

Regional Cabled Array

OOIFB Meeting May 2019

Deb Kelley and RCA Team

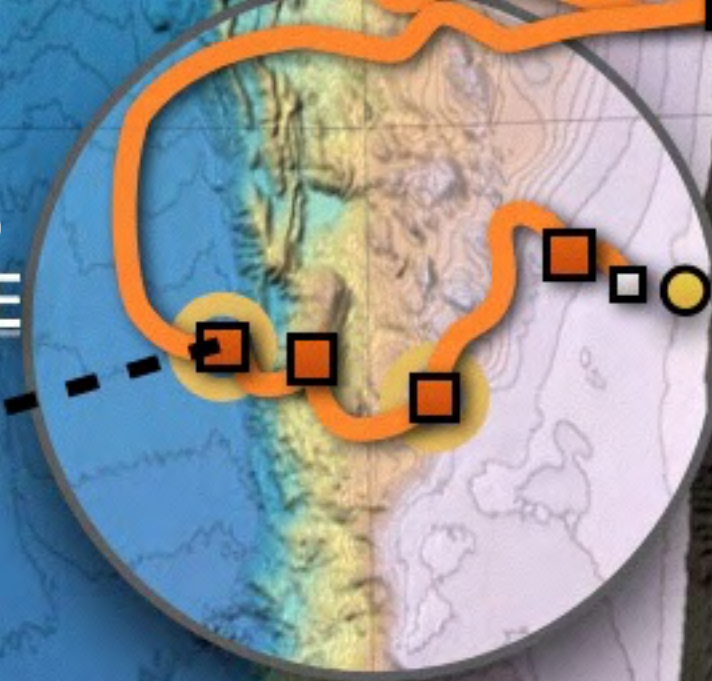


School of Oceanography and Applied Physics Lab
University of Washington



JUAN DE FUCA
PLATE

HYDRATE

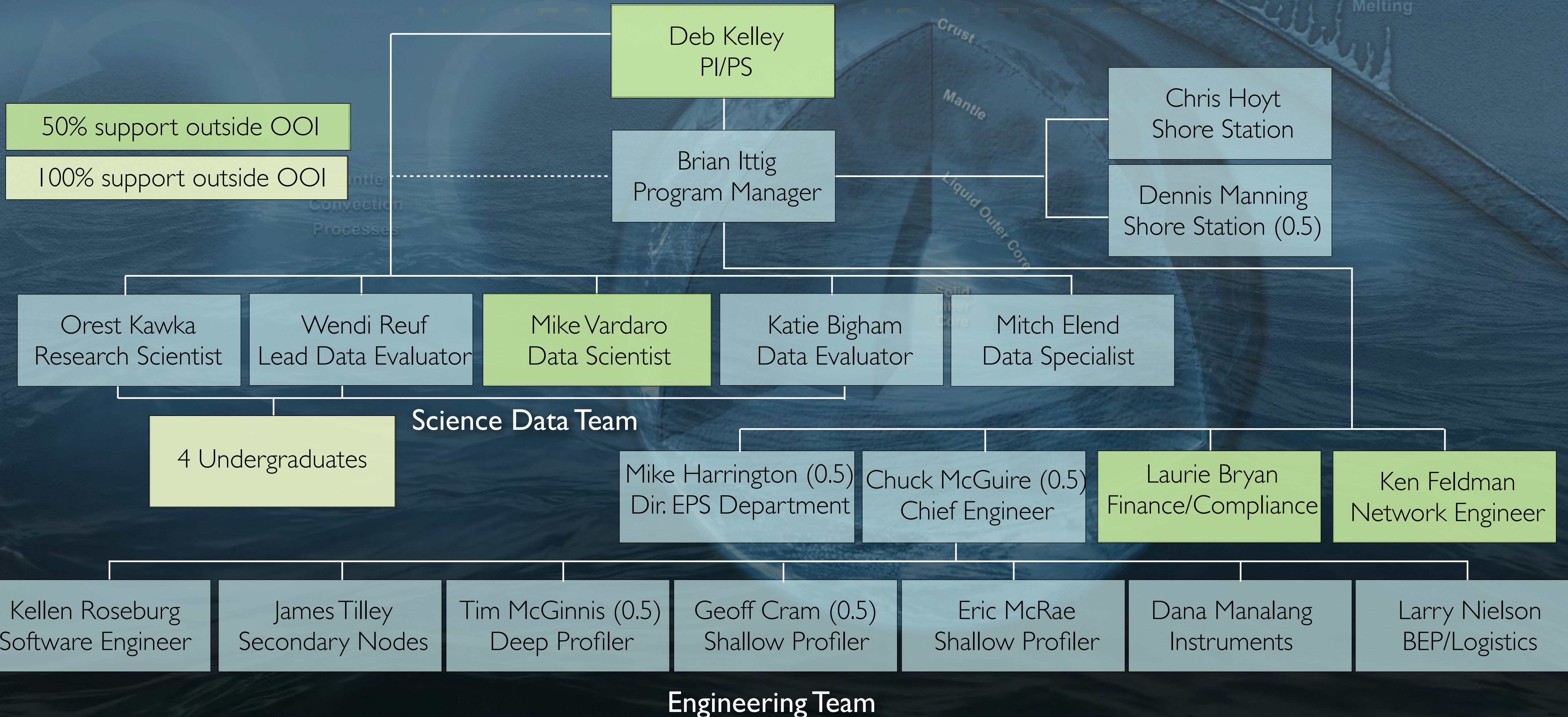


cev



REGIONAL CABLED ARRAY TEAM: BENEFITS FROM STRENGTH OF APL

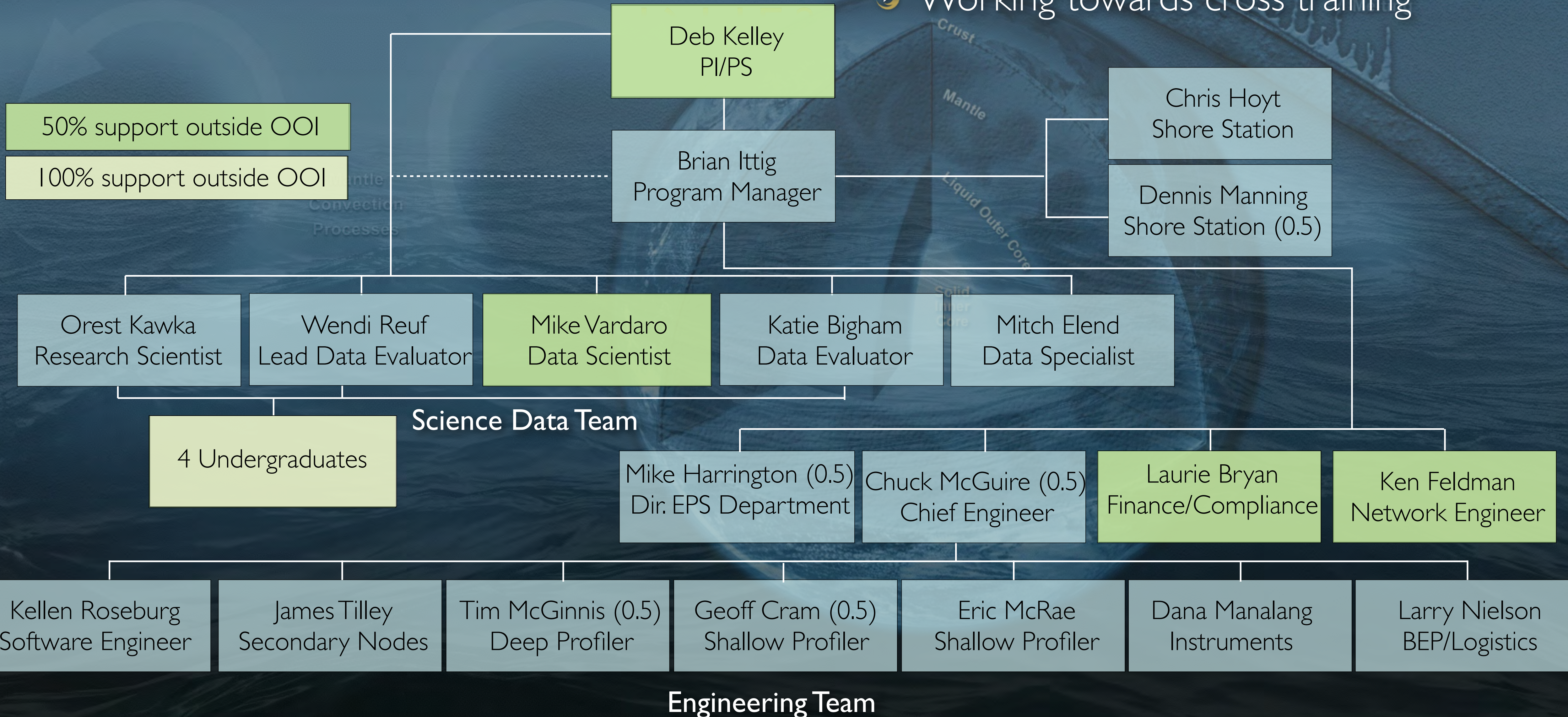
19 FTE's INCLUDING 7.5 FTE's LOE



REGIONAL CABLED ARRAY TEAM

19 FTE's

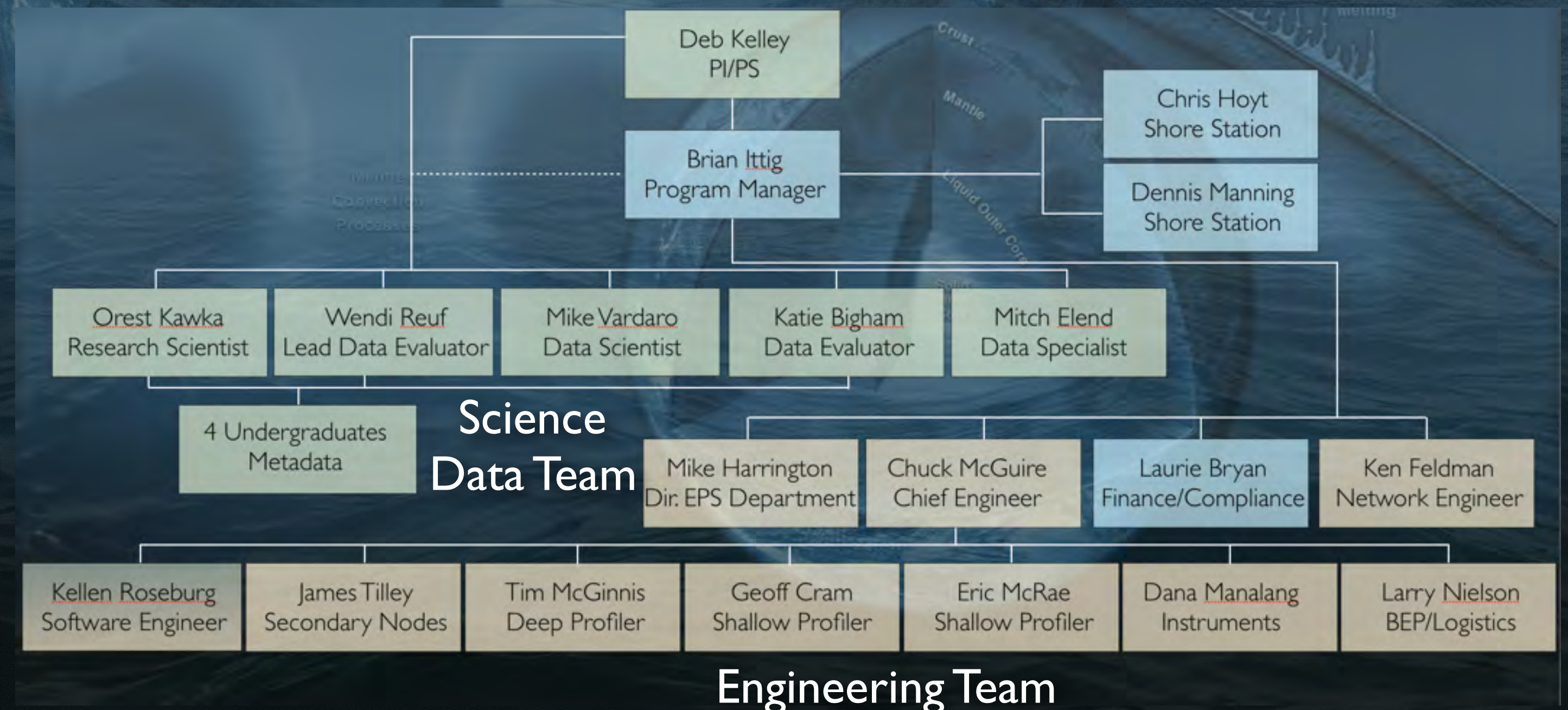
- ▶ Risk - Breadth but not depth
- ▶ Working towards cross training



Cabled Array

How We Operate

- ▶ PI-PM-Finance: Talk Daily
- ▶ PM-Finance-Engineering: Talk Daily to Weekly
- ▶ Data Team Talk Daily; Formal meeting weekly
- ▶ Weekly Meeting Data-Engineering Instrument: Metadata, Evaluation - Are Instruments Working?
- ▶ Weekly Meeting Control Account Managers: Refurb Status and Budgets
- ▶ Monthly All Hands Meeting
- ▶ Several Precruise Meetings



5th 2019 Maintenance Cruise

44 days with 14 days of mobe/ demobe; >40 dives

Table 1: 2019 OOI-UW Regional Cabled Array Cruise R/V Atlantis (AT42-12: Newport - Newport All Legs)

Legs	Depart	Arrive	Chief Scientist	Funding
Leg 1	Axial Base Shallow Profiler Mooring Recovery & Reinstallation			
Mobilize Begin 5/30	Depart 6/2	Return 6/9	James Tilley	1-4: NSF-OOI-UW
Leg 2	Offshore, Slope Base, Axial Base, ASHES, PIAs' and SIA's, ASHES CAMHD, OSMO, COVIS (recover)			
Mobilize 6/9,10,11 (Jason)	Depart 6/12	Return 6/20	Deborah Kelley	1 NSF-Bemis Heat flow at ASHES
Leg 3	Shelf, Offshore- BEPS & Instruments, SHR Instruments, Benthic Observer Shelf and SHR, MARUM			
Mobilize 6/20,21	Depart 6/22	Return 6/29	Orest Kawka	1 - OTHER (UW) MARUM 2 ONR - Remiers Benthic Observer
Leg 4	Offshore, Slope Base, Axial Base Deep Profilers, International District Instruments, Bemis ASHES Thermistor Arrays recover, COVIS (install), Chadwick CTD, Wilcock AOA, ONR-HTVE			
Mobilize 6/29, 30	Depart 07/01	Return 7/9 Demobe 7/9-12	Deborah Kelley	2 NSF - Bemis Heat flow at ASHES 1 NSF - Wilcock AOA Pressure 1 ONR - Breedlove - HTV-UE

- 105 core OOI instruments turned
- 2 Benthic Experiment Platforms
- 6 Shallow Profiler Science Packages
- Repair of Axial Shallow Profiler Mooring
- 3 Deep Profiler vehicles
- 9 PI instruments
- ~16 CTDs verification sampling
- New York Times best seller author
- 19 students
- Live streaming
- New website
- 78 berths to manage



