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# Regional Cabled Array Update

Deb Kelley & RCA Team

OOIFB Spring 2025


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# RCA Maintenance Cruise AT50-41 (VISIONS'25)

July 31 - September 1, 2025

- 32 OOI-RCA days, RV Atlantis and *Jason*

  turn >100 instruments, 5 junction boxes, 2 BEPs, Axial Base Deep Profiler Vehicls, 4 PI days: 1 B. Chadwick (OSU), G. Xu, D. Soule, K. Bemis 3 days
- Workforce development: NSF Postdoc Katie Bigham Chief Sci Leg 1, 13 VISIONS students, 1 graduate student
- Leg 2 sails August 16: Complex logistics - *Jason* will unplug Oregon Offshore and Slope Base Deep Profiler Moorings Leg 2 & buoy off with surface float

## Deep Profiler Turn Sally Ride

- Depart August 18, will turn Offshore and Slope Base Deep Profiler Moorings
- *Jason* will return and plug them in.

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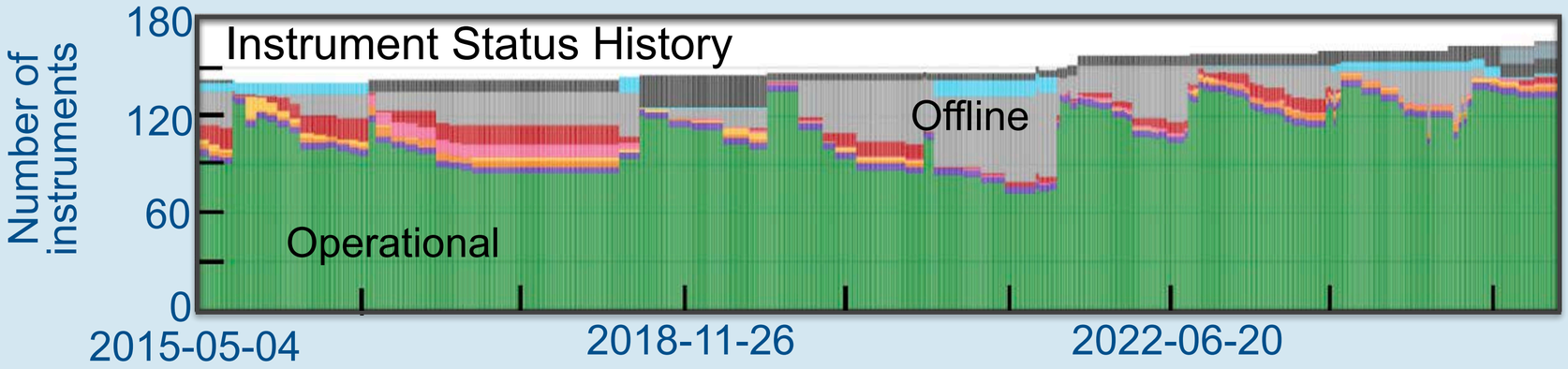
# RCA Increasing Operational Success Over a Decade

Nereus | Operational Status Overview | May 2 Friday 20:47 UTC

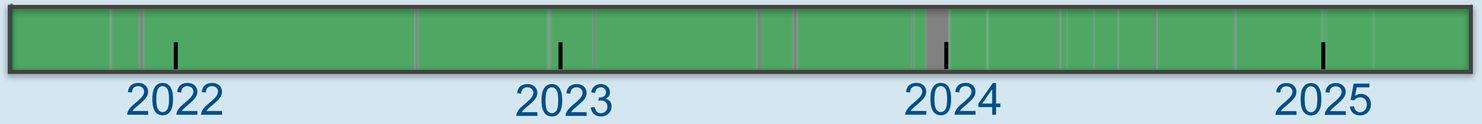
NEREUS provides decade-long tracking of infrastructure history, issue tracking & resolution, and live reporting
APL: K. Rosburg




166 instruments | 131 Operational | 4 Uncabled
3 partially functional | 1 trouble shooting | 4 failed

81% of Instruments Operational as of May 2 (2 Deep Profiler instruments offline)

Observatory Status History




1346 days uptime (96%) 55 days downtime (4%)

Junction Box (Secondary Nodes)

18 junction boxes uptime 100% since 2014

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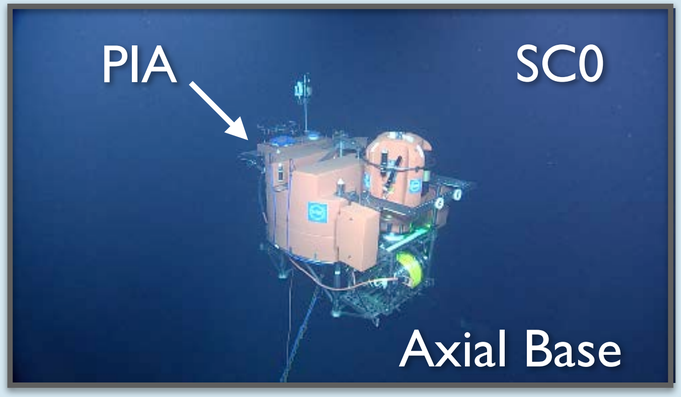
# RCA Increasing Operational Success: Shallow Profilers

Nereus | Operational Status Overview | May 2 Friday 20:47 UTC

From 2015, three shallow profilers have made >50,000 profiles hosting up to 18 instruments




## Platform Interface (PIA) Stationary 200m

- pH
- Broadband hydrophone
- Fluorometer
- CTD-dissolved oxygen
- 5-beam ADCP
- 150 kHz ADCP
- 80 kHz Zooplankton Sonar*
- Digital Still Camera

## Winched Science Pod (SC0) Profiles 9 times/day 200-5m

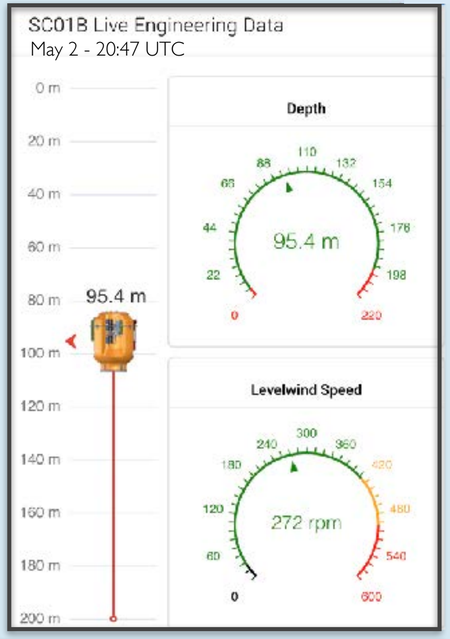
- pH
- $pCO_2$
- 3W Fluorometer
- CTD-dissolved oxygen
- Nitrate
- Spectral irradiance
- PAR
- Current meter + Temp

*Oregon Offshore

Slope Base [SC01A]- 750 km
Oregon Offshore [SC01B]- 825 km
Axial Base [SC03A]- 675 km*

*Axial Base

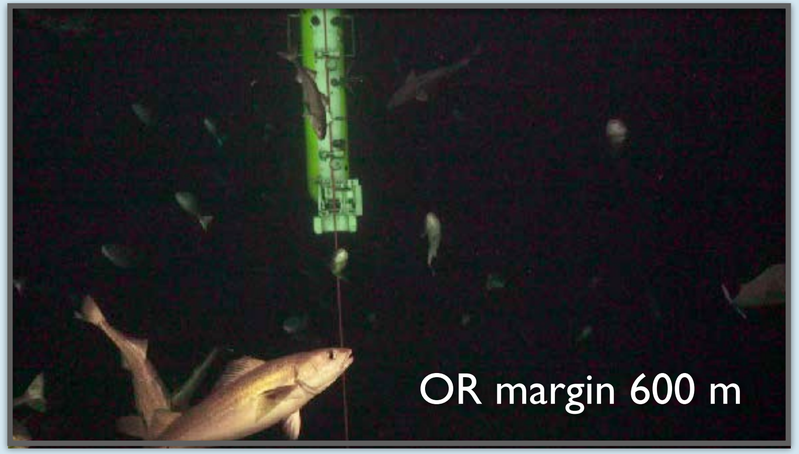
gash in cable


| | | | | | | |
|---|---|---|---|---|---|---|
| SF01B | Operational | Enabled | | | Good | |
| CE04OSPS-SF01B-2A-CTDPFA107 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-2A-DOFSTA107 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-2B-PHSENA108 | Failed | Silenced | Unmonitored | Unmonitored | Unmonitored | Unmonitored |
| CE04OSPS-SF01B-3A-FLORTD104 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-3B-OPTAAD105 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-3C-PARADA102 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-3D-SPKIRA102 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-4A-NUTNRA102 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-4B-VELPTD106 | Operational | Enabled | Good | Good | Good | Normal |
| CE04OSPS-SF01B-4F-PCO2WA102 | Failed | Silenced | Unmonitored | Unmonitored | Unmonitored | Unmonitored |

# RCA Increasing Operational Success: Deep Profilers

Nereus | Operational Status Overview | May 2 Friday 20:47 UTC




Deep Profiler (12 times/day)

Modified McLane Profiler

CTDCurrent meter + temperature
Optical Attenuation
CDOM Fluorometer + CHLBackscatter
Dissolved Oxygen

