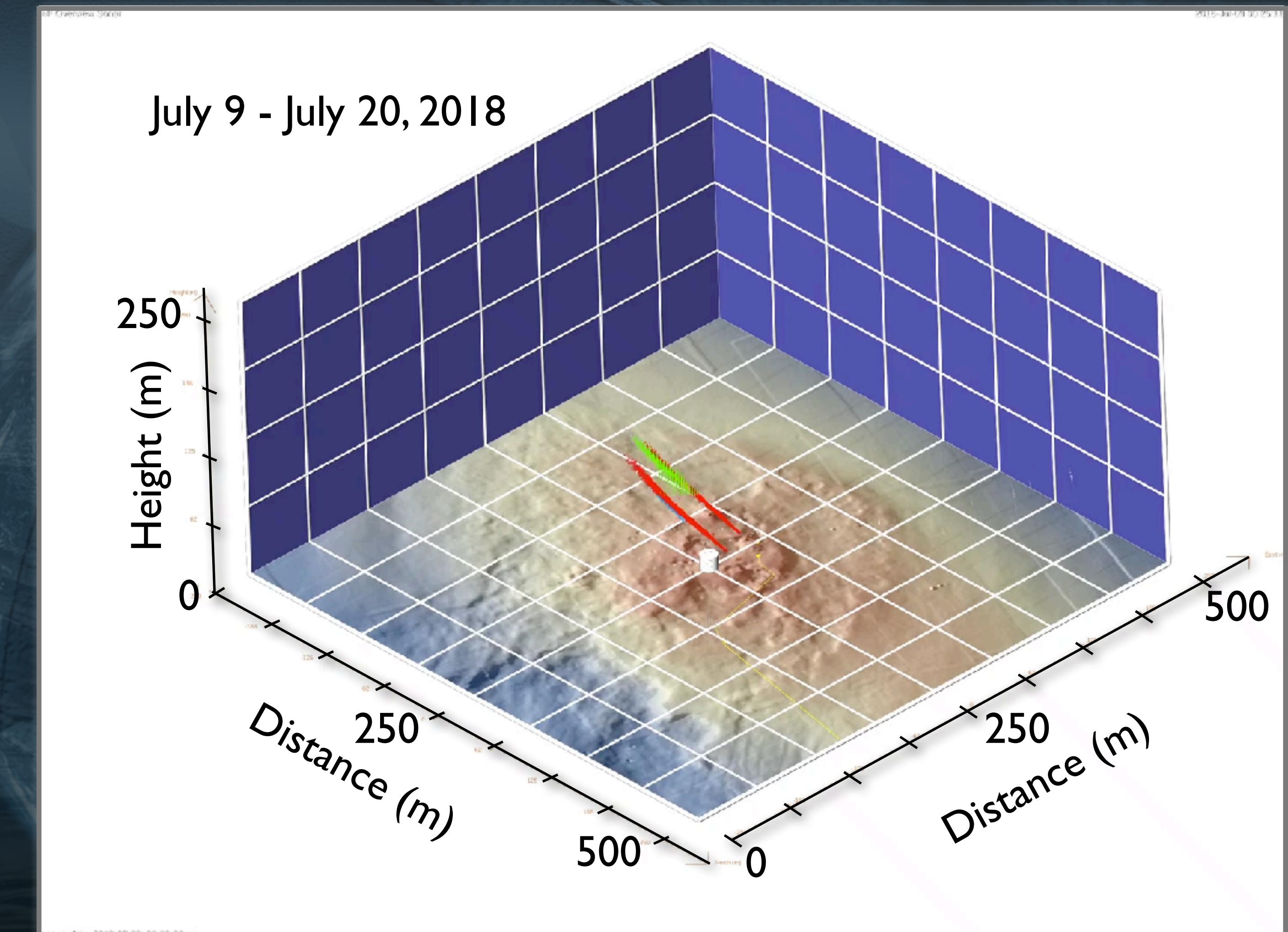
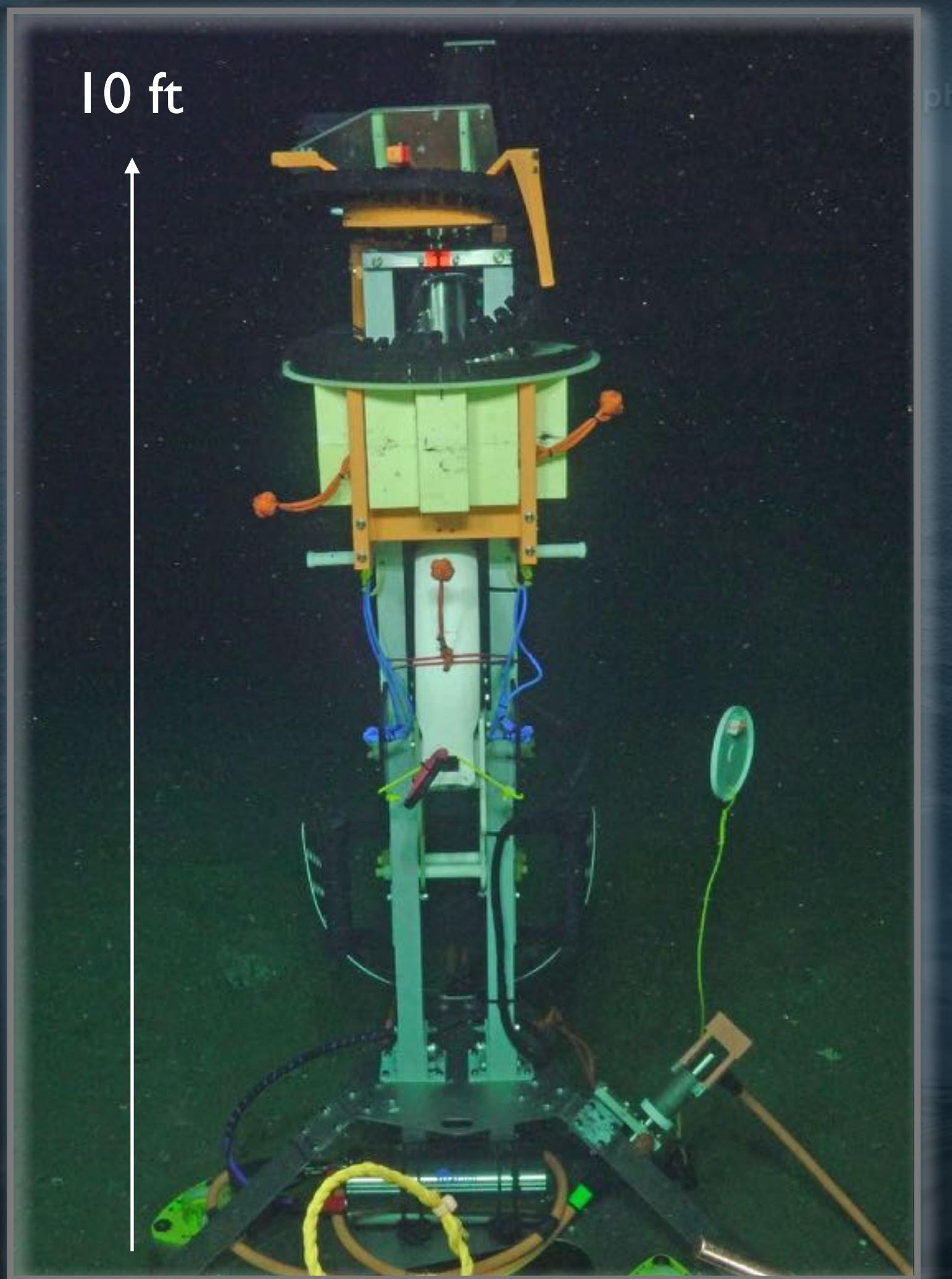
Ocean