Regional Cabled Array

Leg 1: May 29-June 9

Partial Recovery of Mooring Drove Schedule

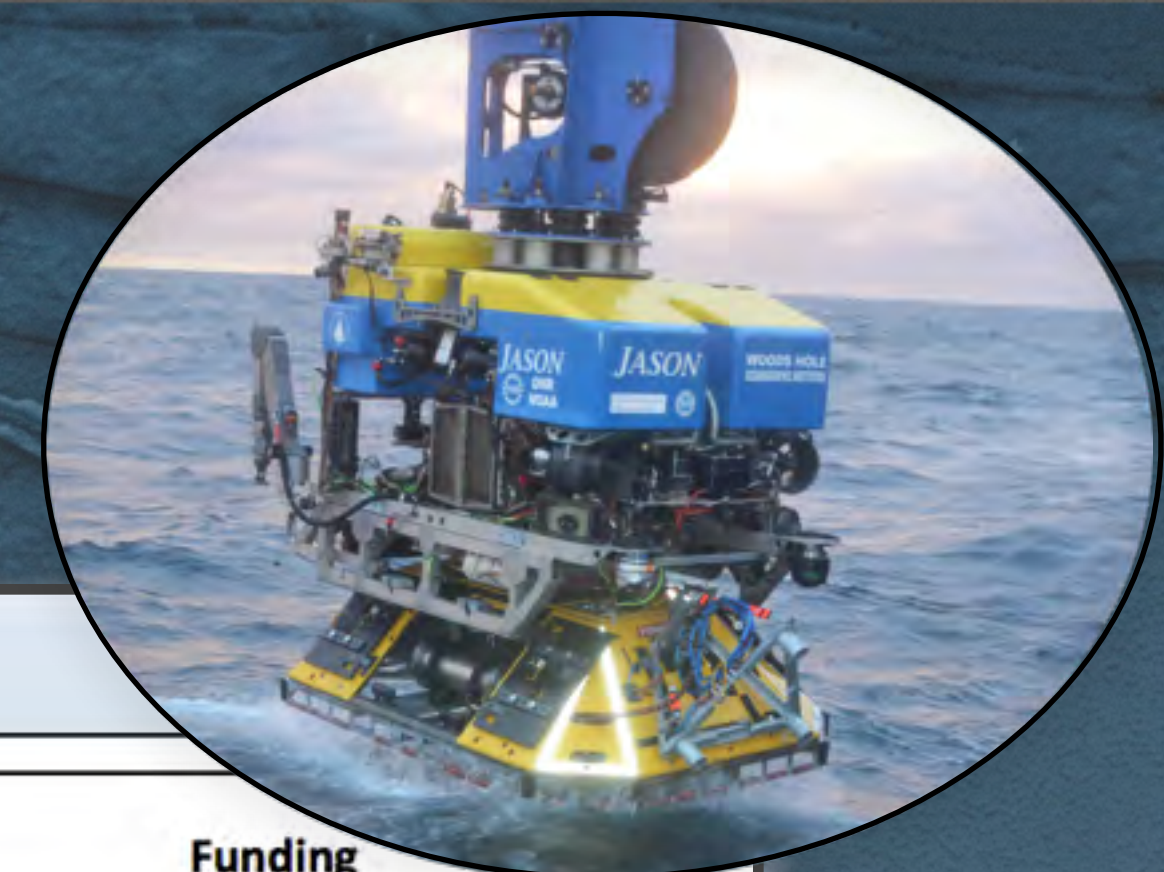


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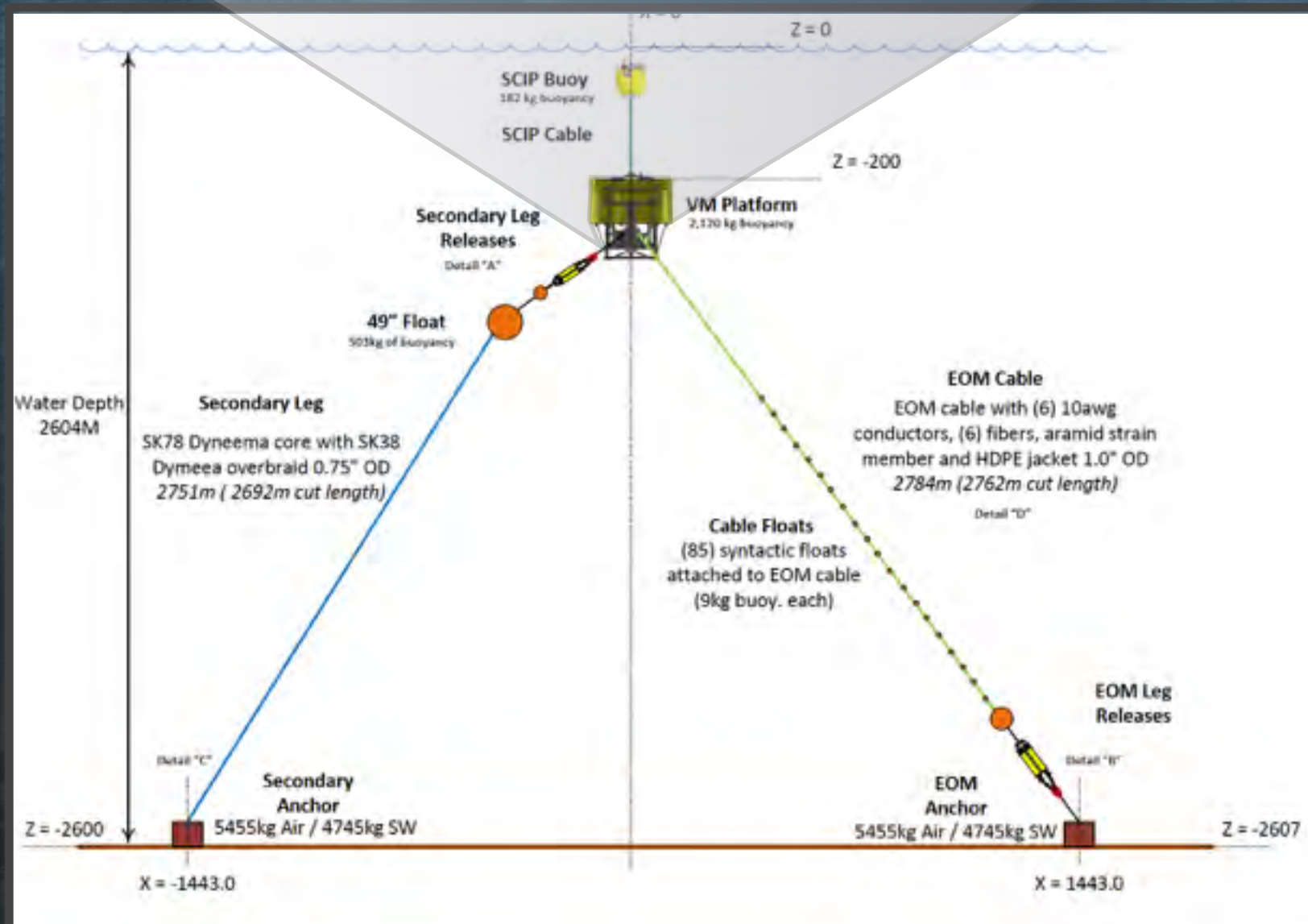
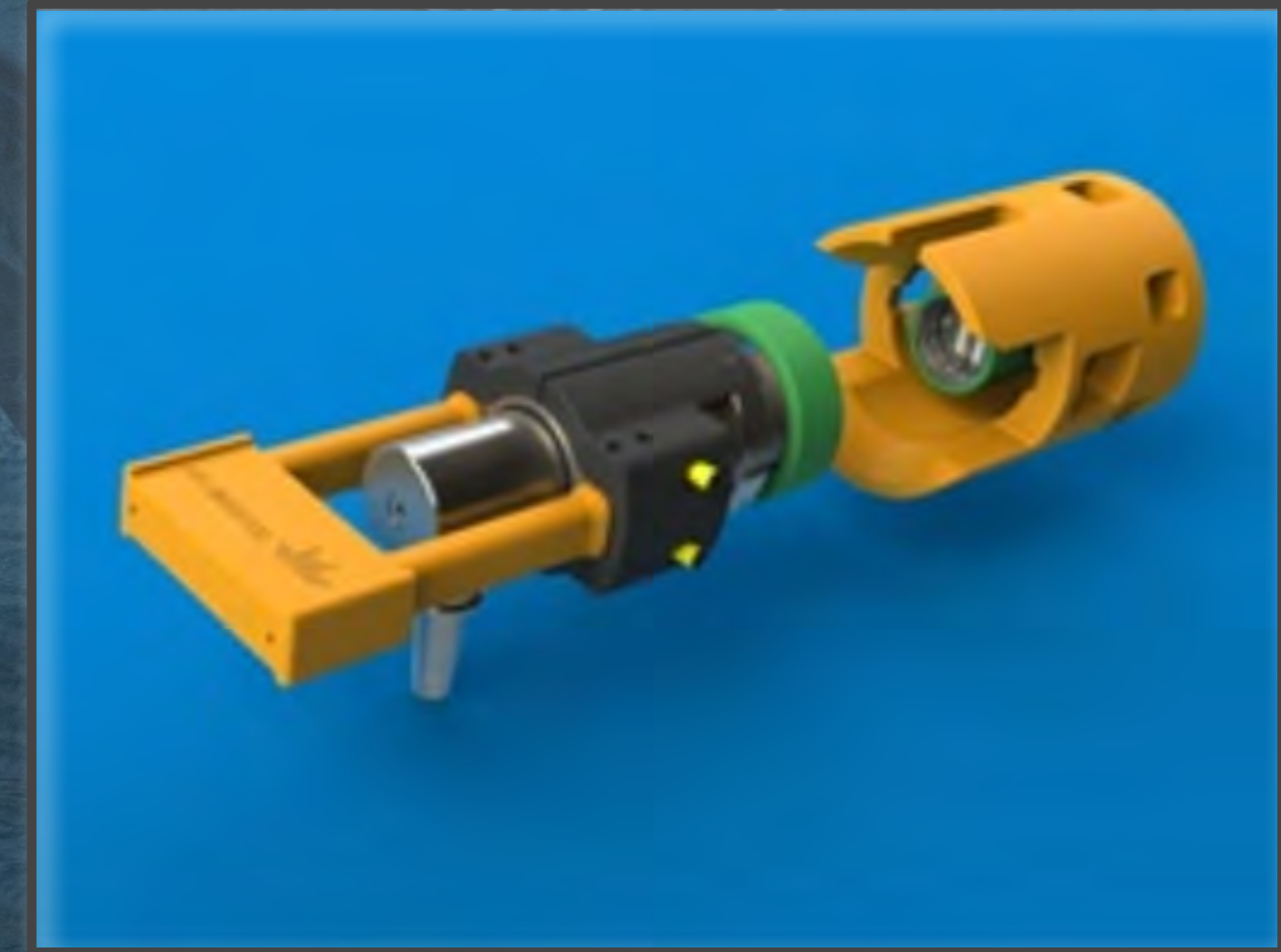
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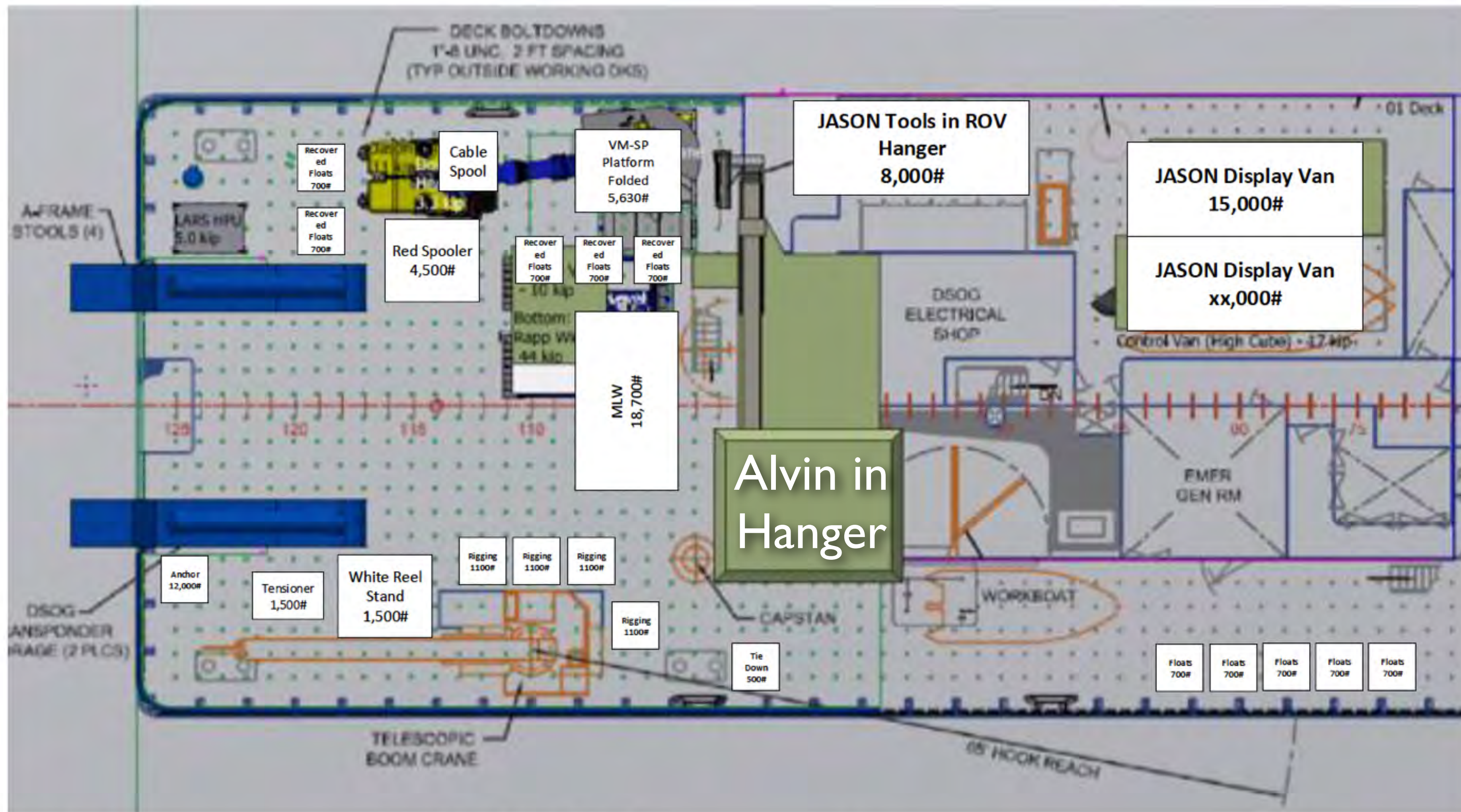
SHALLOW PROFILER MOORINGS - WORK HORSES, >40,000 PROFILES



- ▶ Now reaches 5 m
- ▶ Very smart - will “hide its head” if wave height is large
- ▶ May 30-June 9th - First time conducting only a partial recovery of a Shallow Profiler Mooring (platform and 1 Leg) to fix connector damaged by ROV



Leg 1: Shallow Profiler Mooring Partial Recovery: Jason Offloaded, RCA 78,000 lbs, Jason and RCA Vans 87,000 lbs



V19 Leg 1

JASON + RCA VAN = 87,000 lbs
RCA Deck + Inside Science = 78,300 lbs

Total = 165,330 lbs

V19 Leg 1

Regional Cabled Array AT42-12 (VISIONS'19)

May 30-July 12, 2019

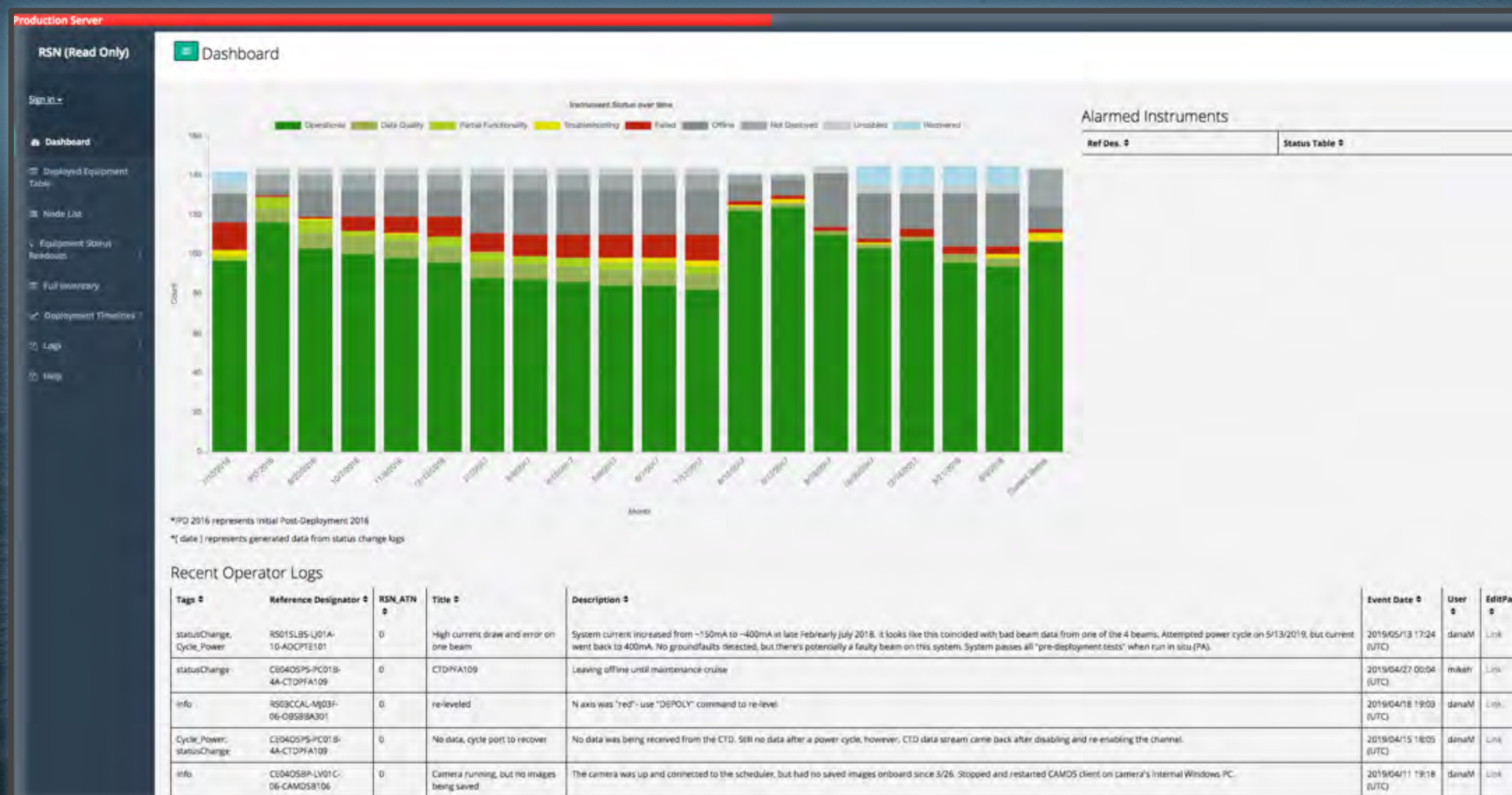
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Cabled Array Operational Status: Blue Ocean Explorer