Slope Base [DP01A] - Offline, ground fault in dock

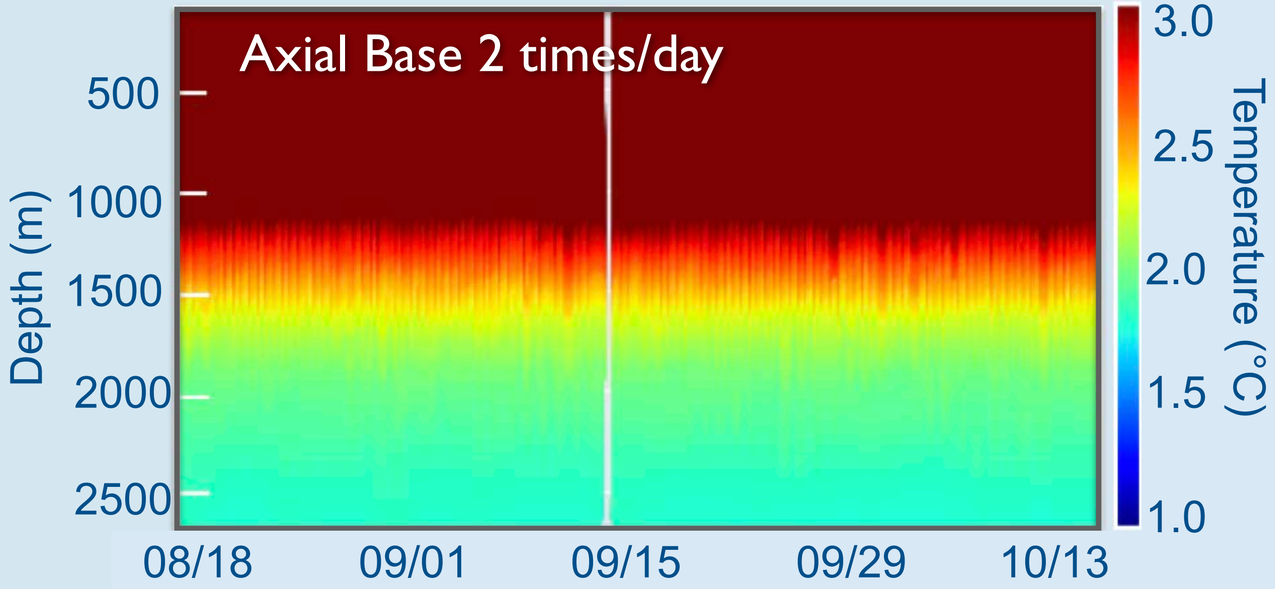
**Could not turn 2024 because on *Atlantis*

Oregon Offshore [DP01B]- 1,420,203

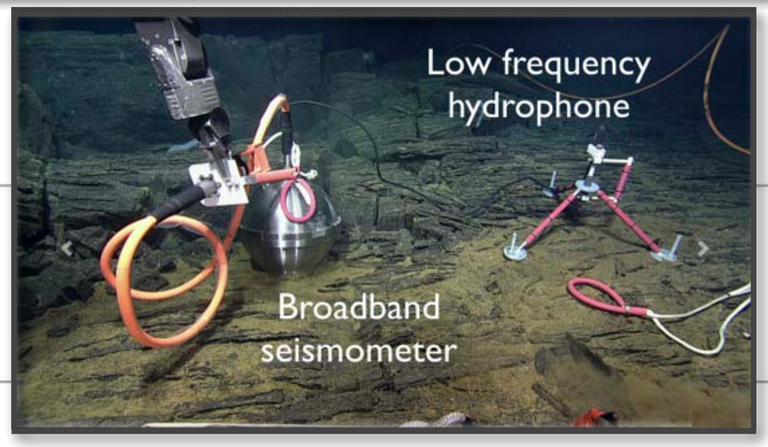
**Traversing 70 m - flawed cable from manufacturer

Axial Base [DP03A]- 2,365,463

**Will turn on Sally Ride August 2025

# Important RCA User Community:
# Earthscope Consortium (IRIS) RCA Metrics
# International User Community




## RCA Seismic Data

Unique Addresses

2000
1500
1000
500
0

2015
2017
2019
2021
2023
2025

March

## All seismometers operational (1 turned since 2014)

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# Important RCA User Community: Earthscope Consortium (IRIS) RCA Metrics


## Total Data Downloaded

Gigabytes

2500
1500
1000
0

2015
2017
2019
2021
2023
2025

March

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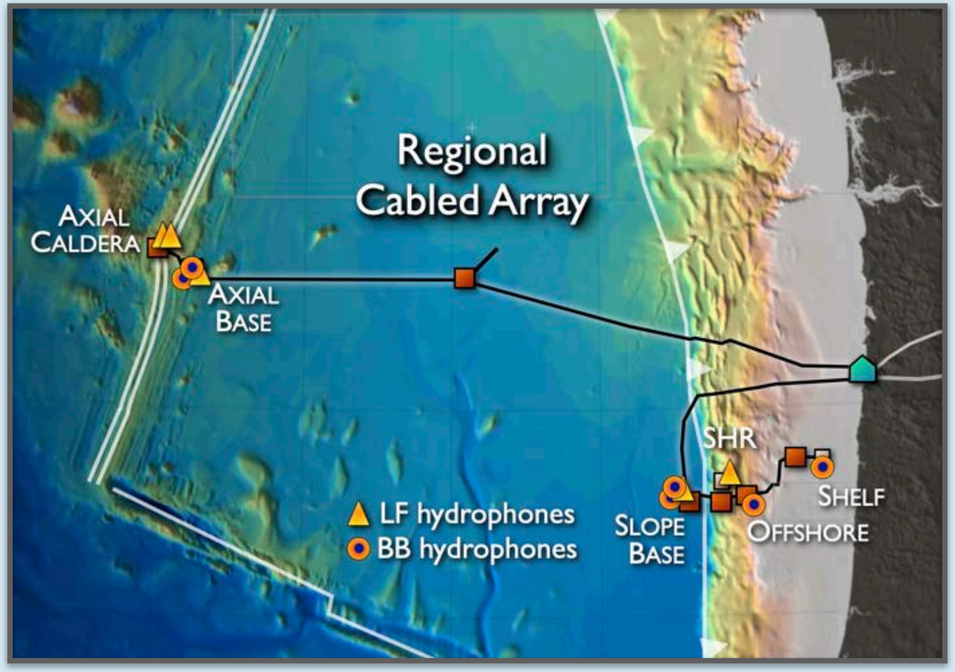
# Broadband Hydrophones (HYDBB) Update: Sampling Rate Increase




A decade (350,000 hrs) of broadband hydrophone data from 6 instruments spanning seafloor to 200 m platforms

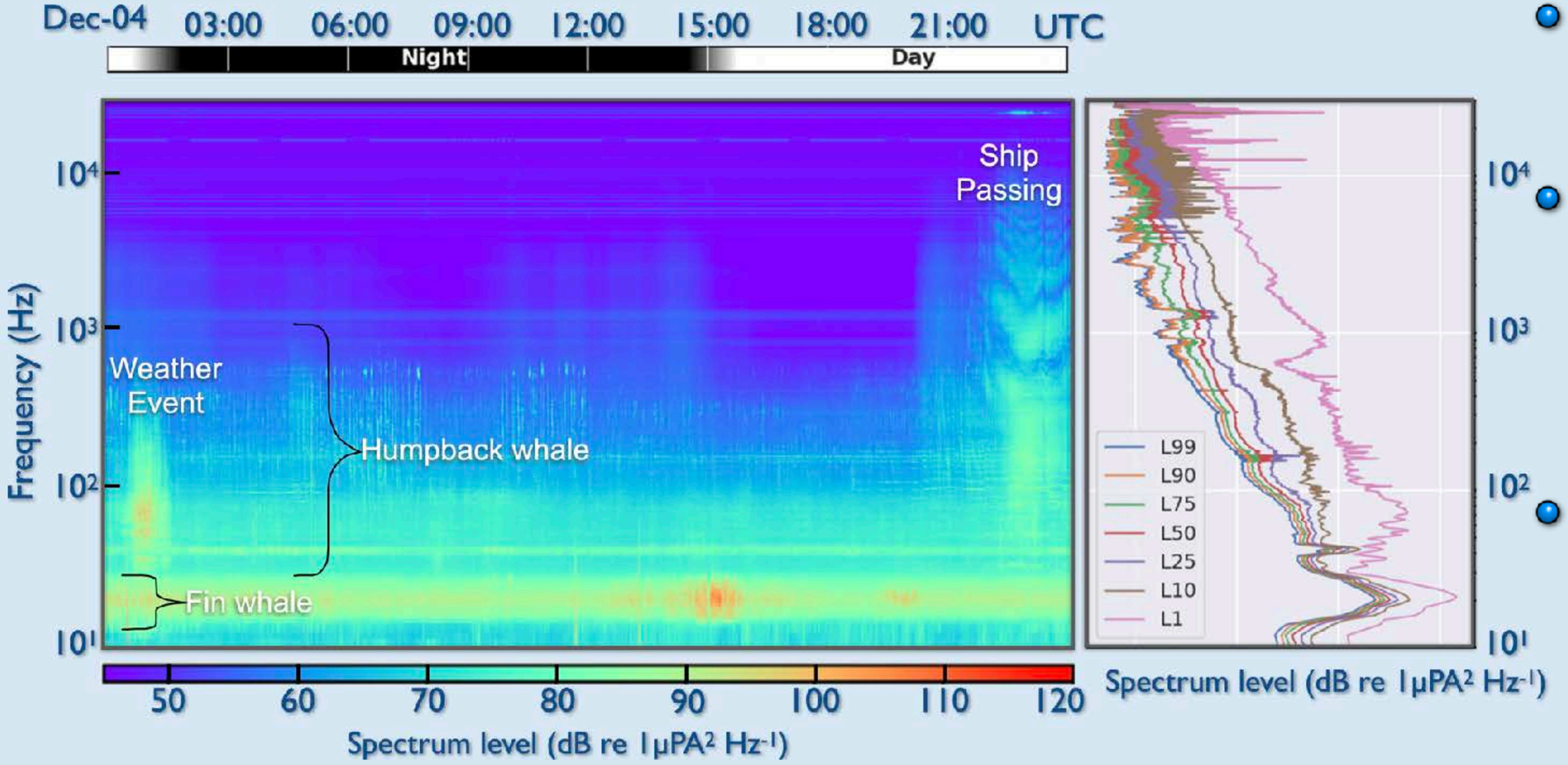
- **Background:** All six HYDBB are currently sampling at 64 kS/sec. Science requirements are for 256 kS/sec.

- **Recent Developments:**
  - Upgrade of Navy W-E transmission line from 45 Mbps to 1 Gbps nearing completion and testing will be forthcoming.
  - RCA visualization tools for QA/QC of HYDBB data streams implemented.
  - Update of CI HYDBB data processing to include production of user-friendly FLAC files in addition to MSEED format near Alpha Testing stage.
  - Navy-APL contractor for data diversion switch will support pilot test of increased HYDBB sampling rate for a day.

- **Moving Forward:** OOIFB Acoustic Summer School (July ’25) will provide SME and user feedback on higher frequency data utility.