Crust

Lithosphere

Subduction Zone

Continental Crust



Quantifying Methane Gas Emissions Southern Hydrate
Ridge (MARUM; Y. Marcon and G. Bohrmann)

Cruise and Instrument Data

The OOI OCEAN OBSERVATORIES INITIATIVE logo is at the top left. A banner image shows a yellow research vessel at sea with scientific equipment deployed. Text in the banner reads: "The OOI is funded by the National Science Foundation" and "NSF". Below the banner is a navigation bar with links: OOI Data, Science, The Observatory, Operations, Researchers, Educators, Events & Updates, About, and a search icon. A large central image shows a close-up of underwater scientific instruments, including a white metal frame with blue and red cables submerged in dark water. A "Information for Researchers" sidebar on the left contains a "Guidance for proposal writers and data users." section. At the bottom, a yellow box contains a "OOI Data Portal Scheduled Maintenance" notice: "Please note, due to the need to regularly upgrade the OOI Data Portal, a recurring maintenance window has been established between 4-5pm Eastern time on weekdays. During this time, system upgrades may be performed that may make the system unavailable for use."

Cruise information, video and still imagery

The Interactive Oceans logo is at the top left. A navigation bar includes links: HOME, SEARCH, PEOPLE, CONTACT US, NEWS, NSF DISCLAIMER, PRIVACY, and TERMS. The main title "VISIONS'16" is in large white letters, followed by "July 10-August 15, 2016". Below the title is a large image of a white fish swimming in blue water. A "FEATURES: VIEW ALL" section shows three images: "Old School Oxygen" (a person working on equipment), "A Roller Coaster of a Ride" (a ROPOS vehicle), and "The End of One Leg Start" (a view from the ship). On the right, a "TWITTER" sidebar displays a tweet from @OceanObserving about the R/V Thompson's journey to Axial Volcano.

oceanobservatories.org

>120 undergraduates and graduate students at-sea on Cabled Array-VISIONS cruises

interactiveoceans.washington.edu



Kelley and Delaney, 2017

Installed and Proposed Seafloor Observatories

Globally-connected science and education opportunities