- ▶ Deployment Equipment Table
- ▶ 18 Junction Boxes - status, alarms
- ▶ Equipment Status Readouts
 - ▶ Weathermap
 - ▶ Status Plots
 - ▶ Blue Reports: Issue description & resolution
- ▶ Full Inventory
 - ▶ Equipment type (instrument, cable)
 - ▶ Description (ADCP-75 kHz)
 - ▶ Manufacturers Serial #
 - ▶ Cabled Array Serial #
 - ▶ Action
- ▶ Deployment Timelines
- ▶ Logs
 - ▶ Equipment Transfer logs (depot, seafloor)
 - ▶ Operator
 - ▶ User Action Log



Integrated daily operational status, assets, issues, resolutions etc

Rutgers syncs RCA data from UW every 24/hrs into U-Frame
because Port Agent Logs are excluded (IP Addresses)

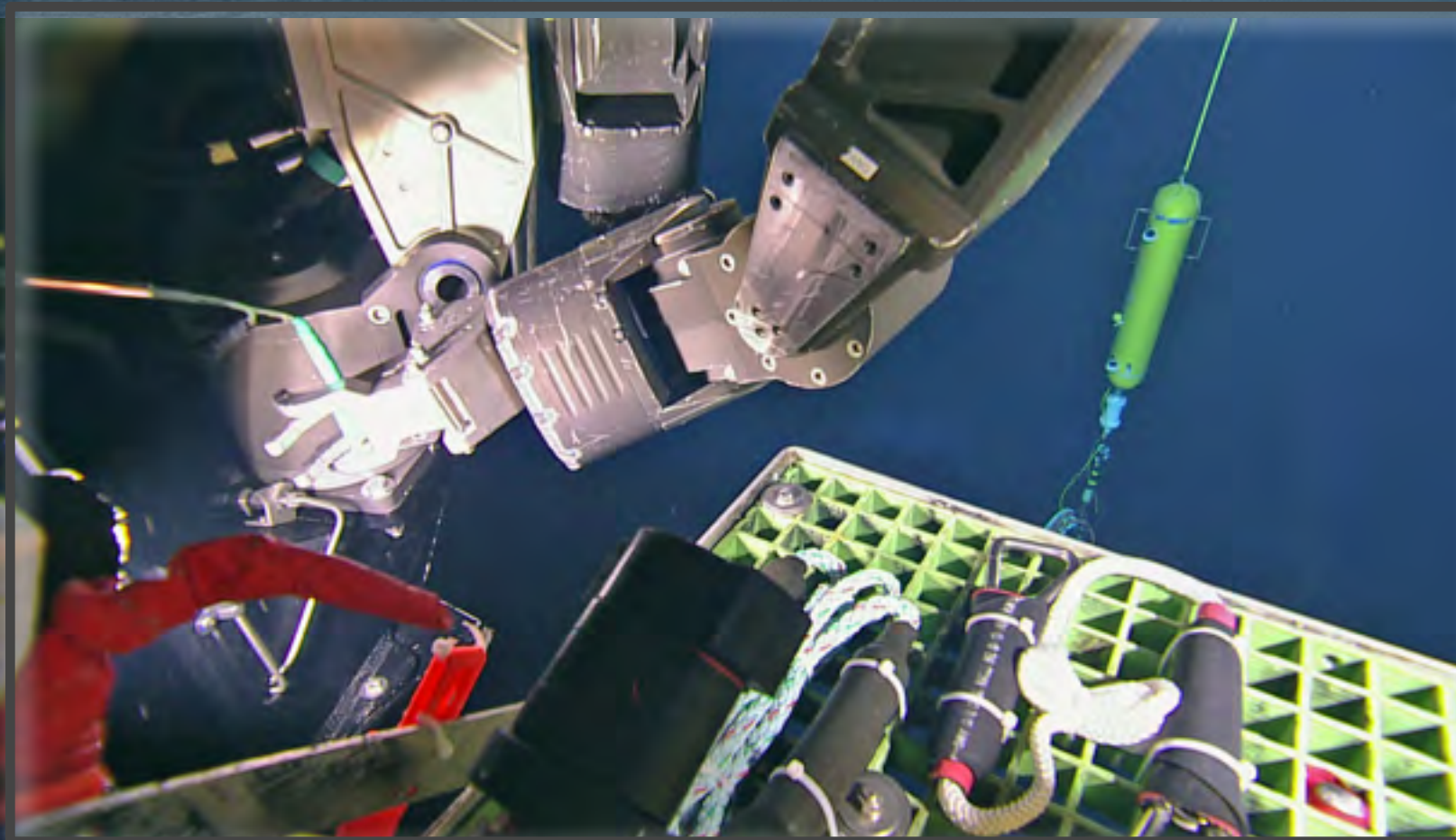


 Junction Boxes | 100% operational

 2 Shallow Profiler Moorings 100%

 Axial Connector damaged 2017 or 2018 during ROV work

Deep Profiler Status

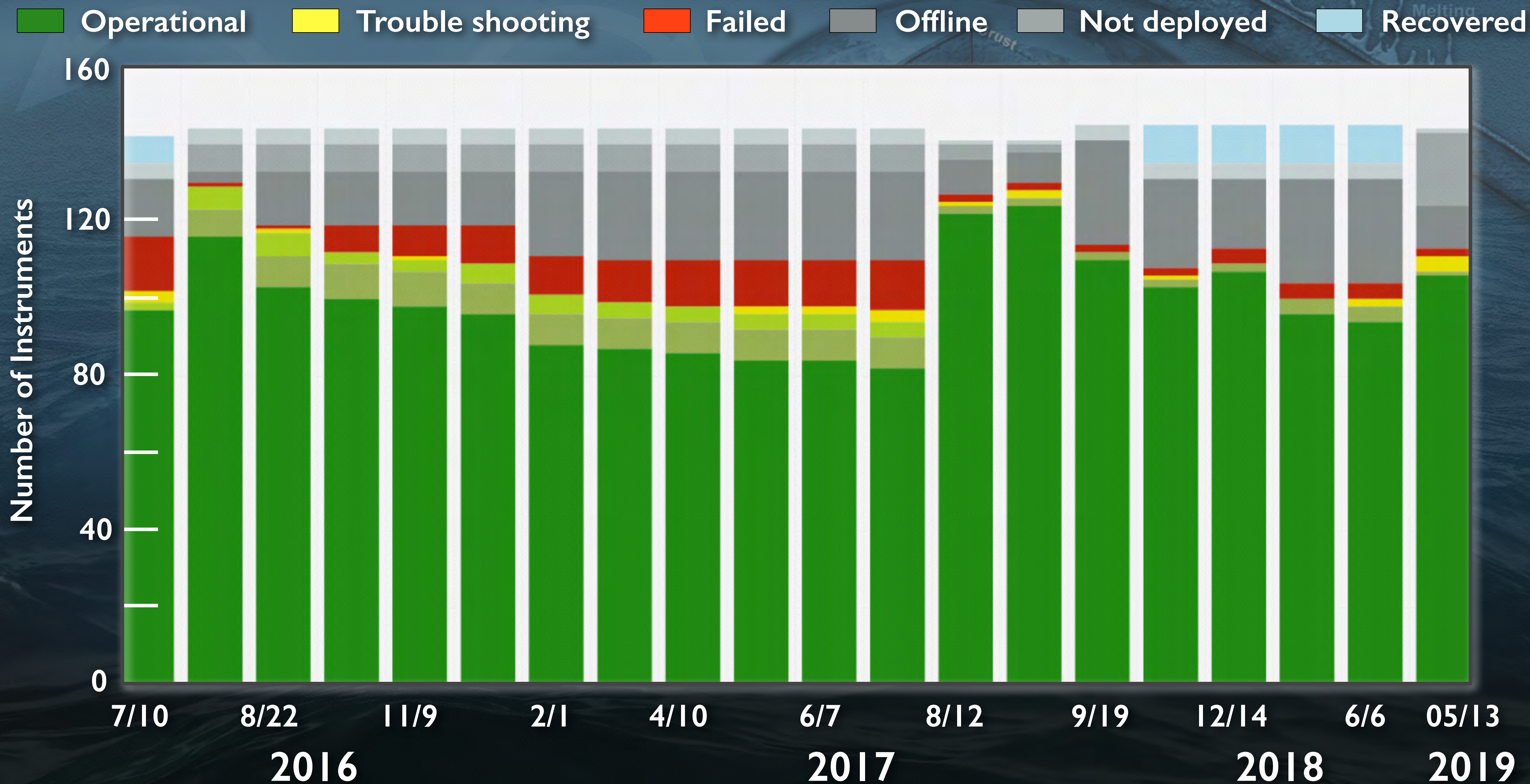


Niskin Verification Sample

- ▶ 2018 two moorings turned (Slope Base & Offshore), 3 vehicles turned
- ▶ Axial Base: **1,800,000 meters** of profiling from July 28, 2018 to April 24, 2019 2600 m to 500 m water depth; May went to 1000 m, data still being sent to shore: data not yet in CI - need playback
- ▶ Oregon Offshore: Vehicle worked until March 13, 2019, but either buoyancy issue or fouling on the cable prevented vehicle from rising > 1 m above the dock; instruments continued to collect data
- ▶ Slope Base failed, developed issues August 16, but was profiling intermittently, system stopped charging September 19, 2018 and vehicle communication lost.

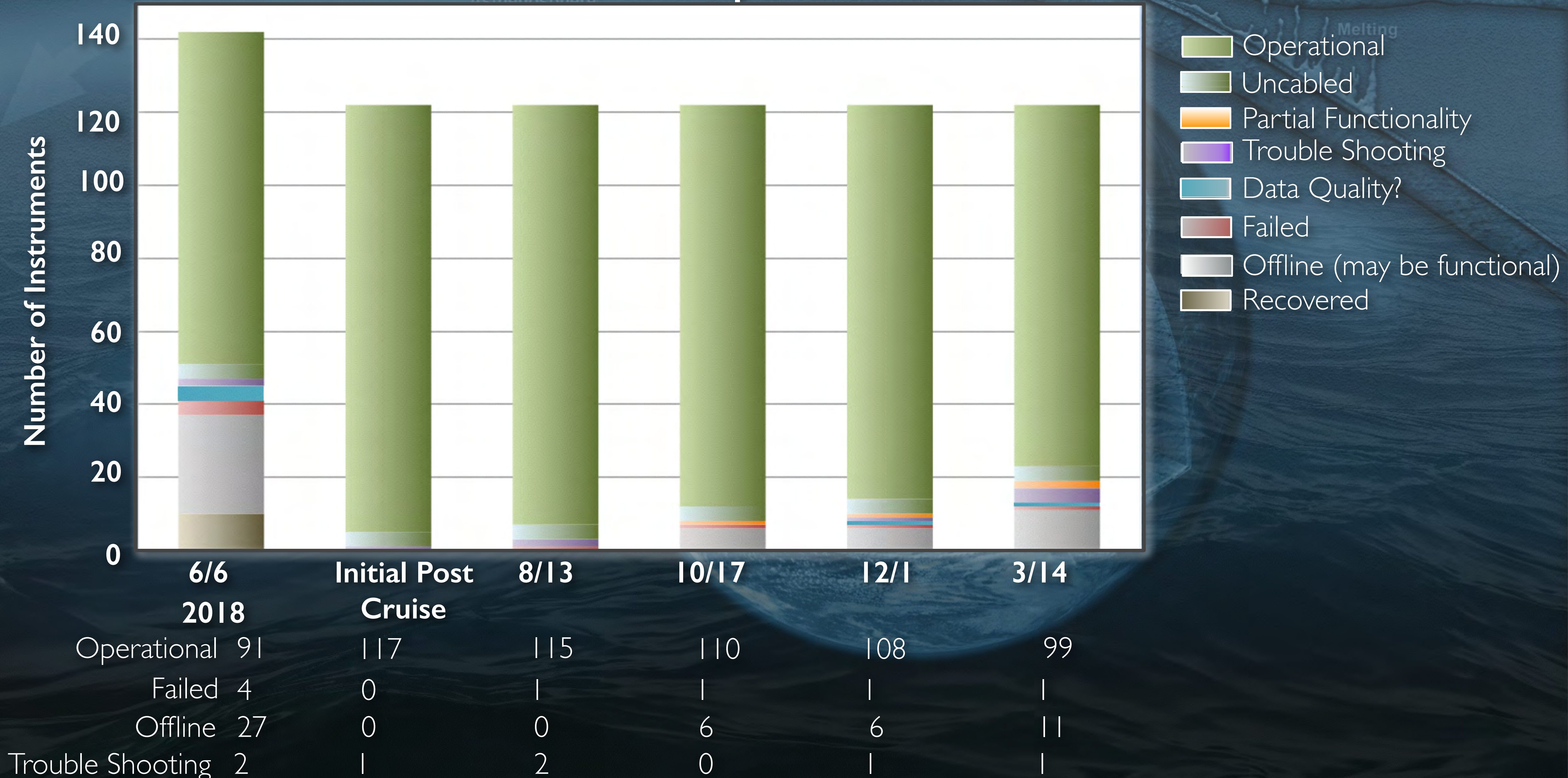
Blue Ocean RCA Instrument Status

Weathermap: Status of all Instruments Live Updates



Cabled Array Operational Status

Cabled Instruments - 84% Operational March 2019



NW GigaPop-UW Partnership Operates and Maintains West Coast Cabled Array Network Including Backhaul

Portland Pittock Building now a pass through - all West Coast CI servers moved to UW IT Data Center 5 minutes from Cabled Array Operations Center - efficient “remote hands”



- ▶ RCA raw data including Port Agents and Logs (Software that “listens” to cabled instruments and places data in a message queue to be uFrame- ingested. Logs contain configuration information in the data e.g., instrument and server IP addresses, port numbers etc) streamed through Pittock, PNW Gigapop directly to Rutgers
- ▶ Raw data without Port Agents (i.e. no IP addresses) flows to UW-located RCA servers and pushed once a day CI-Rutgers
- ▶ All PI raw data, products, documents stored at UW-located RCA servers and pushed once a day to CI-Rutgers