# RCA Developed New Pipeline - QA/QC Visualization Tool of Daily Spectrograms for Broadband Hydrophones (J. Duprey)

## Oregon Offshore Broadband Hydrophone







- A decade of 10-64,00 Hz data from 6 hydrophones (350,000 hrs)
- New pipe line can summarize & visualize a year of hydrophone data in 30 minutes - viewable minute to millidecade resolution
- Users can convert RCA acoustic data to audio files (FLAC or WAV)

*Developed with input from the UW Ocean Data Lab and MBARI Soundscape team, utilizing open source acoustic software tools - ooipy, pypam, and mbari-pbp.*

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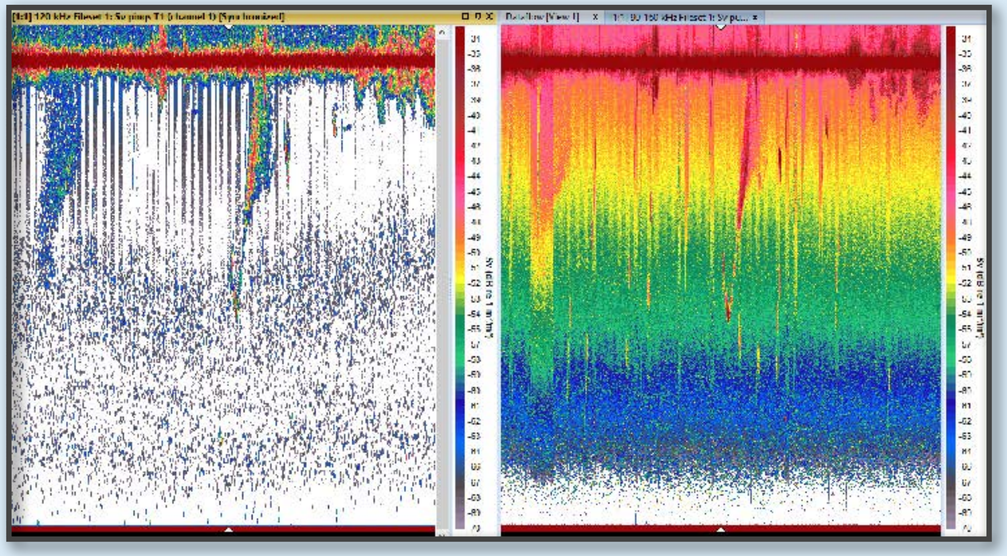
# Technology Refresh: Kongsberg EK80 Cabled Sonars(ZPLSC-B) Status

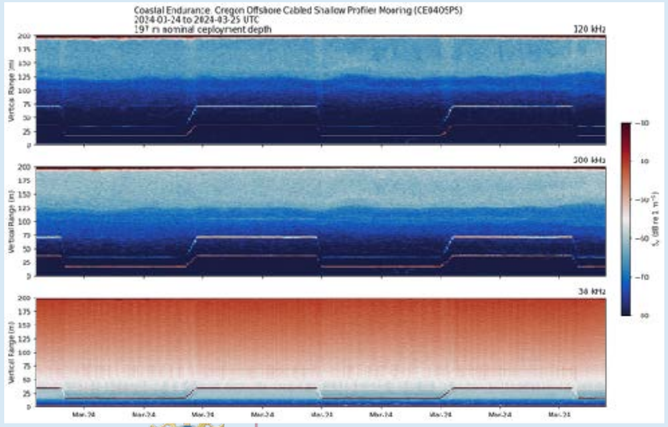
## Single Frequency (CW)

## Broadband (FM)



120khz (CW)

120khz (FM)




EK80 draft echogram produced by J. Case using OOI software incorporating Echopype code; shallow profiler track can be seen in the signal

## Current Sampling Strategy (2024-2025)

- OR Shelf sonar (80 m) running in CW power/angle advanced sequence mode; produces one sequential ping per second at each frequency (38, 120, and 200 kHz)
- OR Offshore sonar (200 m) exhibited large noise spikes at CW target frequencies, so running in limited frequency FM mode, using an advanced sequence with sequential pinging; produces one ping per second using the following frequency ranges:
  - 200: 190-192 khz
  - 120: 124-126 khz
  - 38: 39-41 khz

## Summer 2025 Deployment Planning

- EK80 processing is making progress, with assistance
- Vendor has released new shoreside data logging and control software that may reduce noise
- Calibration of new instruments in Lake Washington on 2 May

## Plan for 2025 Summer School

- Run for 2 months in interleaved FM/CW mode to maximize utility of data for test processing by attendees
- Working with Chris Bassett (UW/APL) and Wu-Jung Lee (SME and Summer School lead) to draft a ping sequence that will minimize noise and maximize data collection

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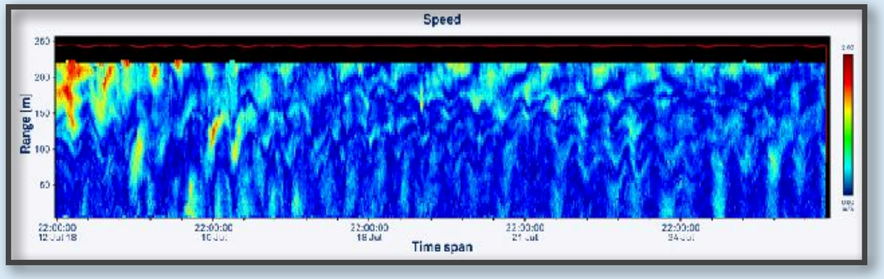
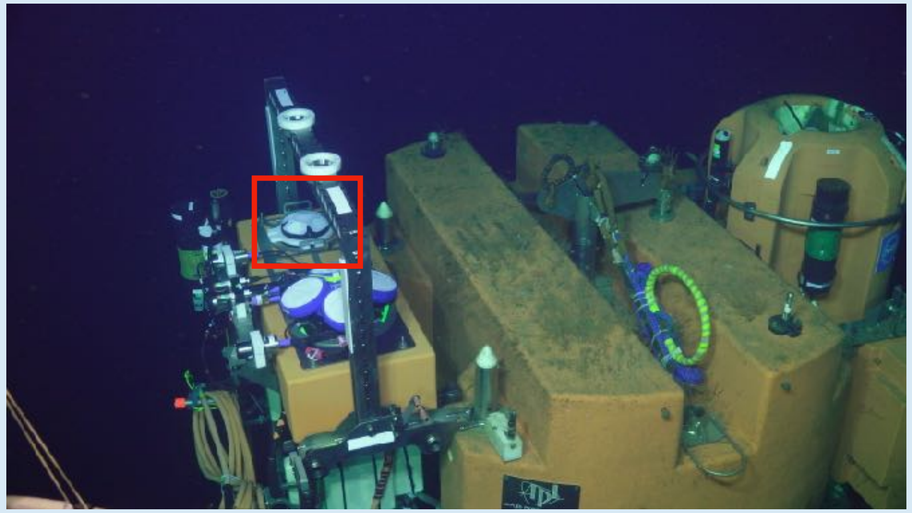
# Technology Refresh: Nortek Signature500 5-beam ADCP (VADCP-B)




Standard binned ADCP current speed & direction output



Slope Base Shallow Profiler Platform (200 m depth) with Nortek Signature500 in upper left and co-located 150 kHz RDI ADCP in lower left (Credit: UW/NSF-OOI/WHOI, J2-1606, V24)

- Refresh for custom Teledyne RDI 5-beam instrument - VADCP-A was no longer supported by Teledyne
- **Current Operational Mode VADCP-B:**
  - Initially running ASCII output due to port input/output capability requirements for plugging into the cabled nodes and ease of parsing
  - Largely the same L0 output parameters as VADCP-A, including 5th beam for vertical velocity correction (only the error calculation is different from RDI)
  - 500 kHz, 25-degree slant beam, 1m bins (see below)
  - Worked with APL and CI to implement new driver and algorithm for this instrument; currently delivering data on production
- **Noise testing and modified sampling**
  - Ran 48 hour test with co-located ADCPs powered down to try to eliminate acoustic noise (03-04 April 2025)
  - Data processing still in progress, but no significant changes or extension to the effective range
  - Will likely change bin size to 0.5 m to maximize resolution over the effective range and implement higher-rate burst sampling to collect turbulence measurement data (as per SME input)
  - Working to create SME community group to assist in further sampling strategy and data processing refinements