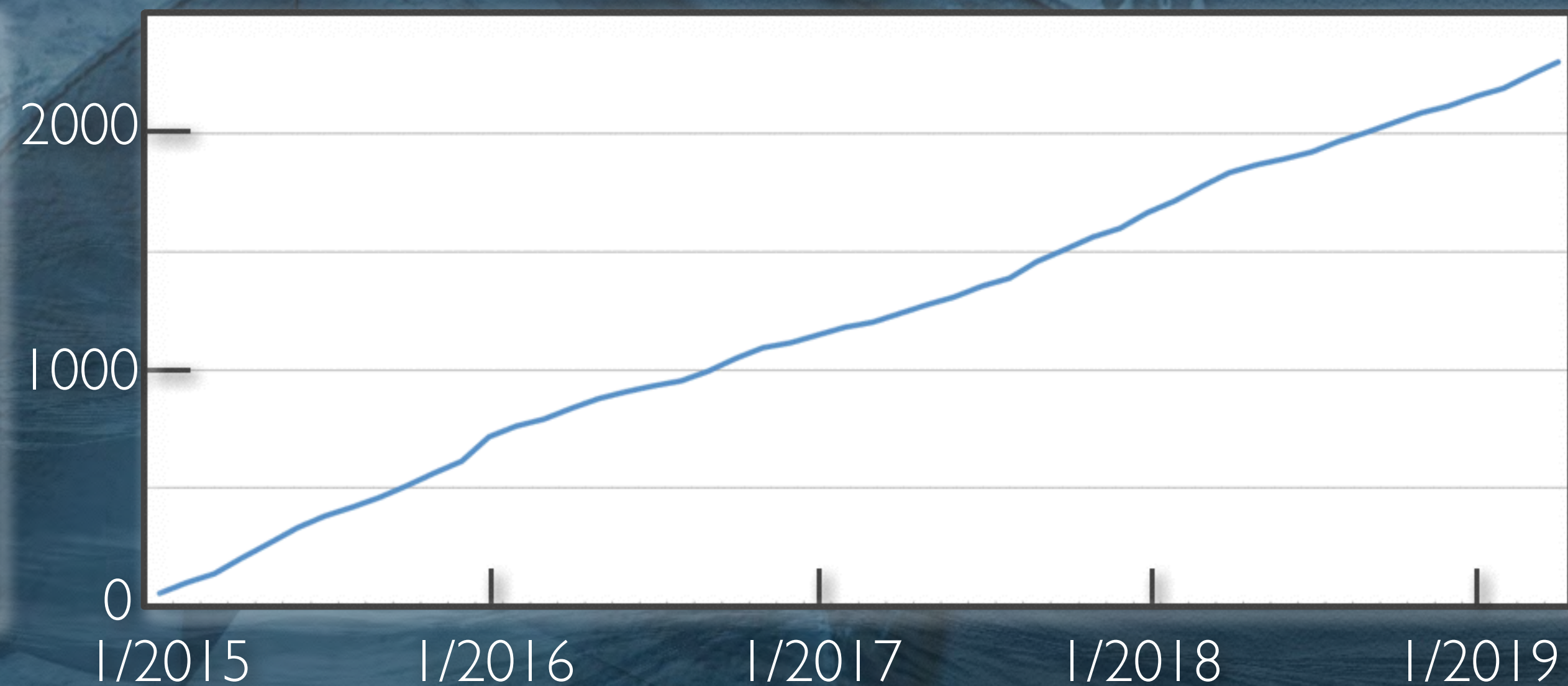
IRIS USER INFORMATION: SEISMIC DATA

Users continue to increase

Repeat Customers



Unique Addresses



- ▶ Total Gigbytes Downloaded = 14,857
- ▶ User base continues to increase ~ 574 repeat customers
- ▶ Project Eddie Environmental Data-Driven Inquiry and Exploration
- ▶ Request to NSF to incorporate Cabled Array data into ShakeAlert
 - Early Warning System for West Coast

Expansion of Cabled Array - PI Instruments

PI Instruments Now On Cabled Array

- ▶ 2017: Chadwick (OSU-NSF) Bottom Pressure Tilt and CTD - ASHES
- ▶ 2018: Bemis (Rutgers-NSF) COVIS Flow Imaging Sonar - ASHES
3 uncabled thermistor array* 2019
- ▶ 2018: Sasagawa and Zumberge (UCSD-NSF) Self Calibrating Pressure Instrument - Central Caldera
- ▶ 2018: Wilcock (UW-NSF) Flipping Tilt Meter Central Caldera
- ▶ 2018: Breedlove (ONR) Vent Energy Harvester (platform)* 2019



Transitioned
to CORE
2019

BOTPT



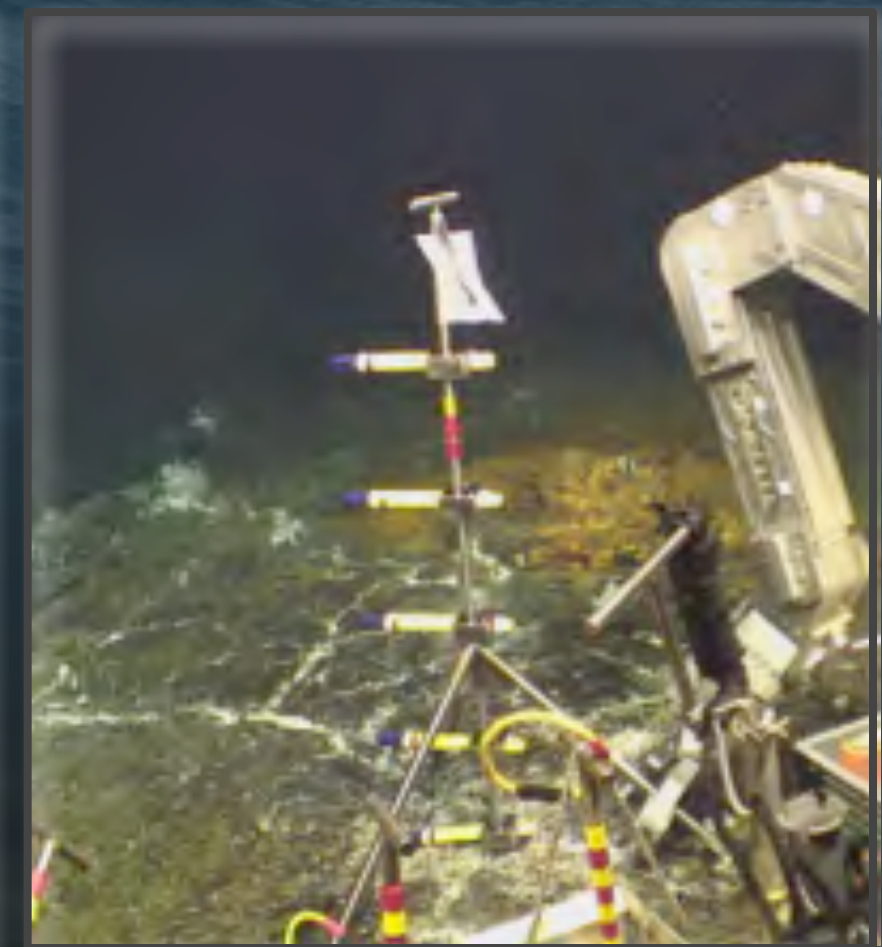
COVIS



Self Calibrating



Flipper



Thermistor Arrays

Expansion of Cabled Array - PI Instruments 2019 - Legs 3-4

Turn 3 instruments and install PI 4 uncabled and 3 new cabled instruments onto the RCA

- ▶ Bemis (Rutgers-NSF) COVIS Flow Imaging Sonar - ASHES - Recover and repair (3 days)
deploy two 2 m-tall uncabled thermistor arrays, conduct thermal survey 20-50 stations
- ▶ Wilcock (UW-NSF) A-0-A Self-calibrating pressure sensor (1 day) - Central Caldera
- ▶ Chadwick (OSU-NSF) two additional cabled CTD'S & 8 mini bottom pressure recorders Axial Caldera (1 day each year, 5 years)
- ▶ Reimers & Girguis (OSU & Harvard - ONR) Benthic Observer Platform - Recover Offshore, Install new platform Southern Hydrate Ridge, 32 push cores
- ▶ Breedlove (Creare - ONR) Vent Energy Harvester - cabled camera & uncabled flow meter (1 day)
- ▶ Bohrmann & Marcon (MARUM-Germany) Recover and reinstall overview sonar (now images 700 m distance; install cabled 4K camera (1 day)

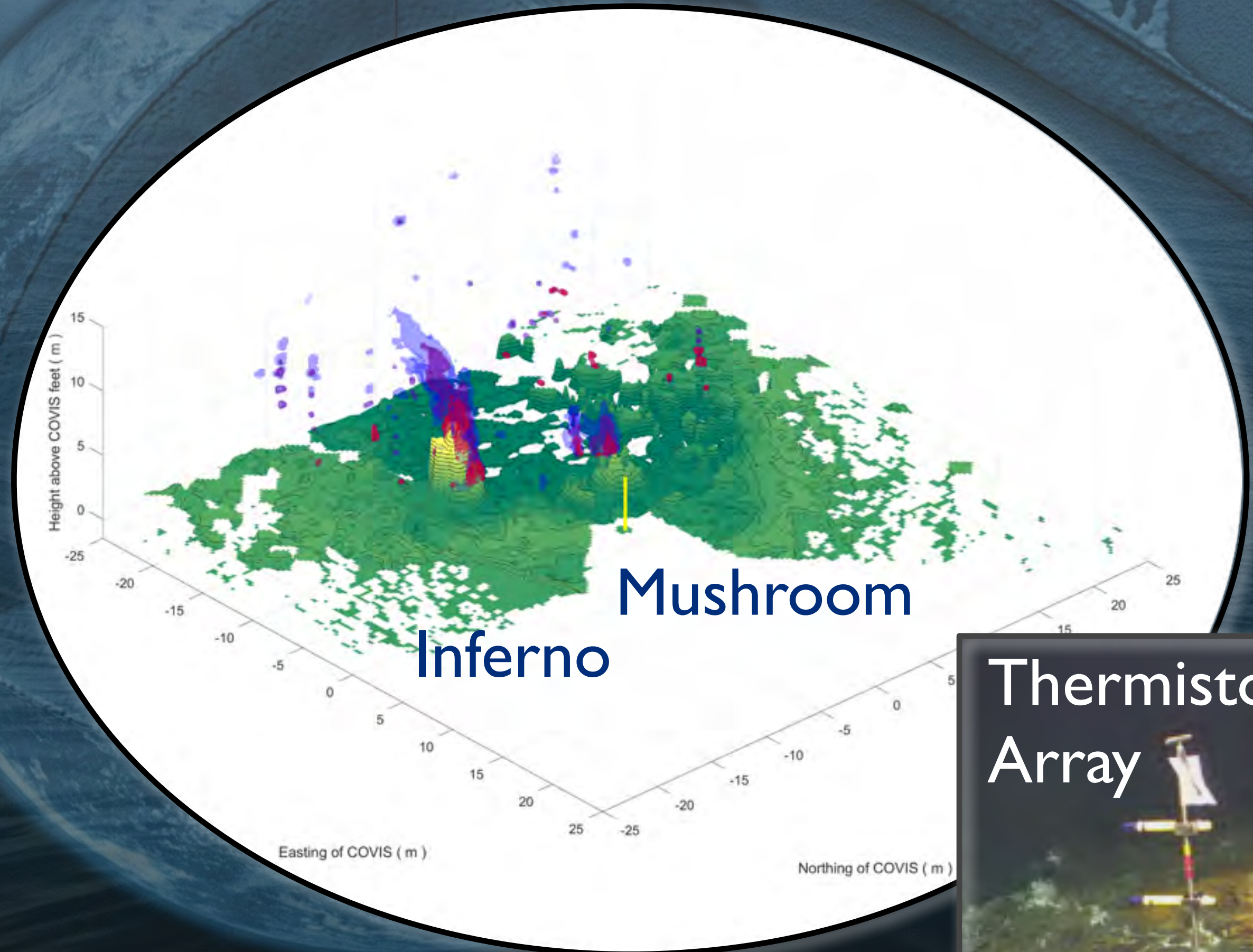
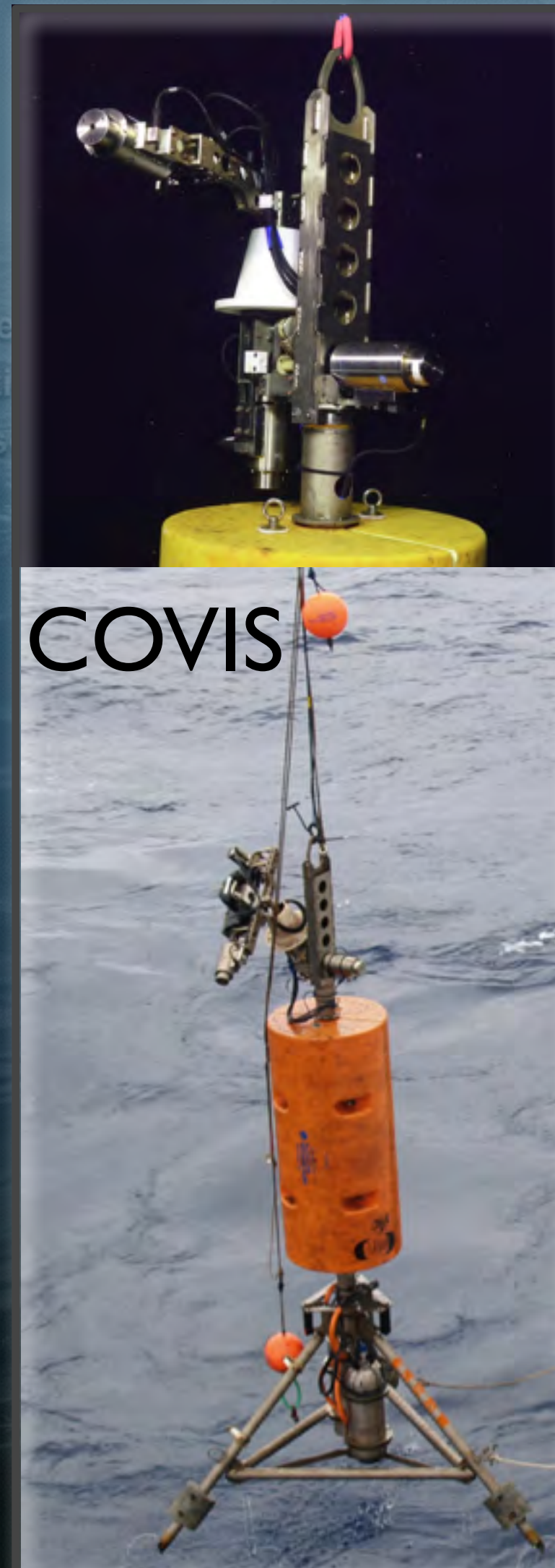
Cabled Observatory Vent Imaging System (COVIS) 2017-2022

Bemis (Rutgers) NSF - Heat flow mapping and quantification at ASHES hydrothermal vent field using an observatory imaging sonar

Inferno



COVIS



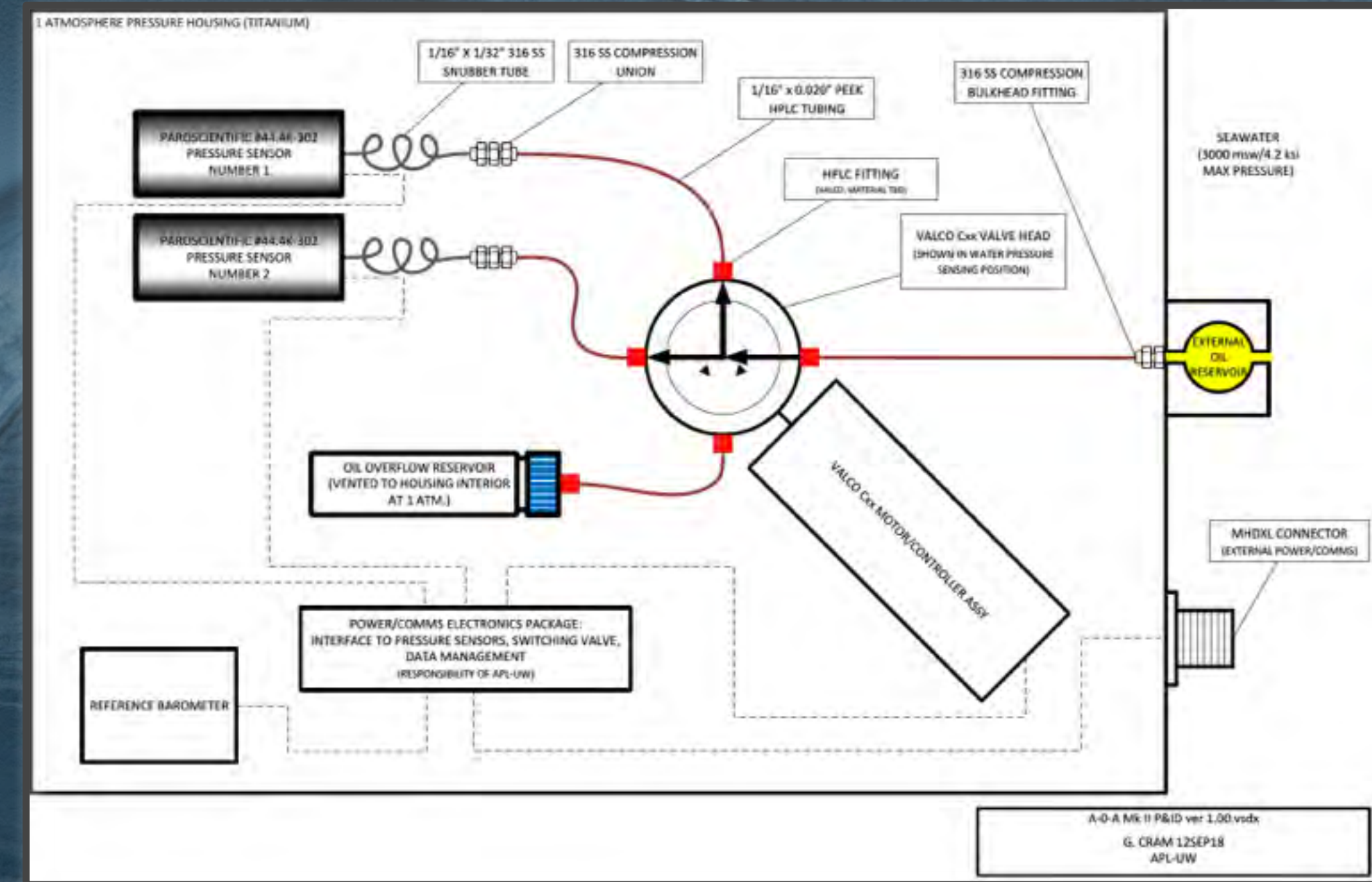
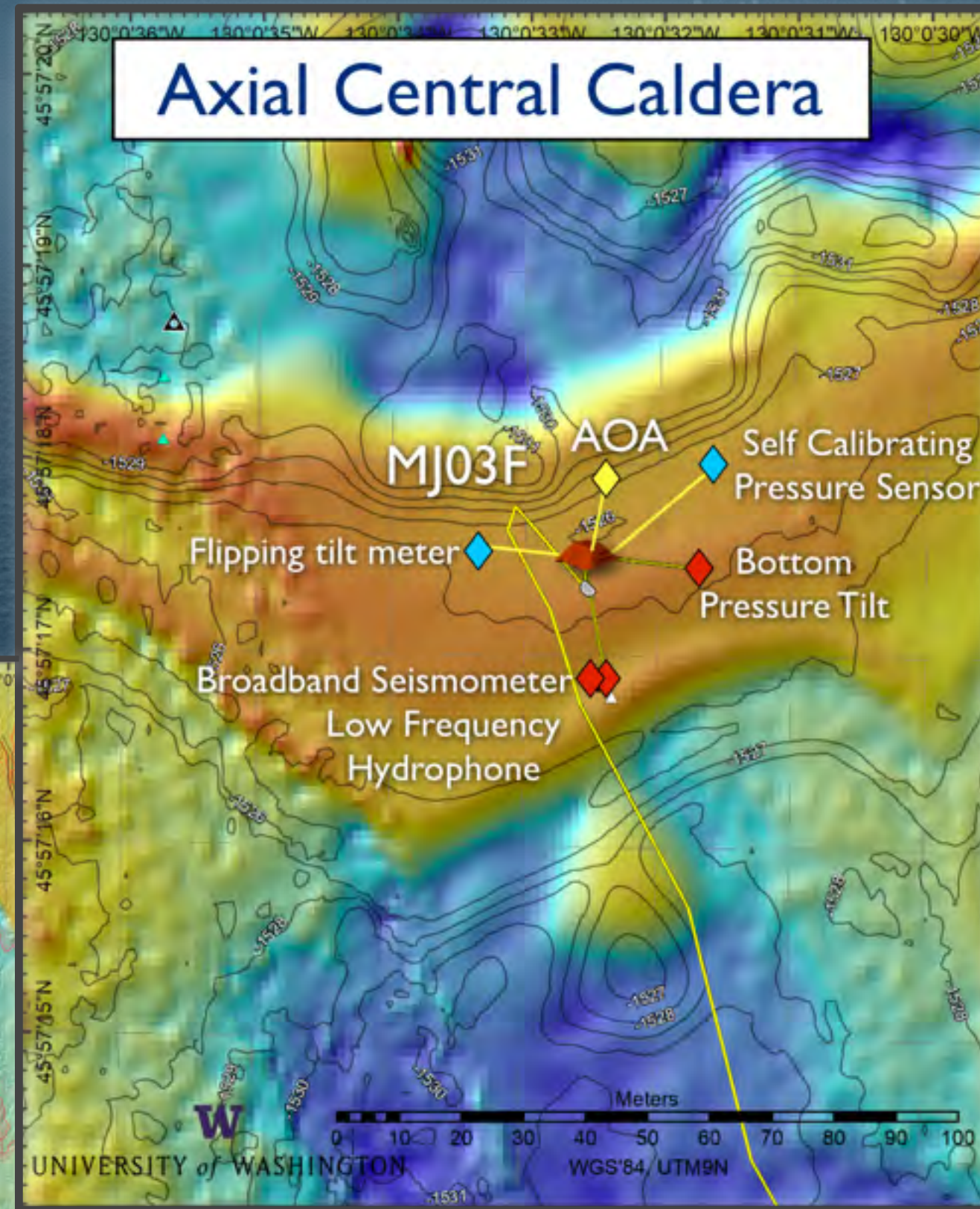
Thermistor Array



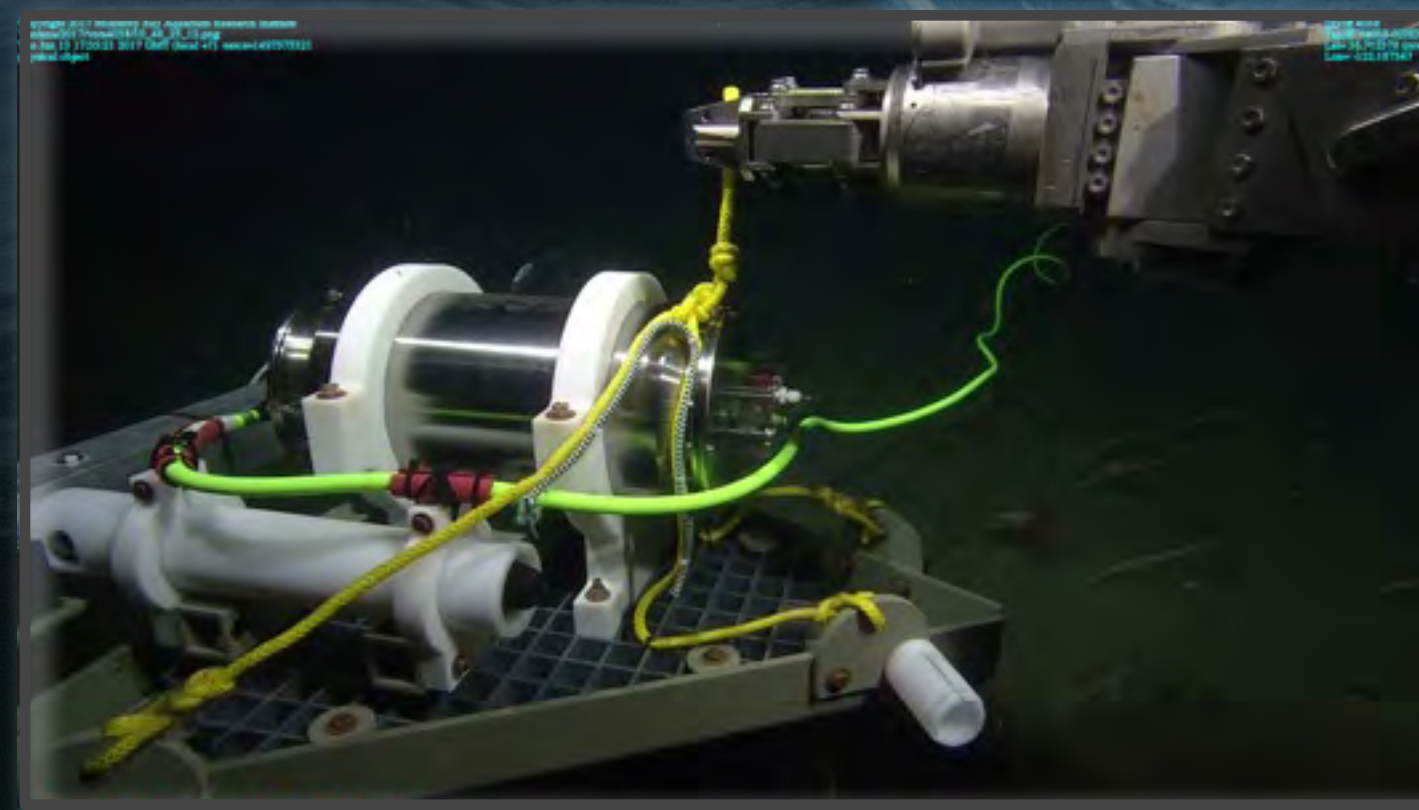
- ▶ NSF supplement to fix sonar head
- ▶ Install 2 new 2-m tall arrays

W. Wilcock (UW) NSF - Self-Calibrating Pressure Sensor (A-0-A

Central
Caldera:
Focused PI
geophysical
study site



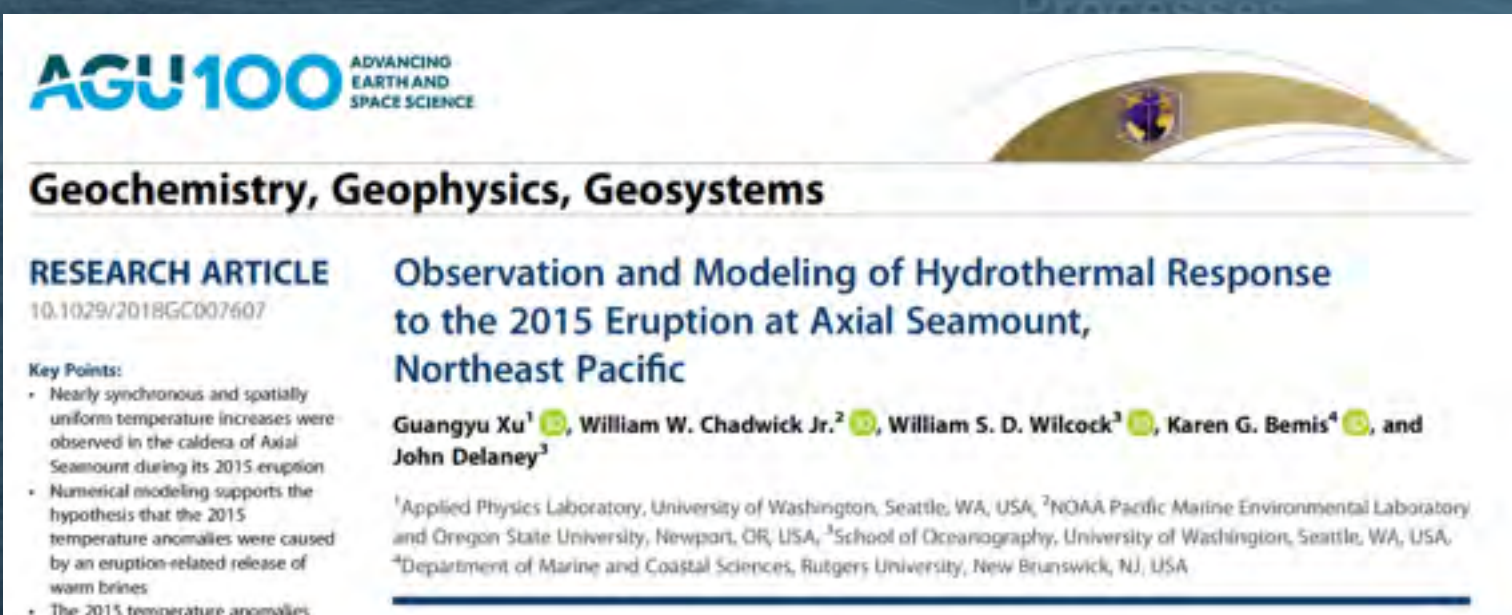
- ▶ Real-time, high resolution monitoring of seafloor deformation at Axial Seamount, extraction of drift component in pressure measurements by measuring ocean pressure compared to pressure ambient inside the housing (valve rotation).
- ▶ Follow-on applications - vertical deodetic studies of Cascadia subduction zone megathrust: patterns of fault locking, creep and slow slip



Expansion of Cabled Array - PI Instruments

- ▶ **NSF** Chadwick (OSU) Phase 2 of Enhancements to the OOI Cabled Array at Axial Seamount (2019-2024) \$625,211 6 years (OCE 1928282 recommended)

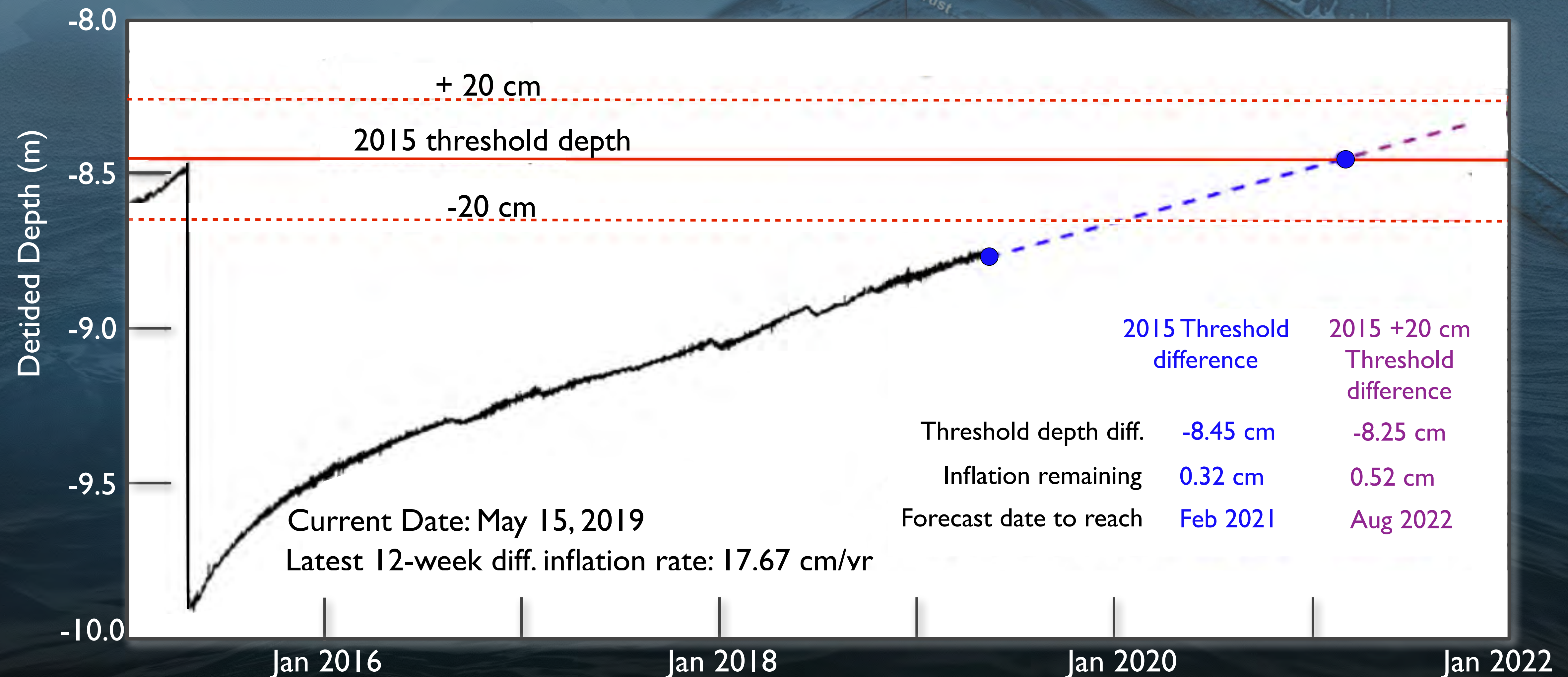
Test the hypothesis that deep-seated brines (formed during boiling) are flushed from the oceanic crust during diking events/eruptions - linkages to crustal hydrology and the deep biosphere (halophiles).