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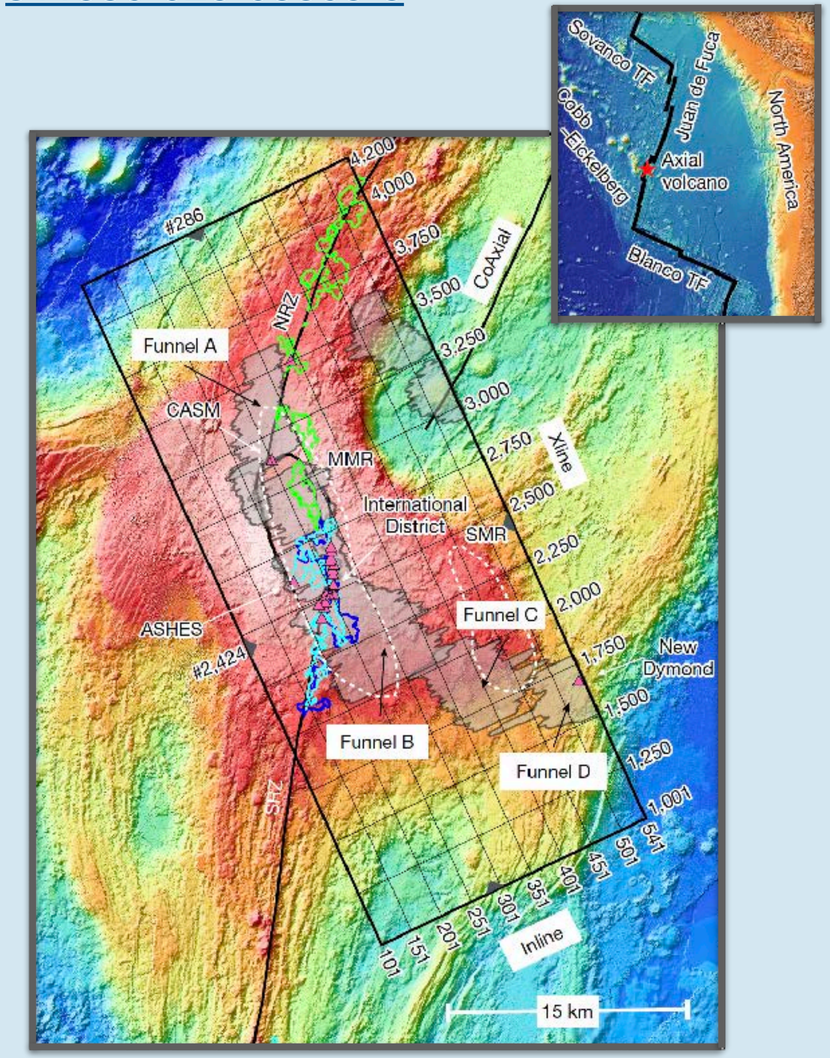
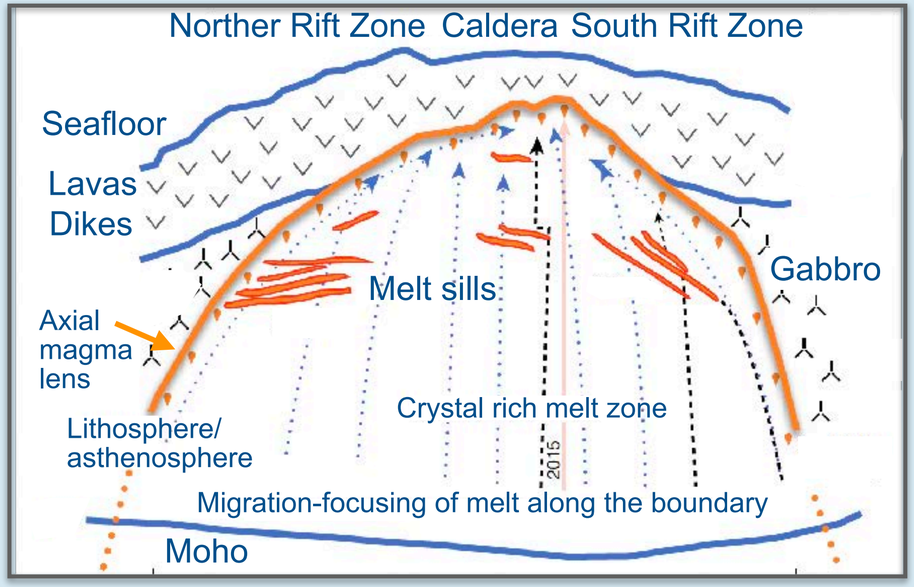
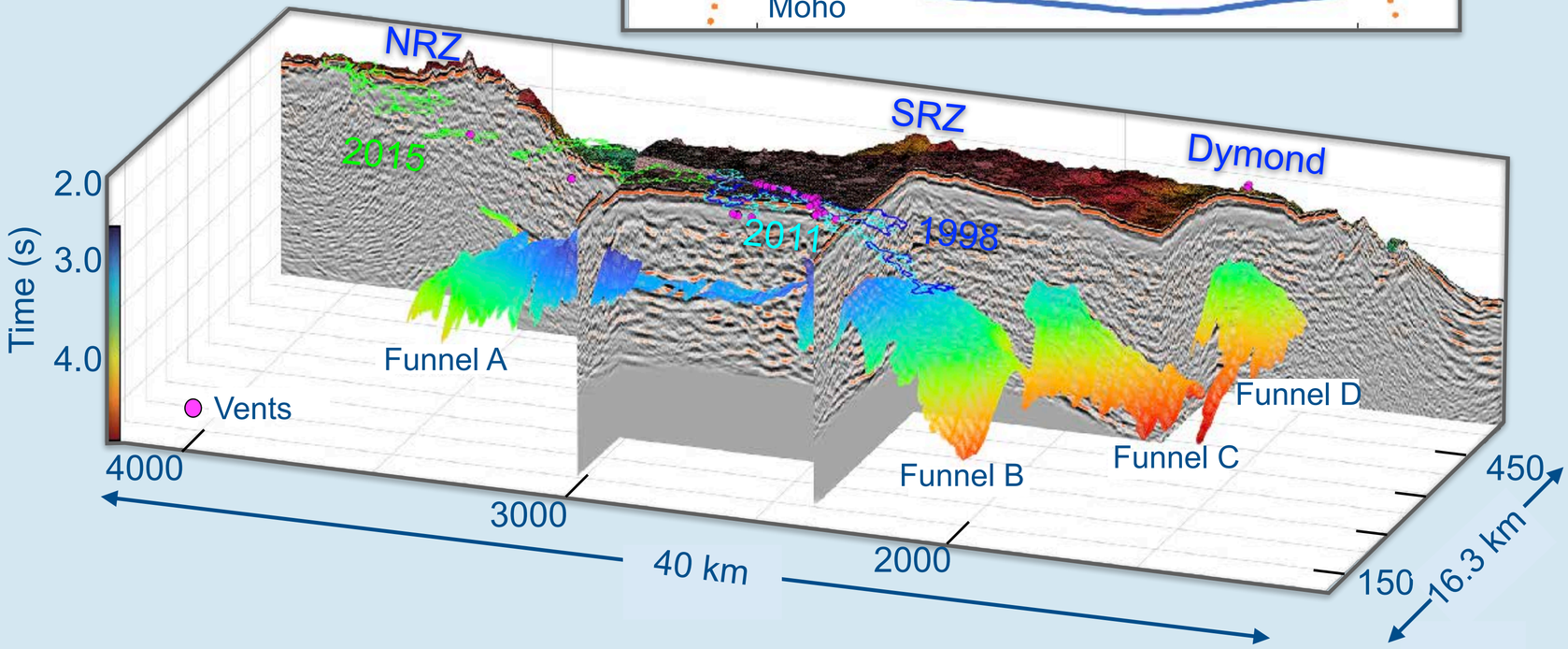
# Axial Seamount: The best imaged submarine volcano

Kent, G.M et al., (2025) Melt focusing along lithosphere-asthenosphere boundary below Axial Volcano. *Nature*,https://doi.org/10.1038/s41586-025-08865-8




Fundamentally changes our view of melt transport beneath mid-ocean ridges the longest mountain chain on Earth

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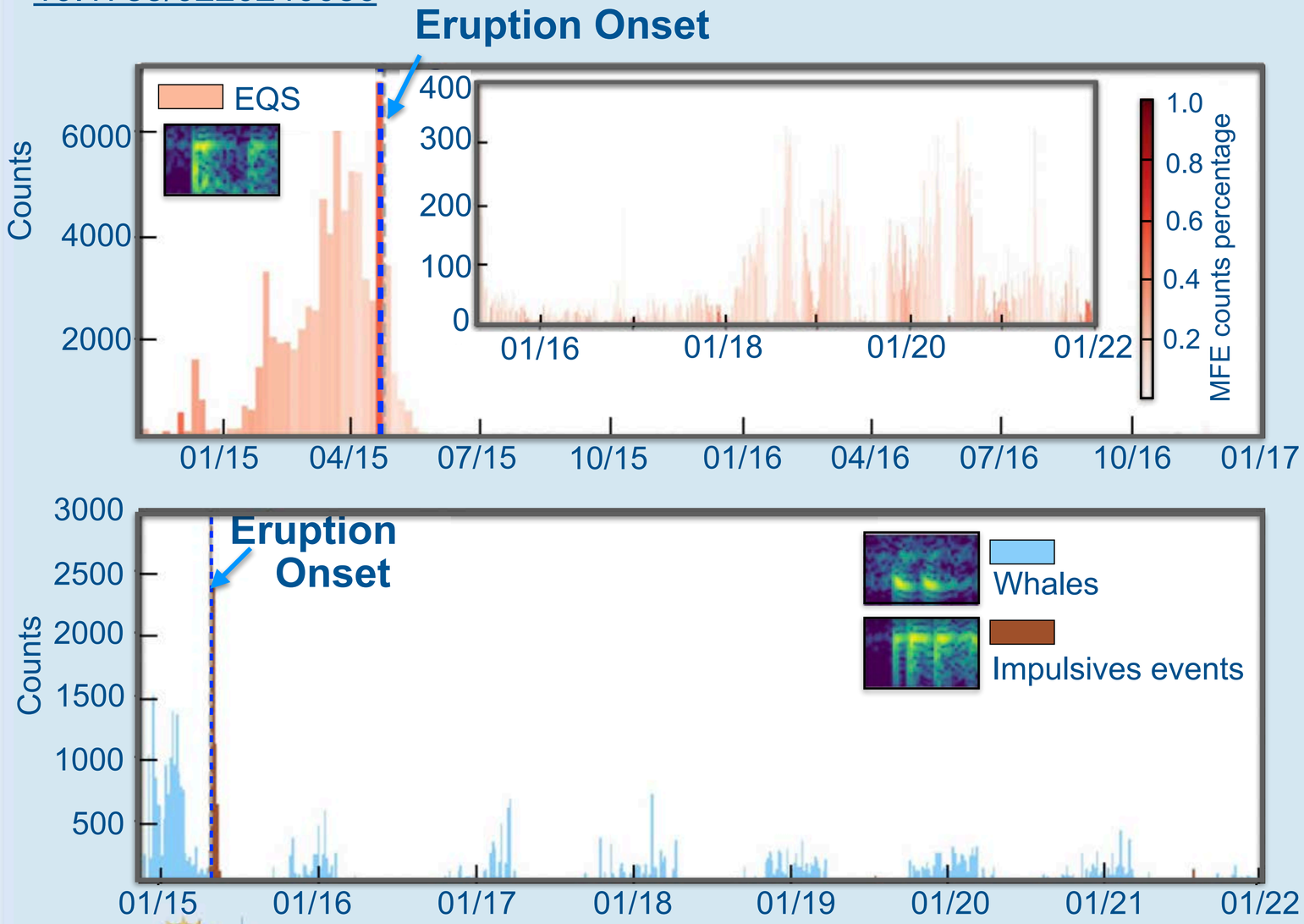
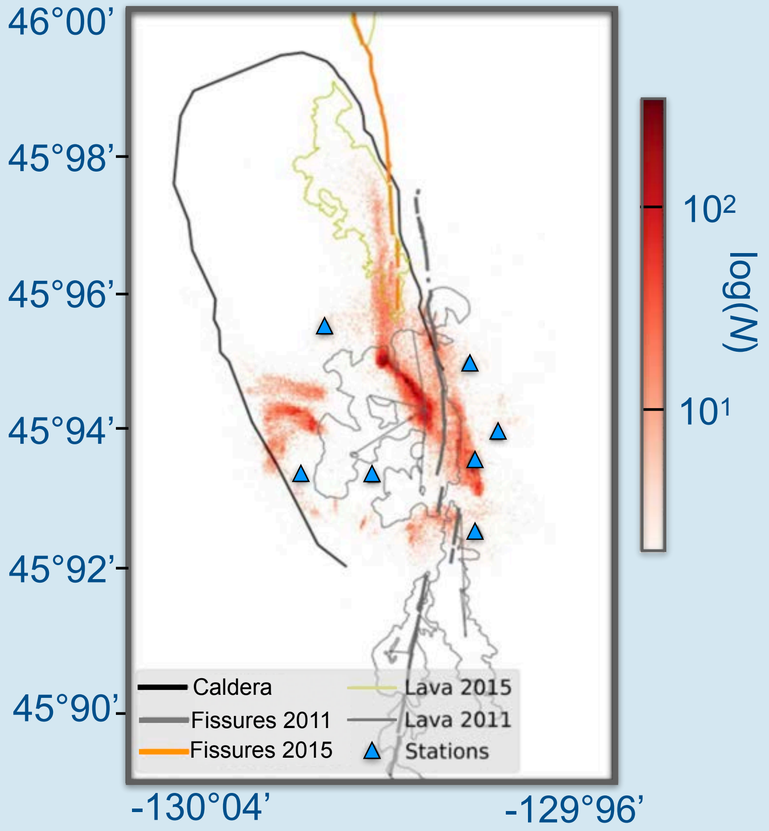
# Machine Learning Applied to RCA Acoustic Data: Axial Seamount