- ▶ Keep Phase I cabled CTD at ASHES for 5 years (on data portal)
- ▶ Add two more cabled CTD's to expand coverage across caldera
- ▶ Includes two additional CTD's for turns each year with ship-ROV-OOI RCA team support
- ▶ Build/install 8 additional bottom pressure recorders to replace 4 moored ones now at Axial, and expand coverage across the caldera as part of long-term geodetic monitoring program complimentary to OOI

Instrument Highlight: Axial Seamount Bottom Pressure Tilt

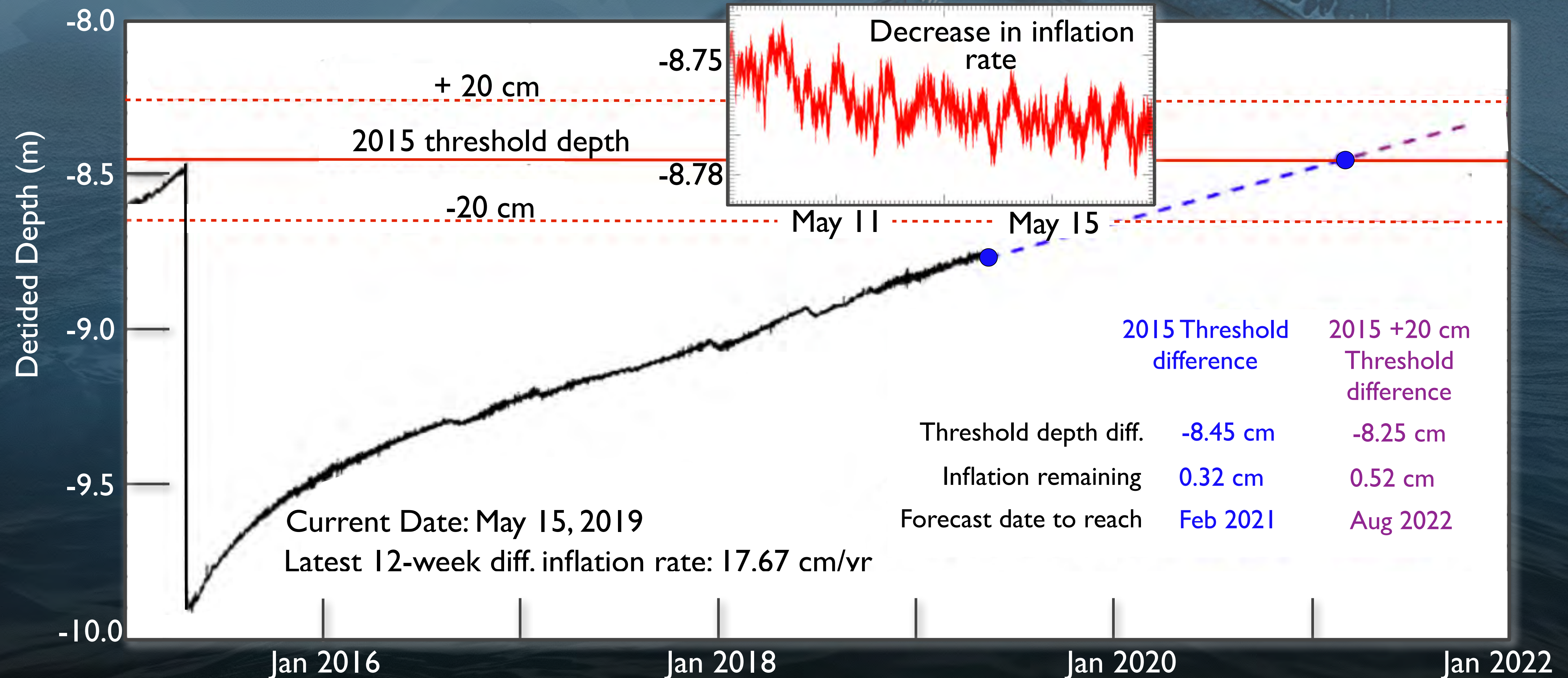
First Volcano Where Eruption May be Predicted



Chadwick: <https://www.pmel.noaa.gov/eoi/rsn/Forecasts3.html>

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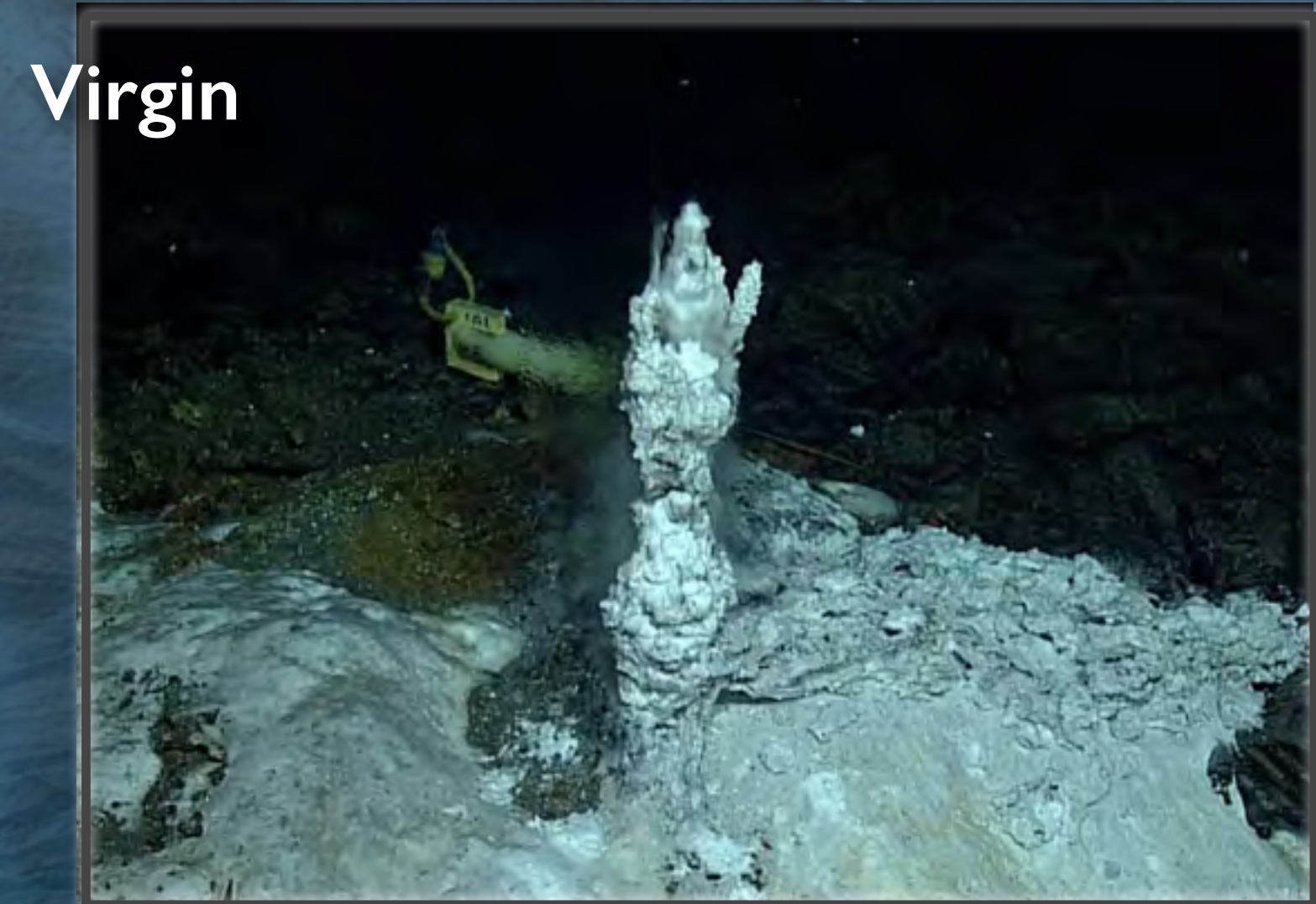
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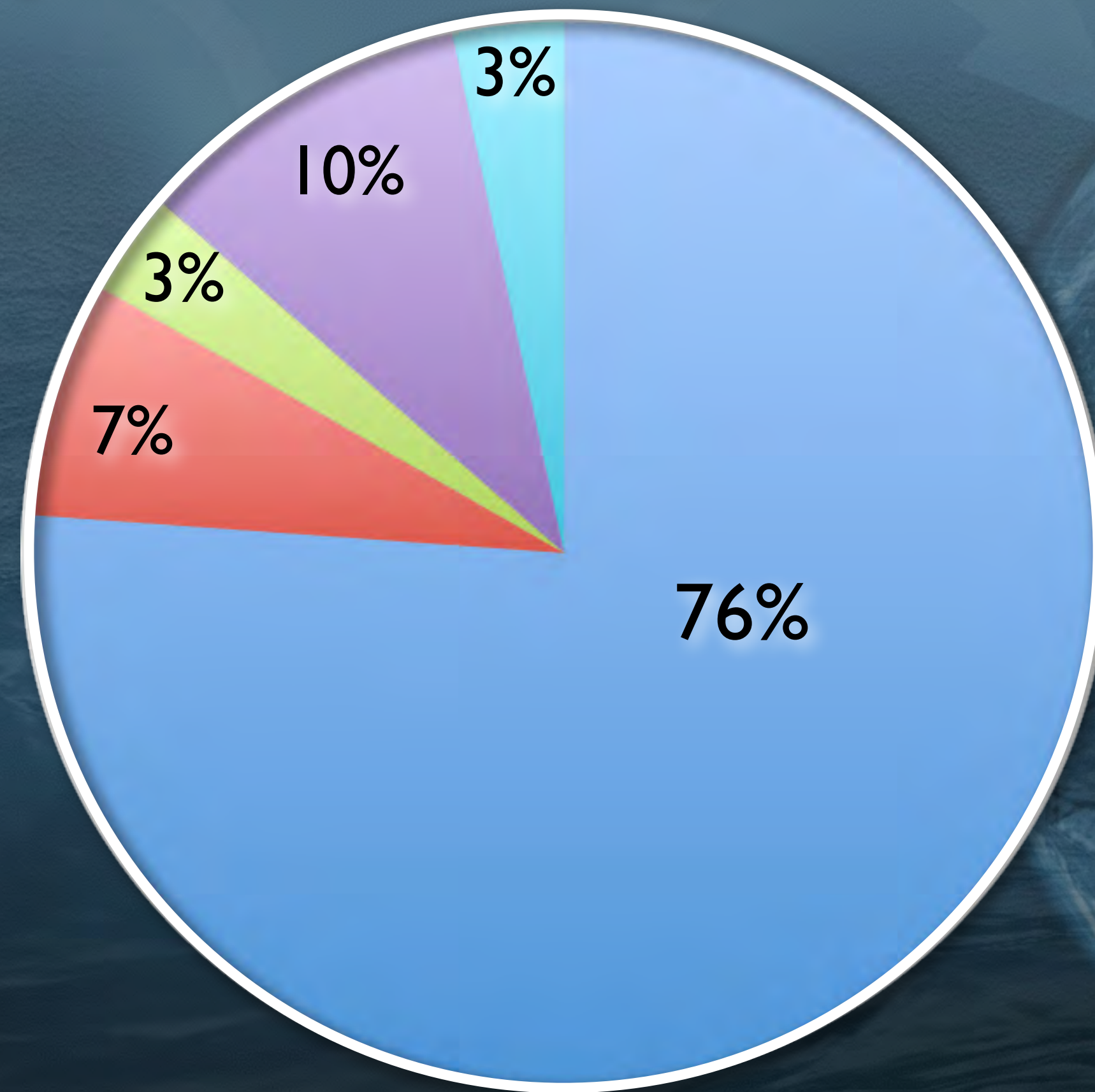
- ▶ **Office of Navy Research** J. Breedlove (Creare Inc) and D. Dyer (UW-APL) “Turbo-Rankin Power system for Deep Sea Hydrothermal Vents. Field programs 2018, 2019, 2020, 2021
 - ▶ Cabled Camera installed RCA 2019 ASHES
 - ▶ Extraction platform 2020
 - ▶ Multiple temperature sensor data will be public
- ▶ **NASA Exobiology:** J. Sobron (SETI Institute) In situ Vent Analyses Divebot for Exobiology Research (INVADER). Field programs 2020, 2021, 2022 (perhaps 2023); Significant outreach
 - ▶ Platform with 3 laser spectroscopic and imaging instruments, real-time visualization, validate operational strategies and adaptive sampling, signatures for life in extreme environments genomic and fluid analyses, Large, multi-year award - PDR May 2019 completed



Regional Cabled Array Awards External to OOI

2016-2019

“If you build it, they will come” M. Leinen, 2006 OOI CDR



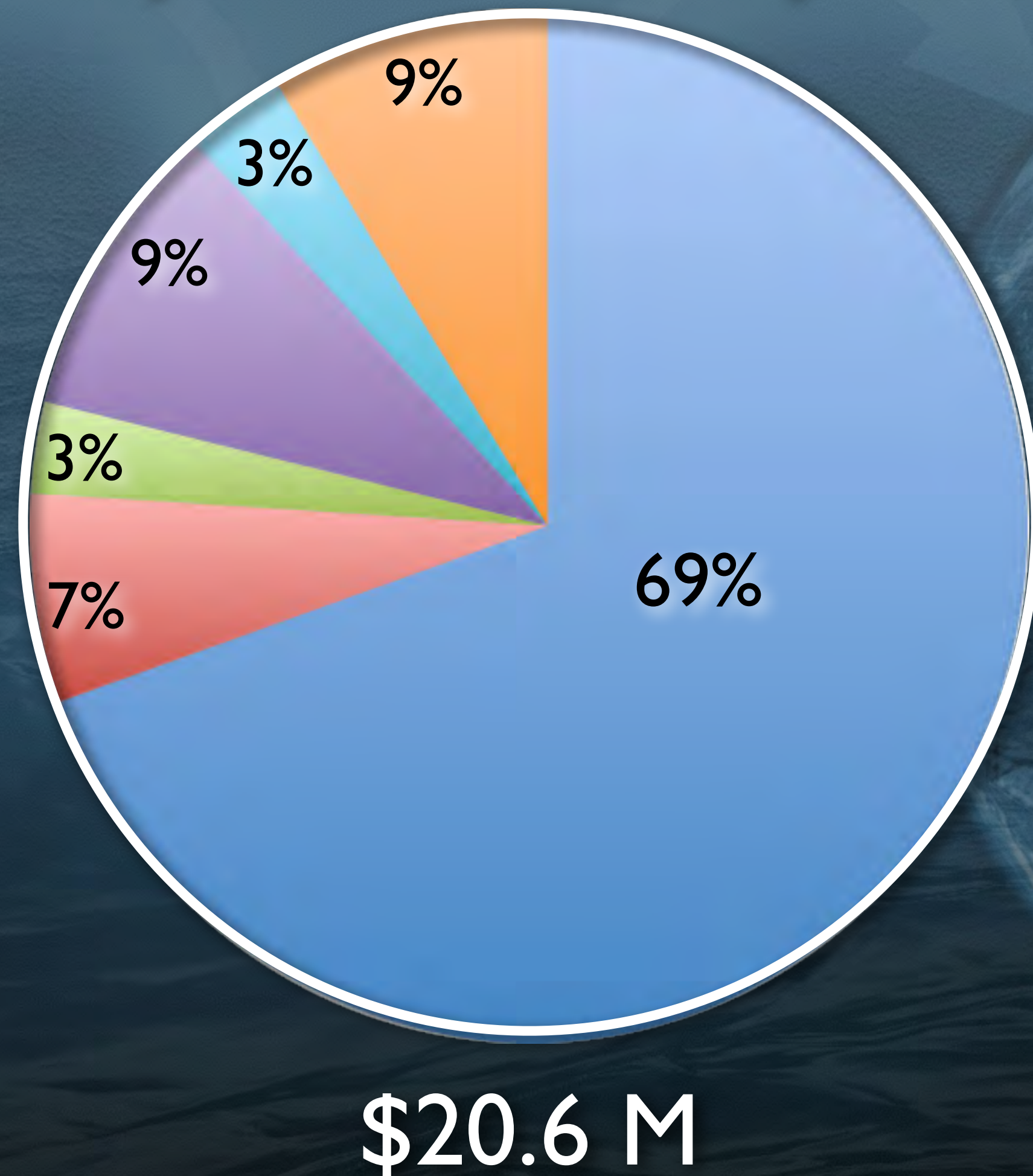
>\$19.5 M

- ▶ 19 PI awards and >10 subawards
 - ▶ >30 Investigators located at 22 universities/ research labs (e.g. JPL, APL); 2 from industry
-
- PI instruments added to RCA
 - Education with RCA focus
 - Development Gift (e.g. Moore Foundation)
 - Research focused on using RCA data
 - Uncabled instruments

Regional Cabled Array Awards External to OOI

2016-2019

“If you build it, they will come” M. Leinen, 2006 OOI CDR



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- PI instruments added to RCA
 - Education with RCA focus
 - Development Gift (e.g. Moore Foundation)
 - Research focused on using RCA data
 - Uncabled instruments
 - Ship + ROV (assume \$75/day)

Access to PI Data Through Oceanobservatories.org



Instrument: Self Calibrating Pressure Sensor (SCPR)
Principle Investigators: Mark Zumberge and Glen Sasagawa
Funding Agency: National Science Foundation
Award: Continuous and Drift Free Vertical Deformation Measurements at Axial Seamount - Installation of a Self Calibrating Pressure Recorder on the OOI Cabled Array (links to award NSF page)

Self Calibrating Pressure Recorder

The Self Calibrating Pressure Recorder (SCPR) was developed by Drs. Mark Zumberge and Glen Sasagawa at the Scripps Institution of Oceanography with funding through the NSF's Office of Technology and Interdisciplinary Coordination (OTIC) and Marine Geology and Geophysics within the Oceanography Program. The instrument includes two redundant quartz pressure gauges that are periodically switched, using motor-driven valves, from the ocean pressure signal to a stable and reproducible reference pressure generated by a piston gauge on board the instrument. By applying the calibration reference pressure value, generated every few weeks, the drift in pressure signals (which can be 10-20 cm per year) can be estimated and removed to create a drift-free time series of seafloor height. The sensors are housed in a 42 cm diameter titanium sphere that is cabled to the medium power junction box MJ03F at the Central Caldera site on the summit of Axial Seamount.