Wang, K. at al., (2024) Real-time detection of volcanic unrest and eruption at Axial Seamount using machine learning. *Seismol. Res. Lett.* https://doi.org/10.1785/0220240086




- Supervised and unsupervised machine learning-based real-time seismic monitoring for volcanic unrest and enhanced eruption forecasting

**Very high resolution data ripe for Machine Learning**

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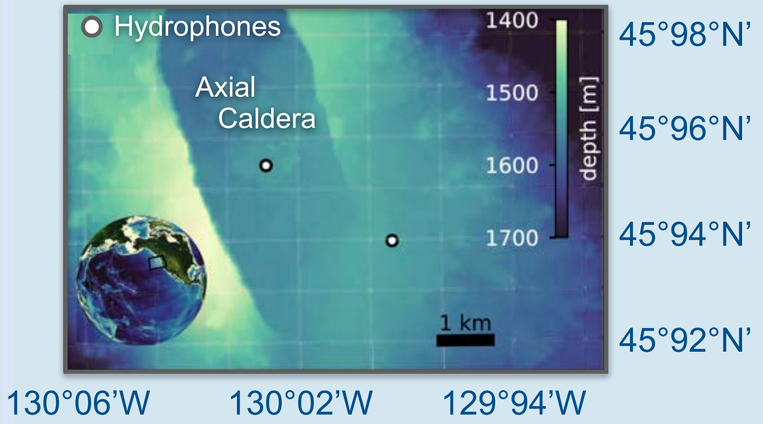
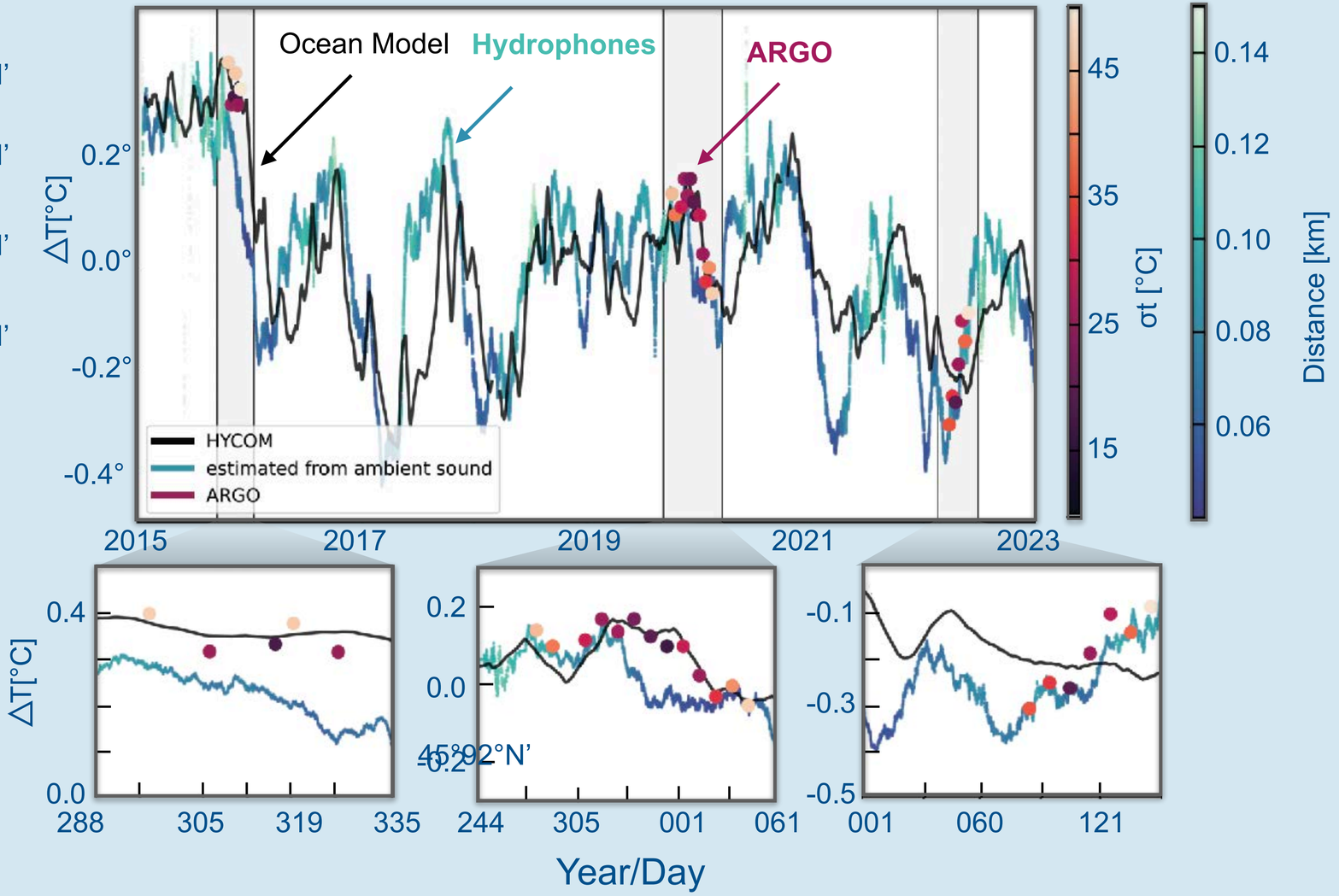
# Using RCA hydrophones to measure depth-averaged deep ocean temperature at ~ 3 km scales

J. Ragland and S. Abadi (2024) Using ocean ambient sound to measure local integrated deep ocean temperature. *Geophys. Res. Lett.* https://doi.org/10.1029/2024GL108943




- Utilized 8 years of hydrophone data (ambient sound).Good agreement with global ocean models and ARGO data.
- Future applications for incorporation of higher spatial resolution data into global ocean models.

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# Substantial Increase in Earthquake Detection Using DAS on the RCA

Shen, Z. and W. Wu (2024) Ocean bottom distributed acoustic sensing for oceanic seismicity and seismic ocean thermometry *J. Geophysical. Res.*,https://doi.org/10.1029/ 2023JB027799

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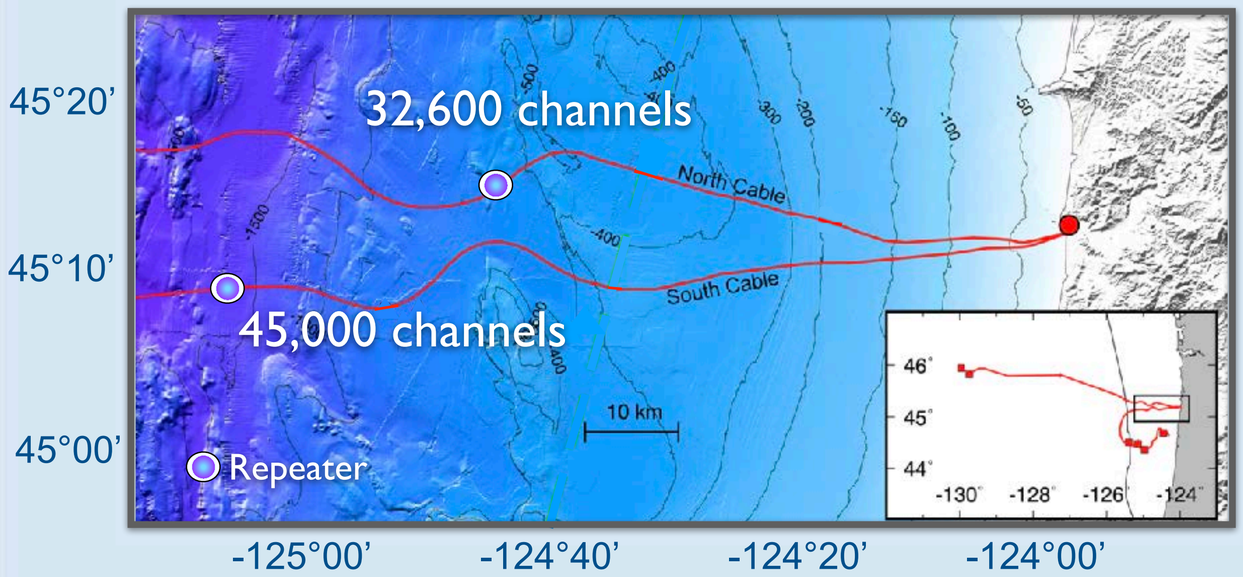
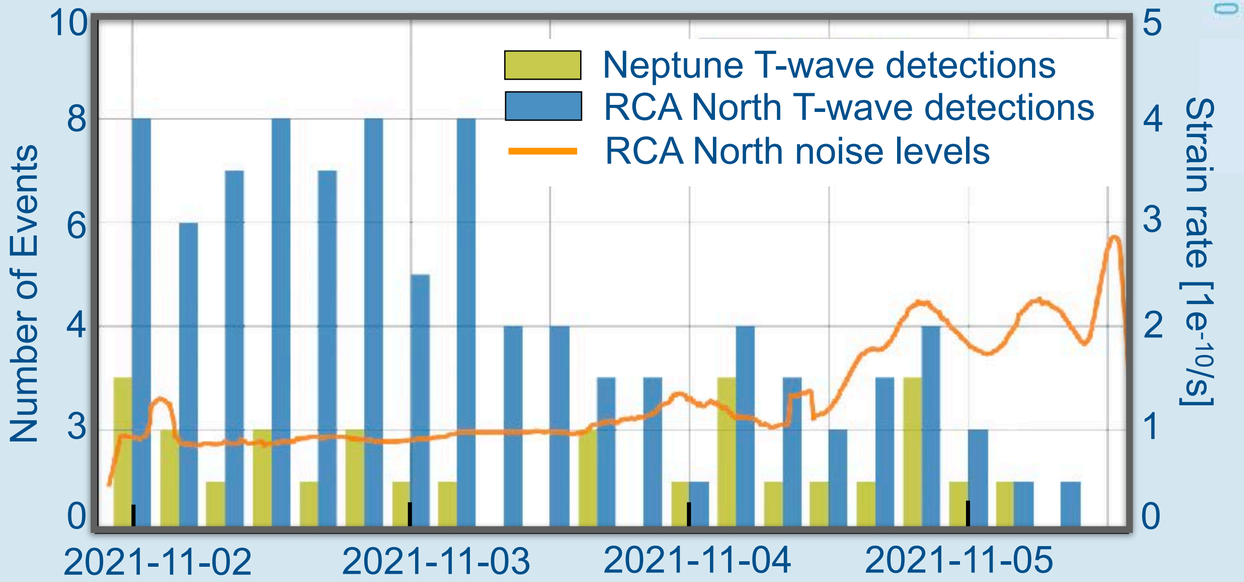
Cable “Dark” 2021




- During the 4-day community experiment in 2021, 92 oceanic earthquakes were detected (T wave events), with most missing from existing seismic catalogues and 3 times the number measured by Ocean Networks Canada.
- Based on close examination of Blanco repeating earthquakes, for earthquakes as small as M3.5, DAS outperforms ocean bottom seismometers for measuring temperature in the deep ocean (seismic ocean thermometry)

*200 Hz, 500 Hz and 1000 Hz North Array*

*200 Hz South Array*

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# The FIRST Community DAS Experiment on a “Lit” Cable & Rapidly Advancing DAS-Like Technology

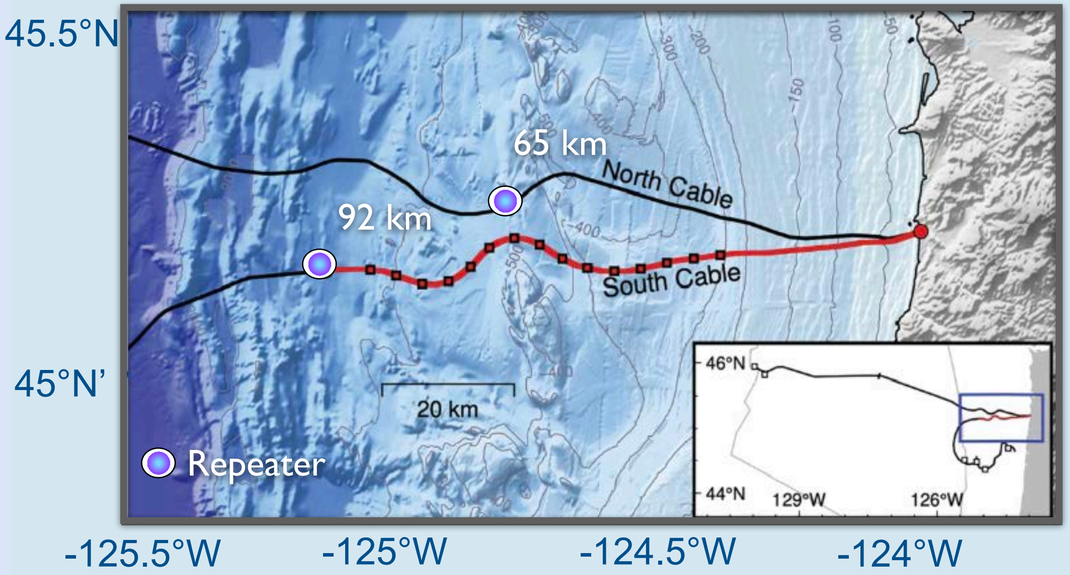


Shi et al., (2025) Multiplexed Distributed Acoustic Sensing Offshore Central Oregon (2025) *Seismological Res. Letters.* https://doi.org/10.1785/0220240460

*Lipovsky et al., RAPID: Multiplexed Distributed Acoustic Sensing (DAS) at the OOI RCA (NSF - OCE 2415521)*

*Cable “Dark” 2004 May 6-May 7*

*Cable “Lit” 2004 May 7-May 10*




## Transforming Ocean Sensing

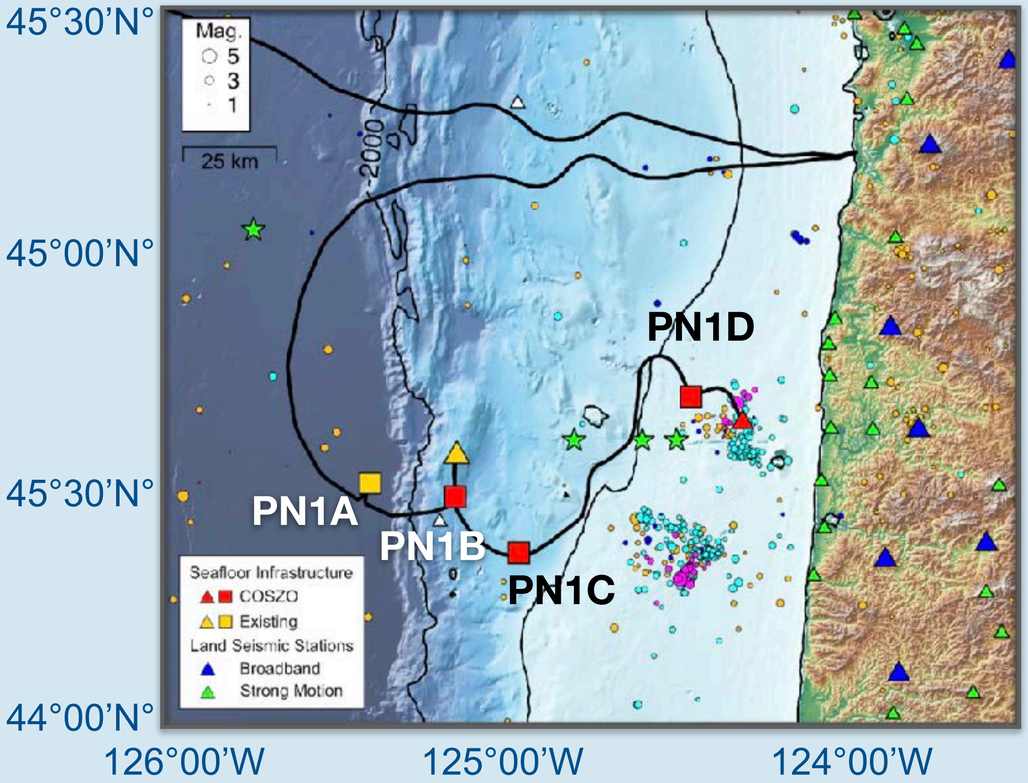
- Optical multiplexing (combining signals of different wavelengths operating independently within the same optical fiber allowed fiber to be lit with NO impact on RCA communications. 41 m gauge length
- Documented ocean surface gravity waves - high frequency waves, low frequency dispersive swell, microseisms, Scholte waves, infragravity waves (Earths hum - waves breaking on shore).

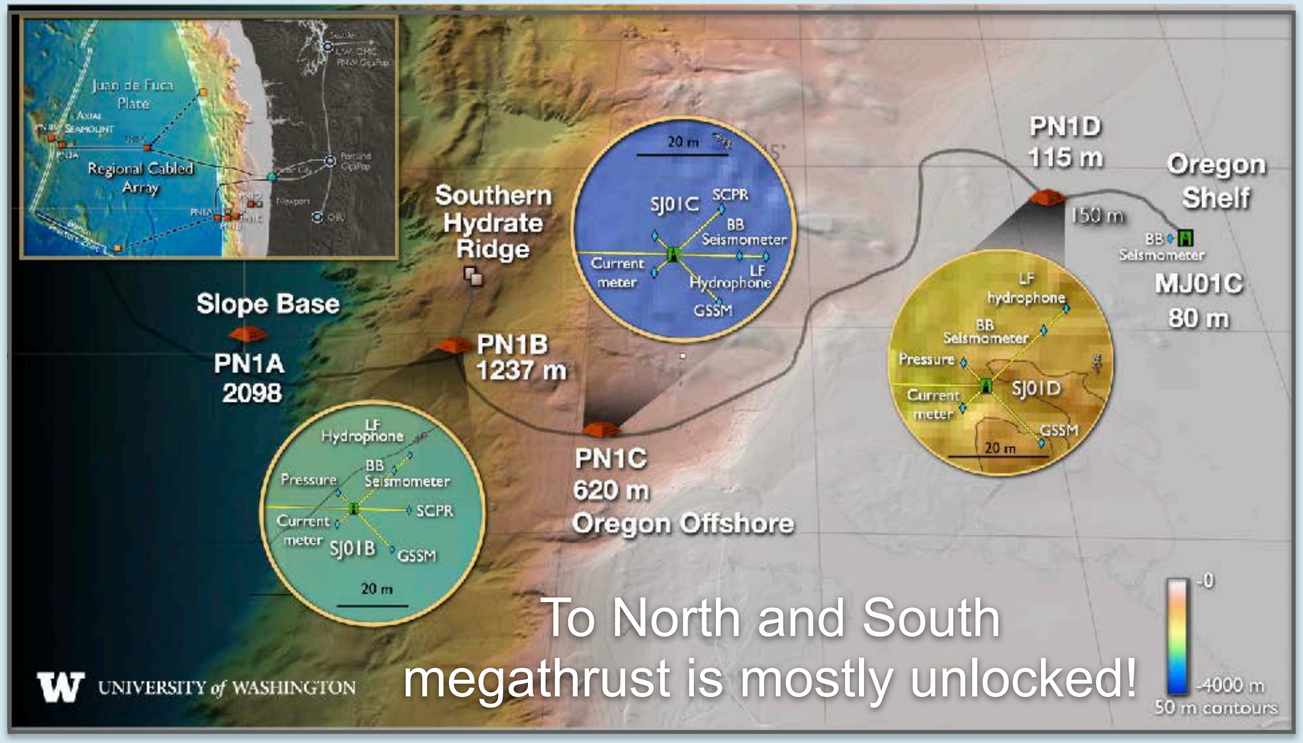
## Imaging the subseafloor to the oceans surface every 100 m over 525 km