This geodetic instrument is designed to measure seafloor deformation at Axial Seamount caused by build up of melt and gases in the subsurface (inflation) and subsidence (deflation), which rapidly occurs during diking eruptive events. Axial is the largest and most active volcano along the Juan de Fuca Ridge, and erupted in 1998, 2011 and 2015; the 2015 eruption resulted in a ~127 m thick lava flow. Real-time monitoring of seafloor deformation at the summit of Axial, as well as knowledge of seafloor depth at the onset of the past three eruptions is allowing, for the first time, forecasting of when an underwater volcano will erupt.

The SCPR was installed on the 2018 Regional Cabled Array cruise on July 6. It is co-located with OOI Core instruments that include a broadband seismometer and low frequency hydrophone, and bottom pressure-tilt instrument, as well as another PI instrument – a Flipping Tilt Meter (see Wilcock SCTAA).

Instrument Model and Deployed Location

The SCPR (SCPRAA301) was installed at the Central Caldera site at the summit of Axial Seamount at a water depth of 1535 m. The instrument houses a pressure sensor based on the Paroscientific instrument, as well as a temperature sensor.


Series	Make	Model
SCPR	Zumberge & Sasagawa, UCSD-SIO	Self calibrating pressure sensor

Reference Information

Raw PI instrument data for the SCPR can be accessed through the OOI data repository. Within the PI specific instrument ftp site, a read me text file provides information about data formats, calibration information, and instrument data.

Access Data
Access SCPR Data

The SCPR two redundant quartz pressure gauges are housed within a titanium sphere that is cabled to the MJ03F junction box. Credit: UW/NSF-OOI/WHOI V18



The Observatory

Research Arrays

Core Instruments

PI Instruments

Data Products

Marine Technologies

Cyberinfrastructure

Technology

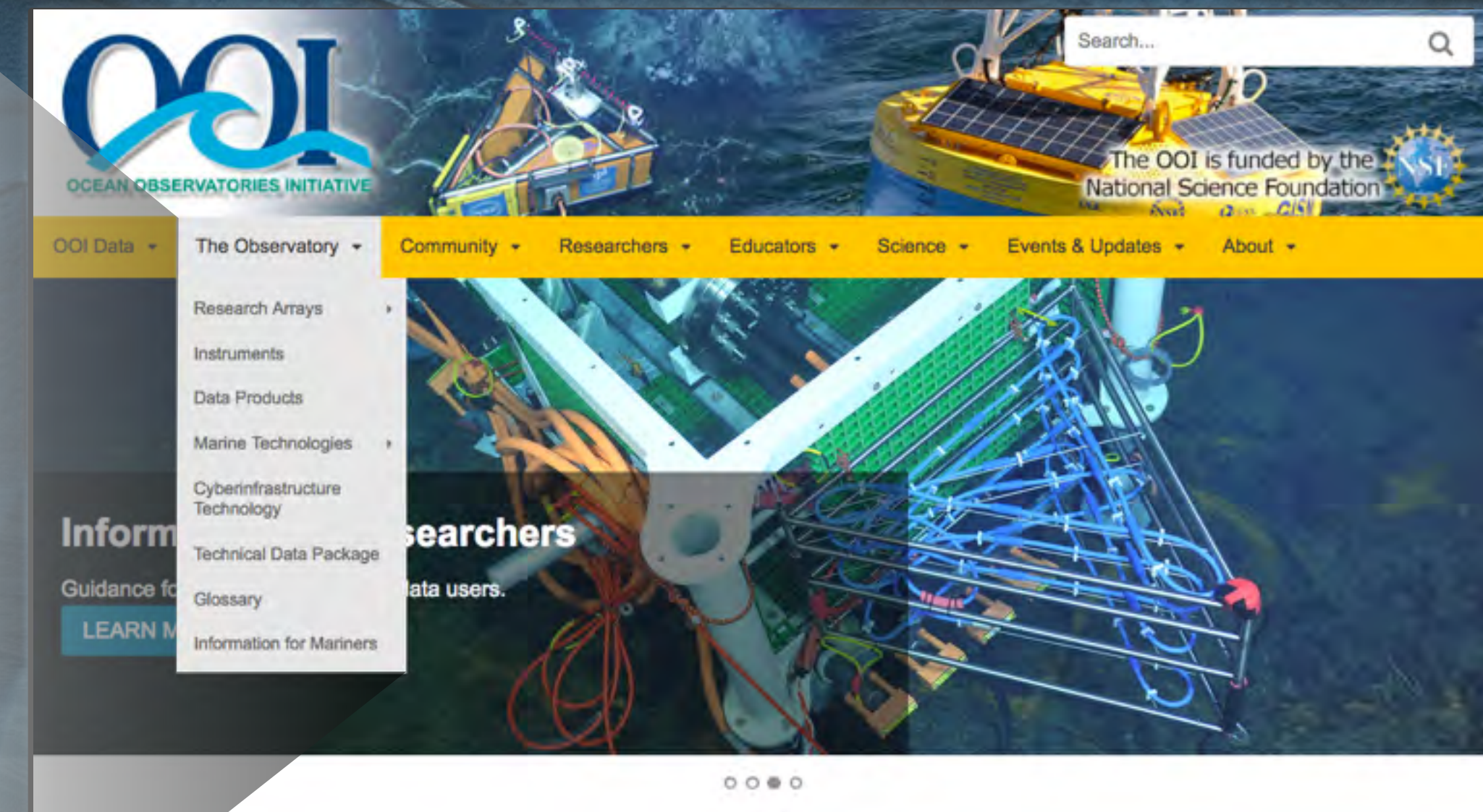
Glossary

Information for Mariners

OOI RSN FTP Site
UW

PI Raw Data Server

PI Processed data &
Products
Readme files



OOI Data
Data Portal
ERDDAP Server
Raw Data Archive
Cruise Data
Live Video from Axial Seamount
Core Instrument Analytical Results
OOI M2M Interface
Sensor Algorithms
OOI Data Usage Policy
Observation and Sampling Approach
Quality Control
Data Issues

OOI Data

Data Portal

PI Instruments

ERDDAP Server

Raw Data Archive

Cruise Data

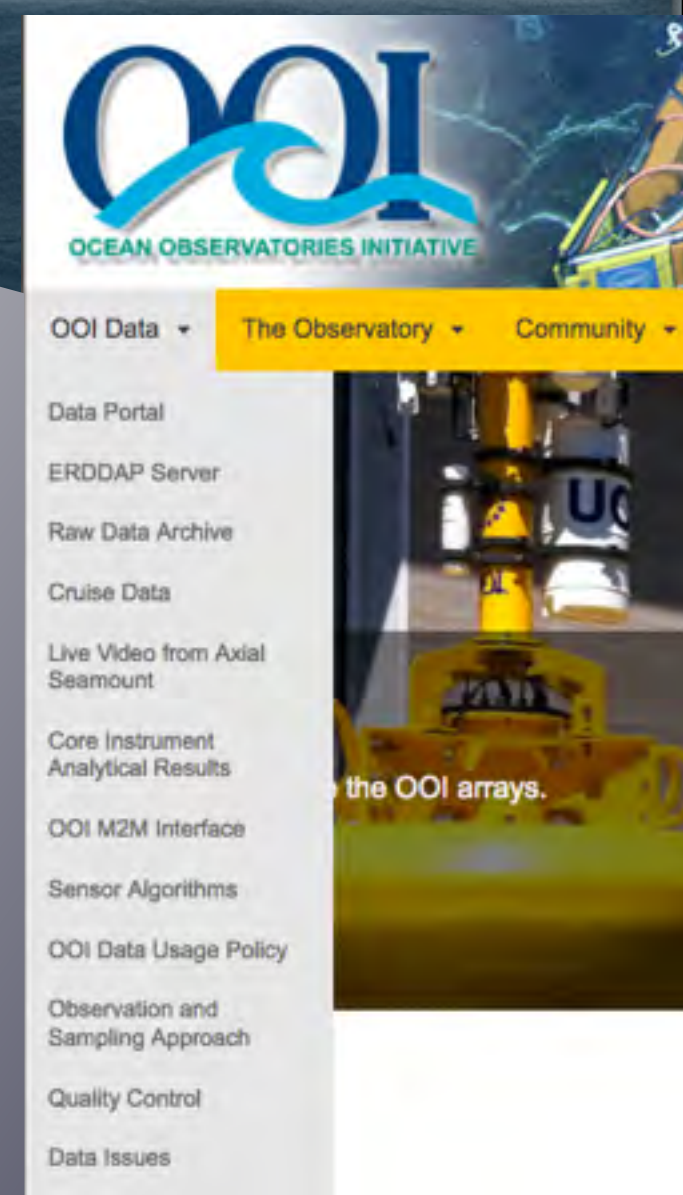
Live Video from Axial

Core instrument

Analytical Results

OOI M2M Interface

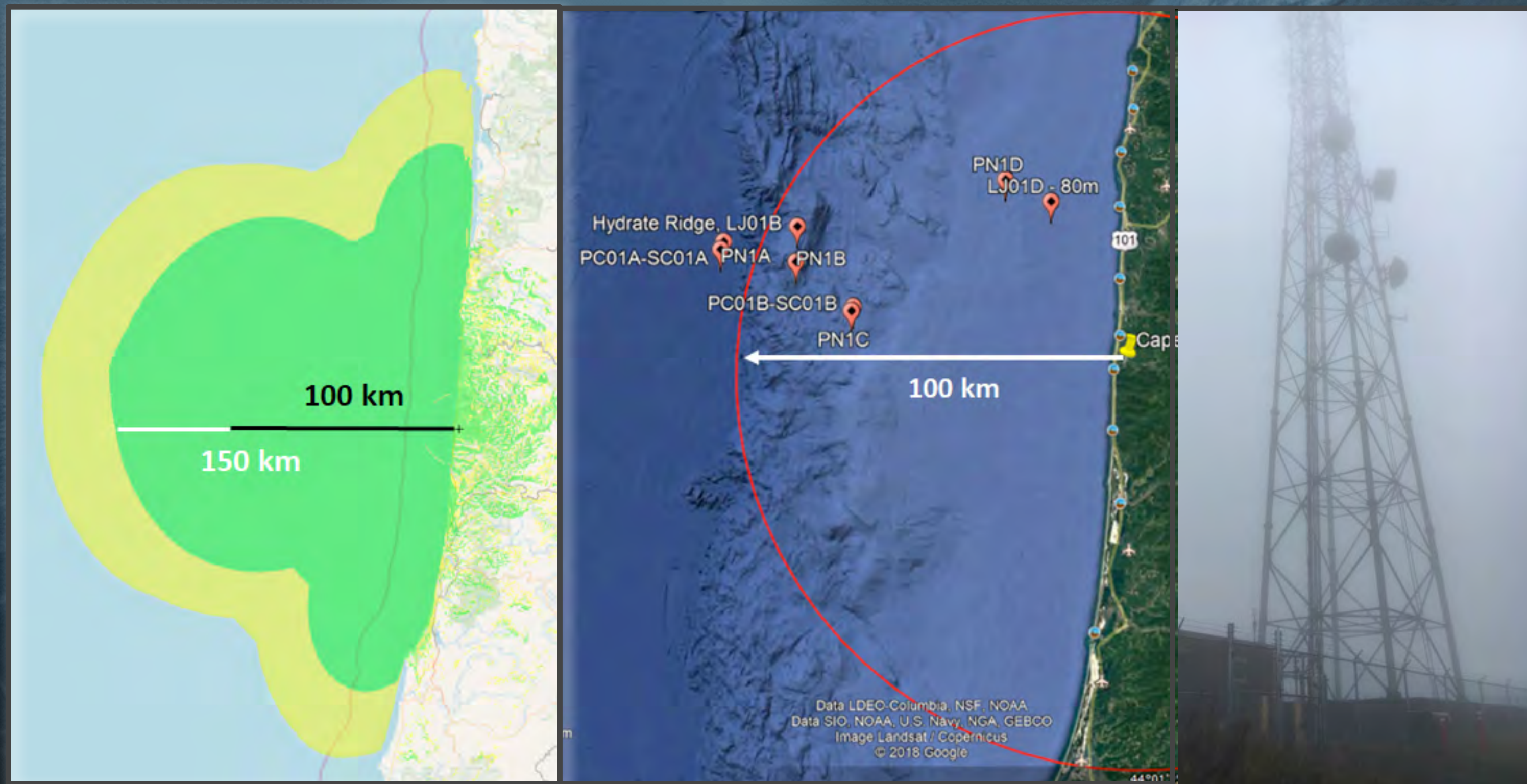
Sensor Algorithms.....



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Virtual Aid to Navigation (AIS - Automatic Identification System)

AIS transmitting information where no physical ATON (aid to navigation) exists (e.g. lighthouses, buoys, moorings)

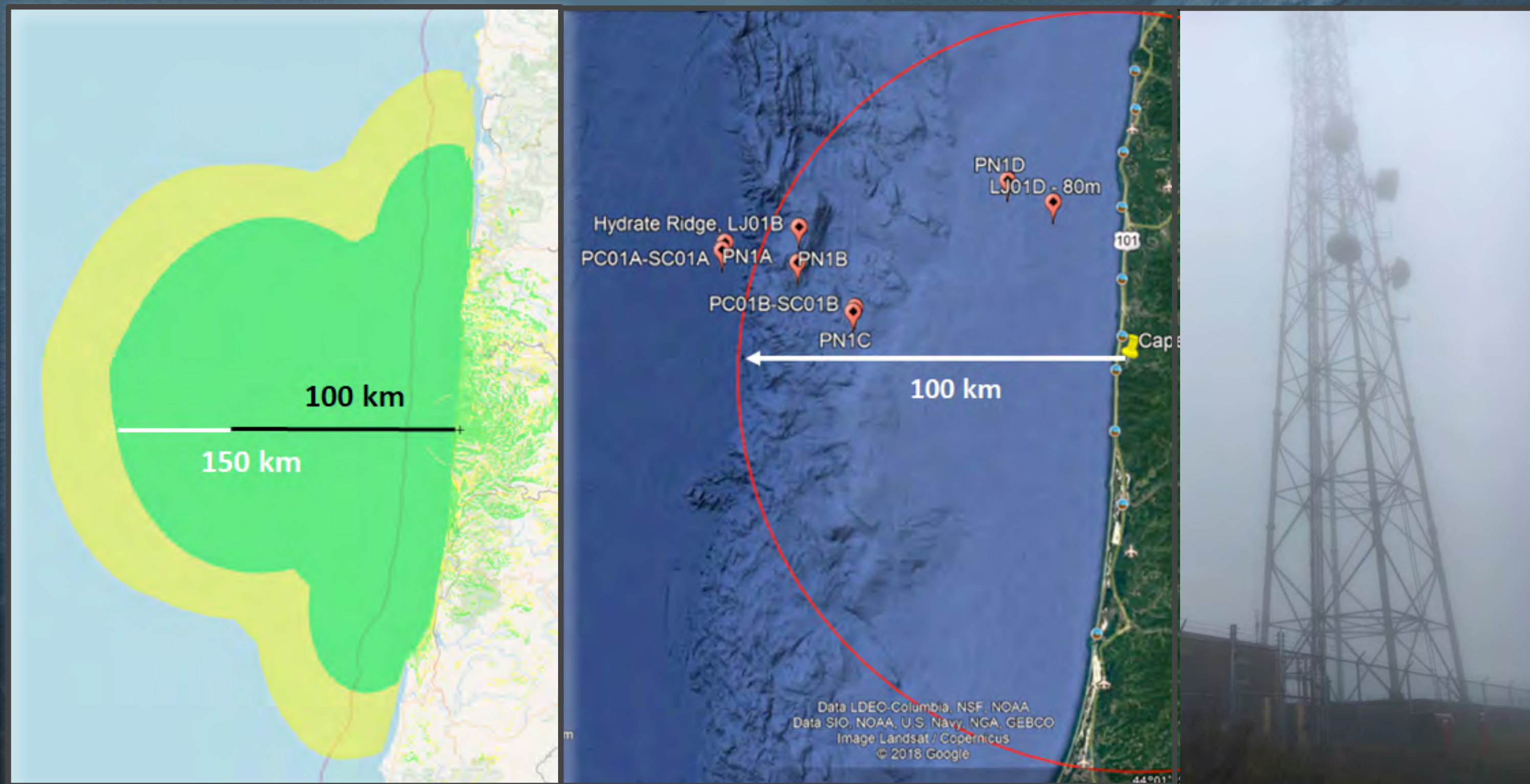


AIS broadcasts from shore with the navigation aide seen on an chart display, ships radar etc . Manual alerts can be sent

- ▶ All our infrastructure is underwater; Offshore site trawled Fall 2018 - Shallow Profiler Mooring
- ▶ Purchased AIS system from Vesper Marine - modeling indicates at least 100 km coverage
- ▶ Owned and installed by Lincoln County Emergency Services
- ▶ Potential partnership with Oregon Coast Repeater Group with addition of OOI antenna on site

Virtual Aid to Navigation (AIS - Automatic Identification System)

AIS transmitting information where no physical ATON (aid to navigation) exists (e.g. lighthouses, buoys, moorings)



RCA sets up virtual targets with a given radius - when a ship/boat gets within a certain distance to the target, a warning is sent to us/boat

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VISIONS: Training Next Generation Students

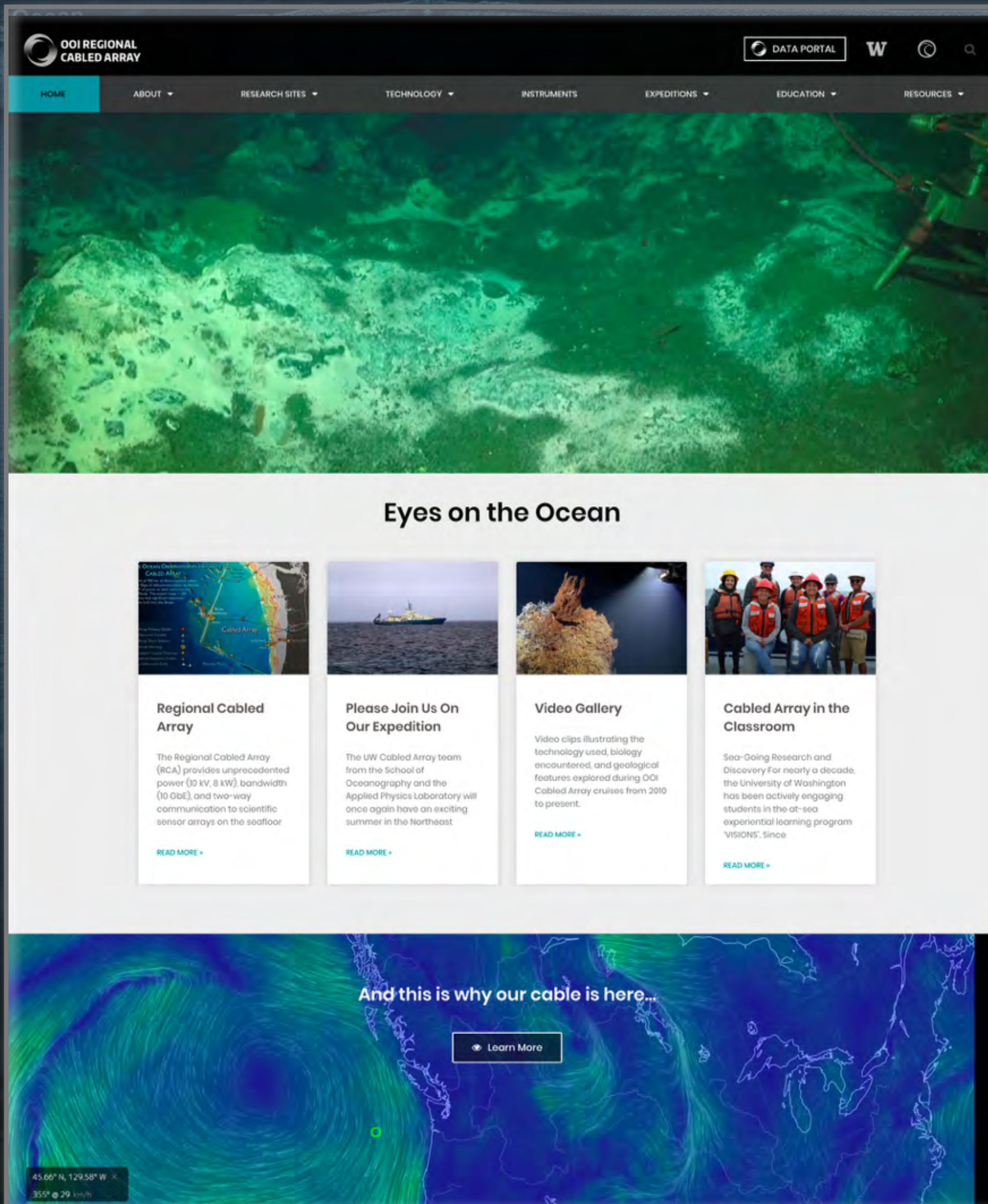
Over 150 undergraduate and graduate students have participated in the NSF-RCA-UW VISIONS educational program; 19 will participate on VISIONS19

- ▶ Entrain diverse population of students - India, China, Taiwan, Korea, Malaysia...
- ▶ Develop science and outreach projects, go back to their K12 schools, community ambassadors
- ▶ Several senior thesis projects, some leading to AGU, IEE, Benthic Biology etc talks, and publications

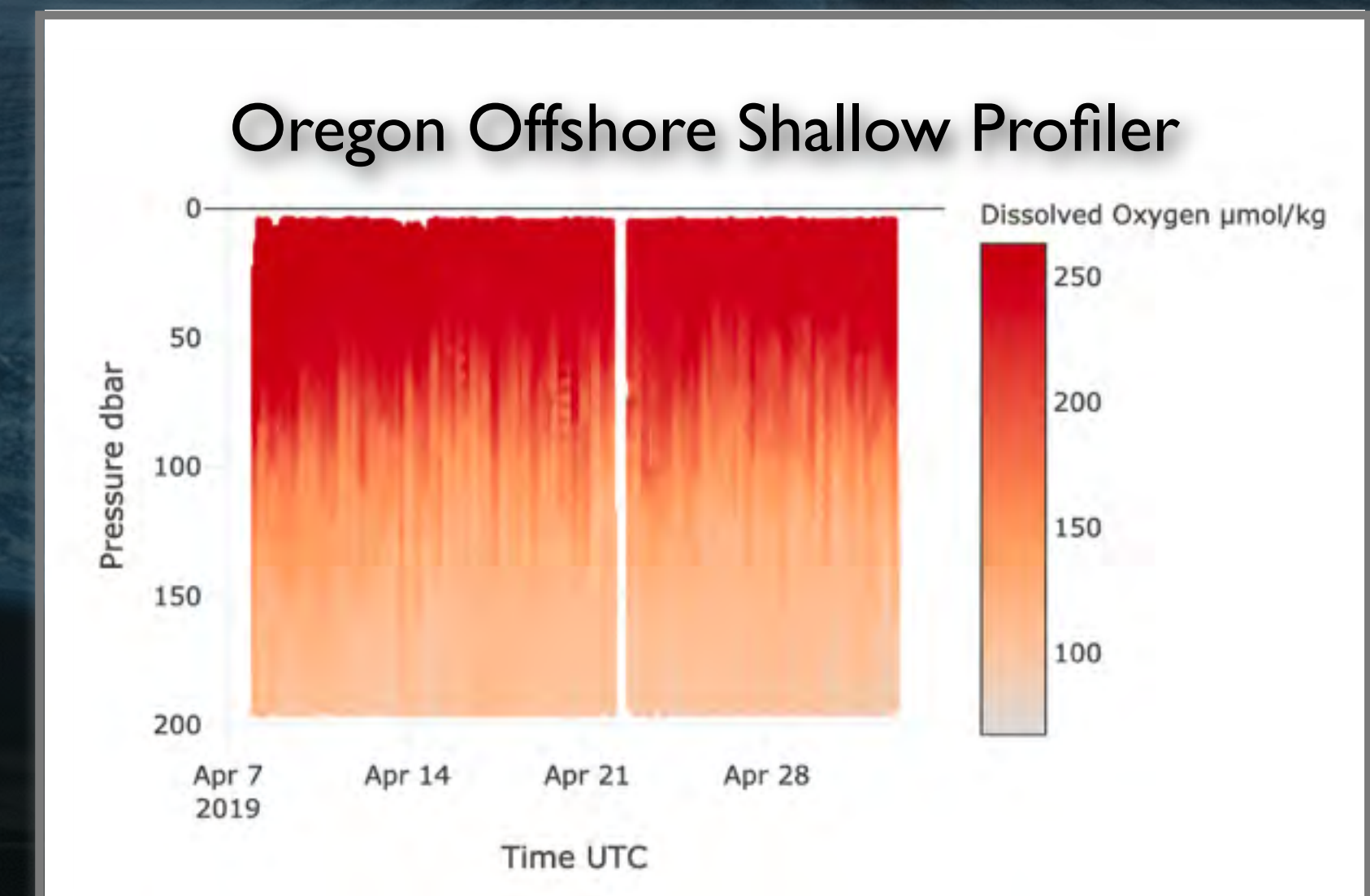
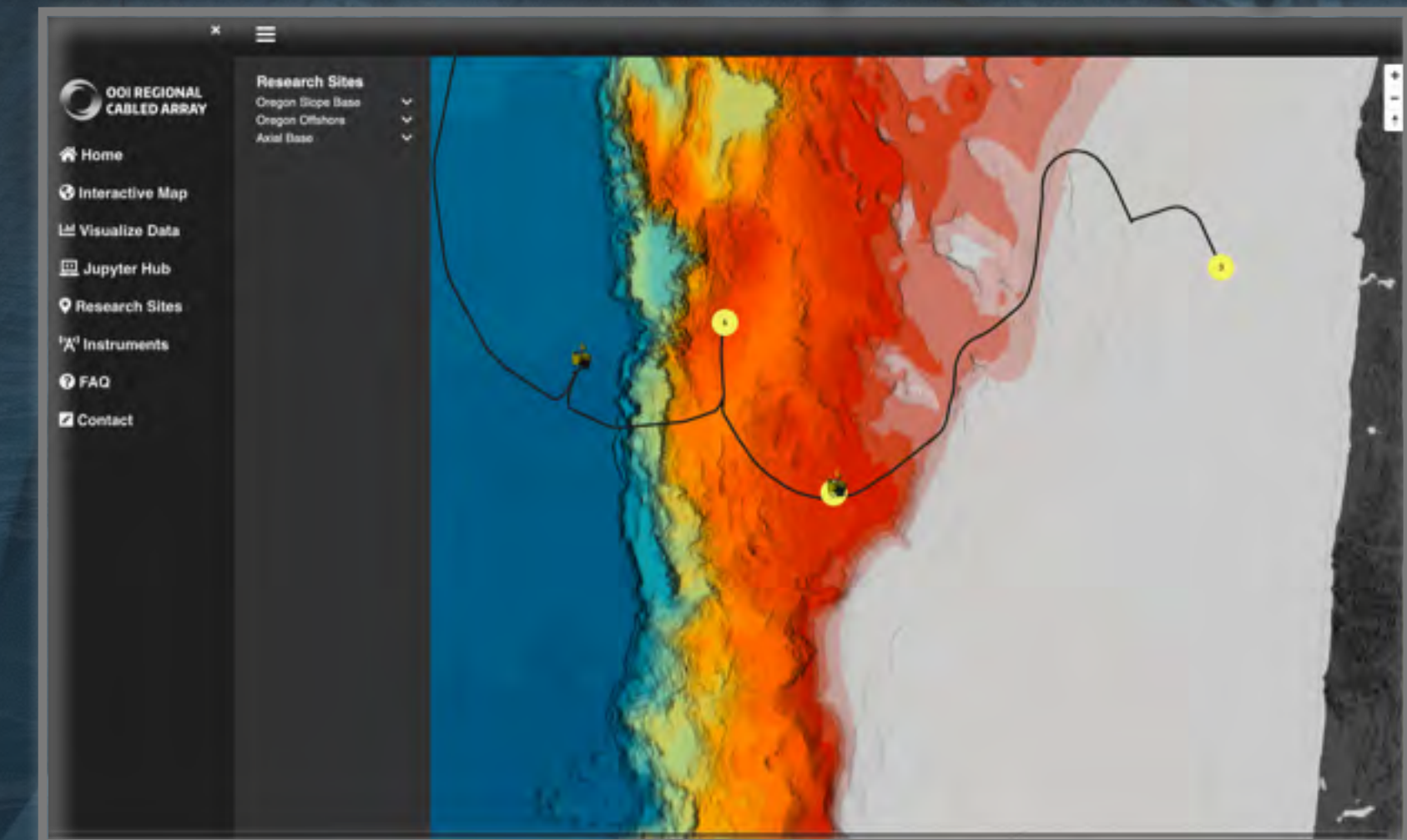


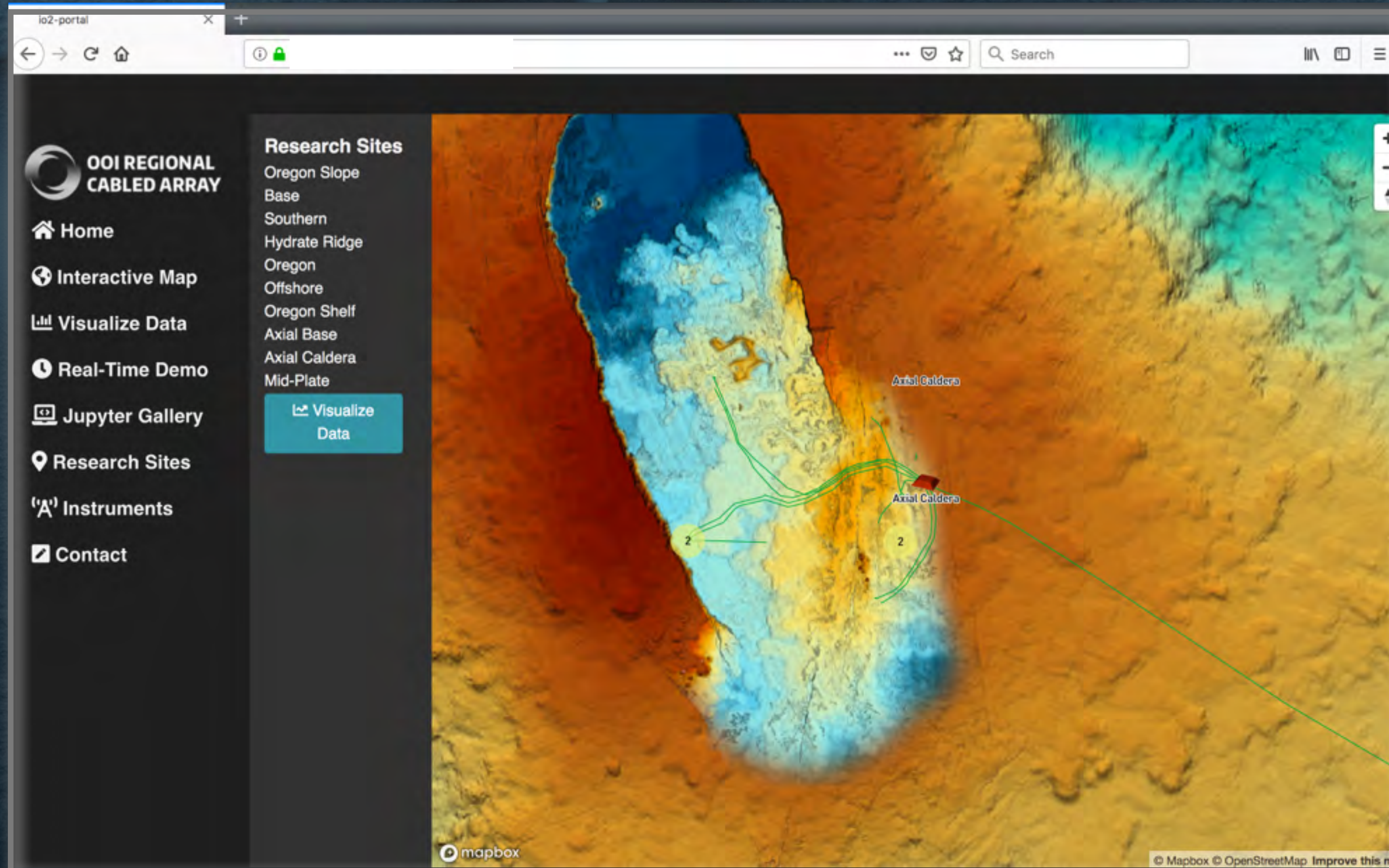
Profoundly changes their lives

M. Rahman "I became obsessed with learning, being open-minded, and curious to the point where my family and friends noticed changes in me when I returned from sea. I embraced the change. Finally, it felt like I was starting to answer the itching question in my mind – who am I and how can I best express myself to do good in this world?"



Launching a new interactive oceans website
Cloud-based science-education site
Orest Kawaka will present
NSF Education Proposal May 2019





- ▶ Implementation of proof of concept back and front-end for hosting and serving data from the public cloud (pulled from u-frame)
- ▶ Highly interactive map interface showing RCA assets that serve as entry point into the Data Visualization Portal
- ▶ Data Visualization Portal with enhanced data search and visualization capabilities
- ▶ Jargon removed, can plot 4 plots on single page, edit each plot (style), range, multivariable, can plot discrete samples versus cabled instrument data
- ▶ Executable Jupiter Notebooks - ability to explore/plot satellite data (e.g. chlorophyl, temperature, dissolved oxygen) and compare to Shallow Profiler 200 m profiler data
- ▶ Educational/outreach tools - science stories and galleries of visually arresting photos and figures, games video and citizen science (megaptera - humpback whale call identification)