**New generation of DAS-like system using ultra-stable laser allows monitoring through repeaters e.g 525 km out to Axial Seamount, south along the Cascadia Margin to 80 m water depth Every 100 m of cable becomes a sensor, full time presence on cable = early warning detection system along the Cascadia Margin.**

# Cascadia Offshore Subduction Zone Observatory (COSZO) Update:

Research Infrastructure: Mid-scale RI-1 (M1:IP): Creating an Offshore Subduction Zone Observatory in Cascadia with the Ocean Observatories Initiative Regional Cabled Array (OCE 2329819 $10.65M), Wilcock et al., 2023-2027.

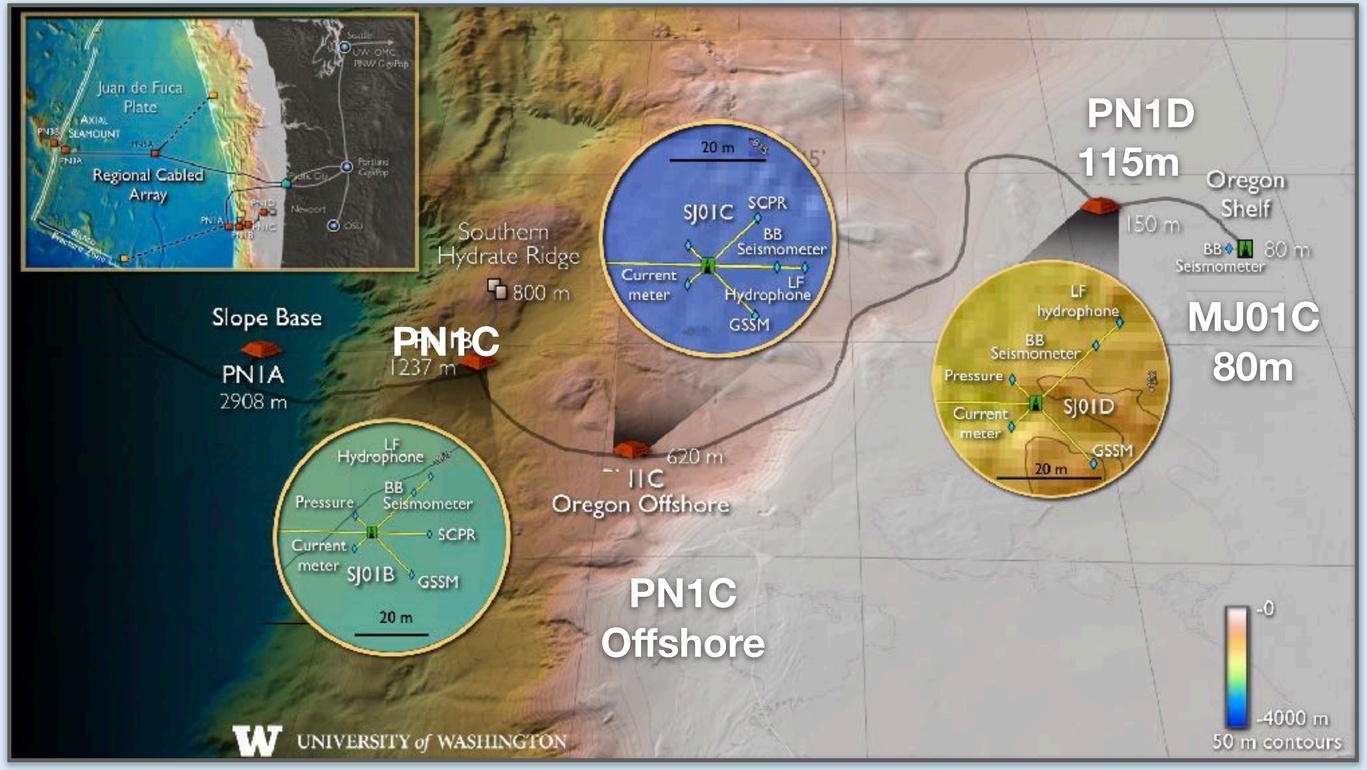



The goal of COSZO is to install a "critical mass" of cabled geophysical infrastructure crossing the Cascadia Margin to collect continuous, high-fidelity data enabling the scientific community to address fundamental questions on how subduction zone faults work and to provide a facility to support the development of the Nation's first offshore real-time earthquake and tsunami warning detector.

# Cascadia Offshore Subduction Zone Observatory (COSZO) Update:

Provides critical infrastructure and instrumentation across the Cascadia Margin and significant technological advancements




| Instrument | Installation Sites |
|---|---|
| Seafloor science junction box | PN1B, PN1C, PN1D |
| Ocean bottom seismometer, accelerometer, digital recorder | PN1B, PN1C, PN1D, MJ01C |
| Low-frequency hydrophone | PN1B, PN1C, PN1D, MJ01C |
| Differential pressure gauge | PN1B, PN1C, PN1D, MJ01C |
| Pressure guage | PrePN1B, PN1C, PN1D |
| Ocean current meter | PN1B, PN1C, PN1D |
| Self-calibrating pressure sensor (SCPR) | PN1B, PN1C, |
| Geodetic & seismic sensor module (GSSM) | PN1B, PN1C, PN1D |

3 junction boxes (SJ01B, SJ01C, SJ01D) on 200 m cables at “empty” Primary Nodes and 23 key instruments to monitor deformation and seismicity. Each junction box will have open ports for additional PI instruments.

Data to be streamed into IRIS - Earthscope

*New junction boxes include important upgrades to original over a decade old design*

# Engagement

- **Undergraduate Education Example Projects Using RCA Data**
  13 undergraduate science and engagement projects (spanning seismicity, biology, chemistry, machine learning - imagery etc)

- 7 long-term undergraduate projects, with four senior thesis/capstone projects (presented at 3 UW symposiums). Three year thesis/capstone projects and three presentations at national meetings

- **Machine Learning.** UW NSF Postdoc Katie Bigham* and VISIONS student Ada Carter - Developed an open source textbook for facilitating undergraduate education in marine computer vision "Computer Vision across the Marine Sciences OceanCV.org" Winter Quarter 11 students created their own models - focus of two thesis projects (phytoplankton and Pythias Oasis macrofaunal machine learning).

*currently can process 50,000 images with annotations in two hours.

# Engagement

- Very Exciting Collaboration **“The Midnight Zone - Black Smoker 2025”** Collaboration withJulian Charrière (Berlin Germany) and two colleagues developing a 6-month duration exhibition in Switzerland.

- Incorporating RCA live streaming broadband and low-frequency hydrophone and seismometer) predominantly focused on Axial Seamount. Insonify sound waves = earthquakes, explosions, whales, rain etc.

- Specialized room with 50 floor transducers and a 3D audio dome sound system with 17 sound sources controlling each sound independently. In total darkness visitors will listen/feel the underwater sound ecosystem. PI’s also contributing to this effort include W. Wilcock and S. Abati (UW) and J. Caplan-Auerbach (Western Washington University). The artists are hoping that the exhibit comes to the US.

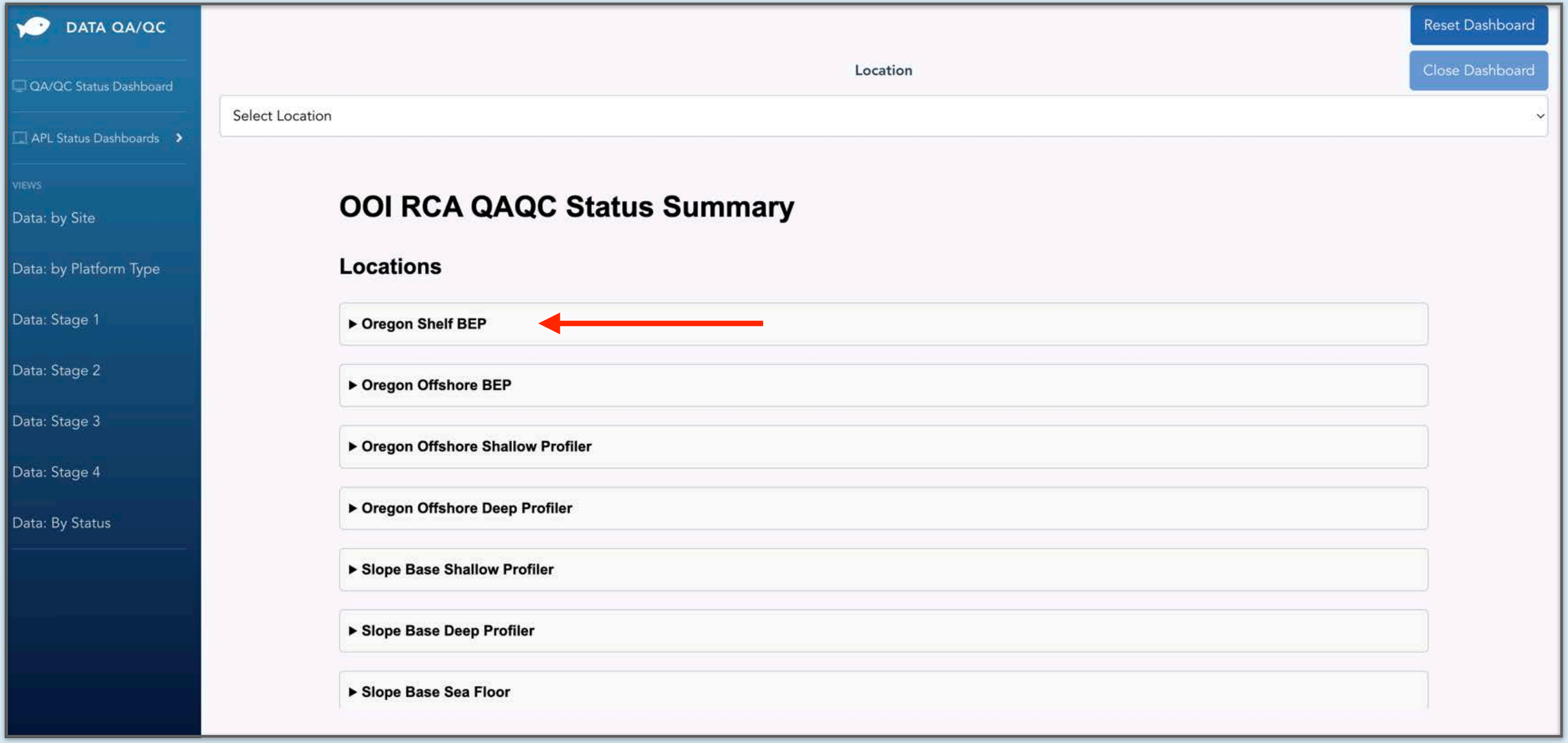
# Development of Internal RCA QA/QC Status Dashboard
## Wendi Ruef

▼ **Automated QA/QC**

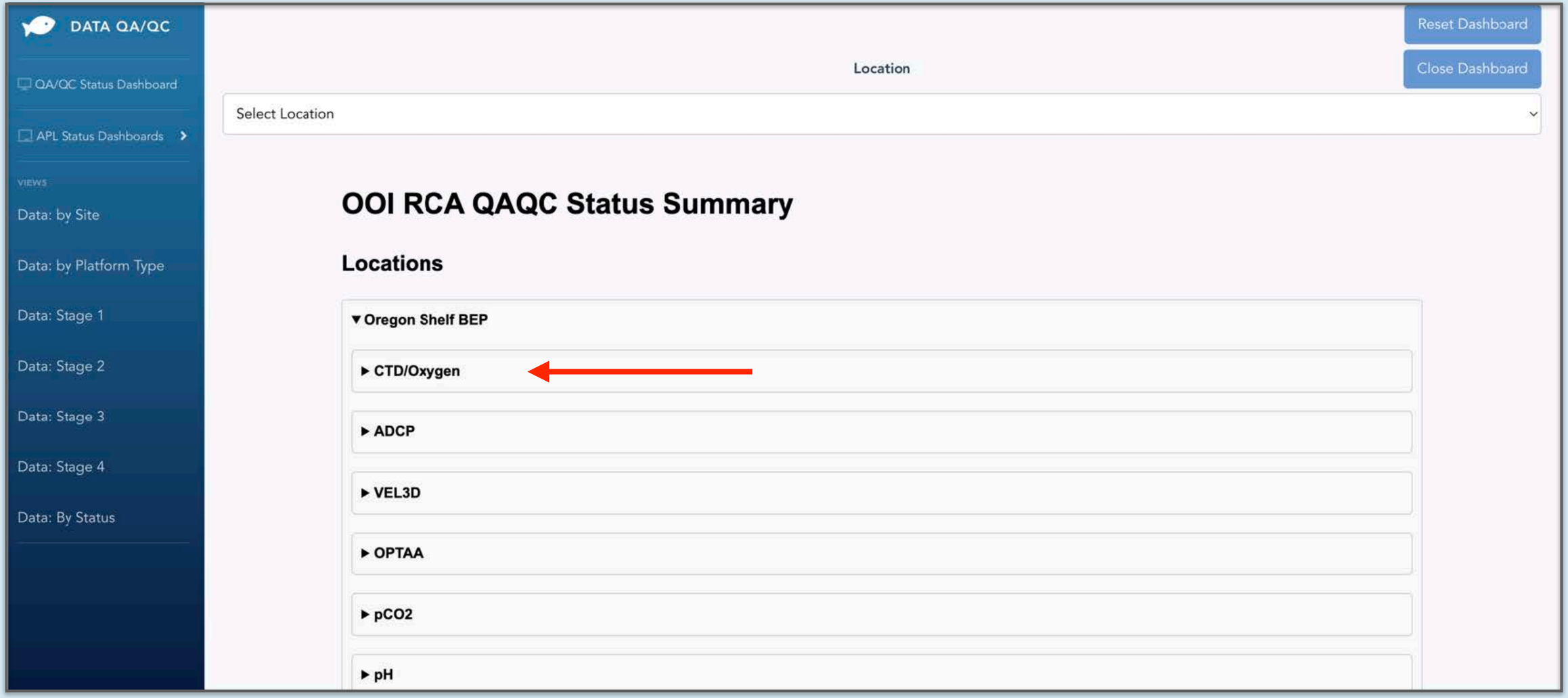
QARTOD Manaul

| QARTOD Test | Test Guidance | Parameters | Status | Implementation |
|---|---|---|---|---|
| Gap | Required | temperature, conductivity, salinity, pressure | In Development | estimated completion 6/2025 |
| Syntax | Required | temperature, conductivity, salinity, pressure | In Production | Parser software; no automated data flags |
| Location | Required | temperature, conductivity, salinity, pressure | In Production | Manual location checks during deployment and recovery; no automated data flags |
| Gross Range | Required | temperature, conductivity, salinity, pressure | In Production | Automated data flags based on compiled tables: View Tables |
| Climatology | Required | temperature, salinity | In Production | Automated data flags based on compiled tables: View Tables |
| Spike | Strongly Recommended | temperature, conductivity, salinity, pressure | In Development | estimated completion 6/2025 |
| Rate of Change | Strongly Recommended | temperature, conductivity, salinity, pressure | In Development | estimated completion 6/2025 |
| Flat Line | Strongly Recommended | temperature, salinity | In Development | estimated completion 6/2025 |
| Multi-Variate | Suggested | temperature, salinity, pressure | Not Started | estimated completion unscheduled |
| Attenuated Signal | Suggested | temperature, conductivity, salinity, pressure | Not Started | estimated completion unscheduled |

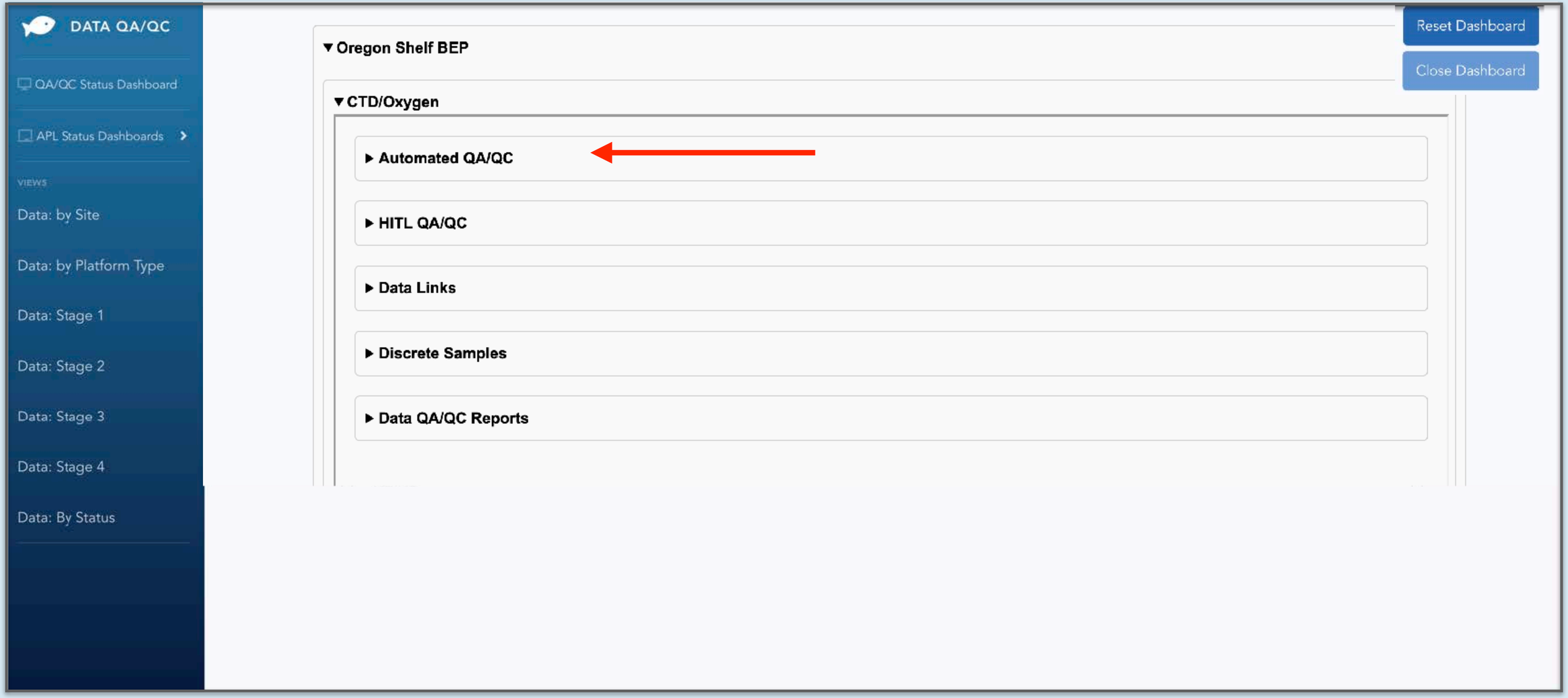
# OOI RCA QAQC Status Summary by Site Location



# OOI RCA QAQC Status Summary by Instrument



# OOI RCA QAQC Information by Instrument



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# Questions?