Cascadia Offshore Subduction Zone Observatory COSZO

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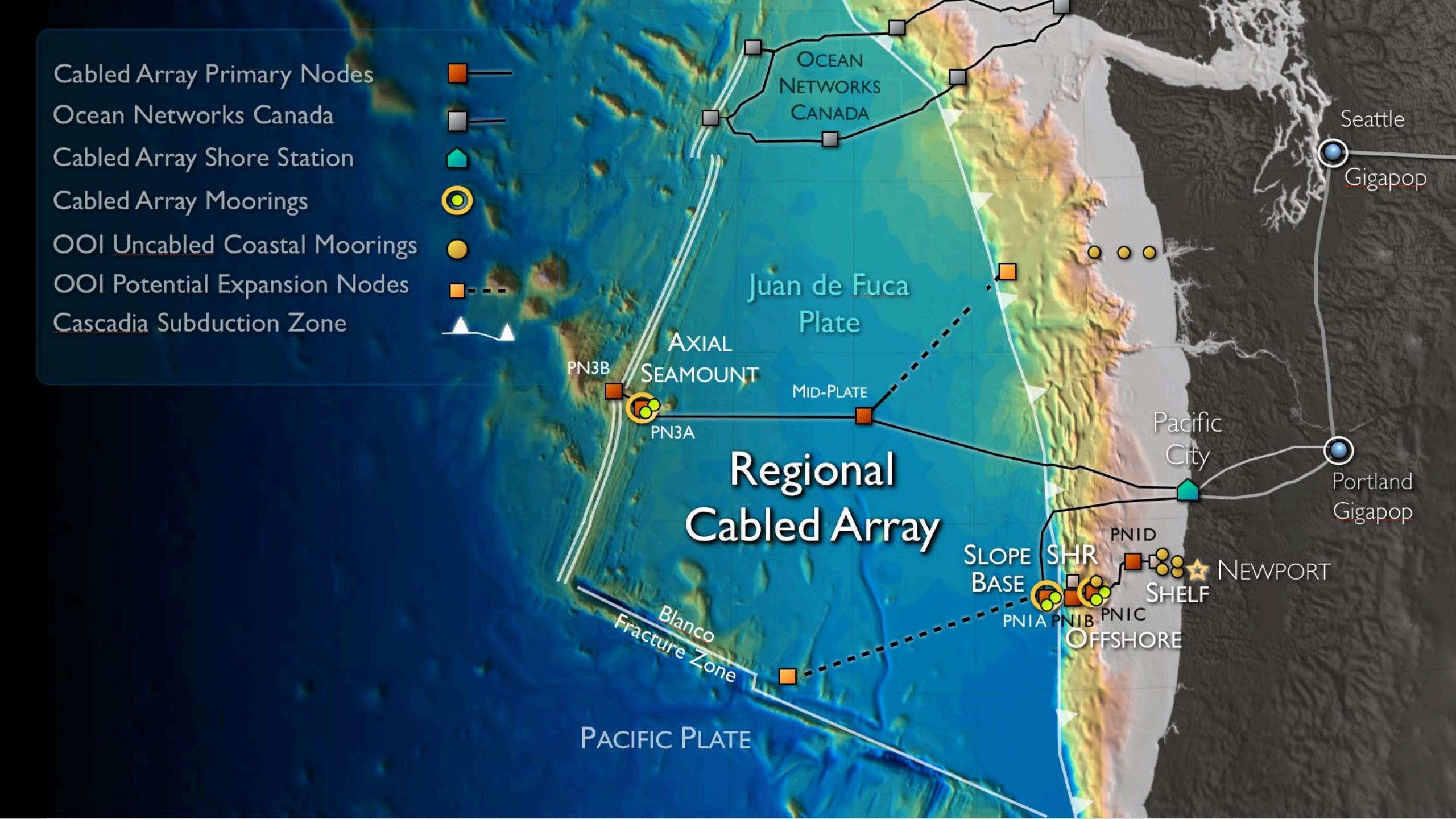
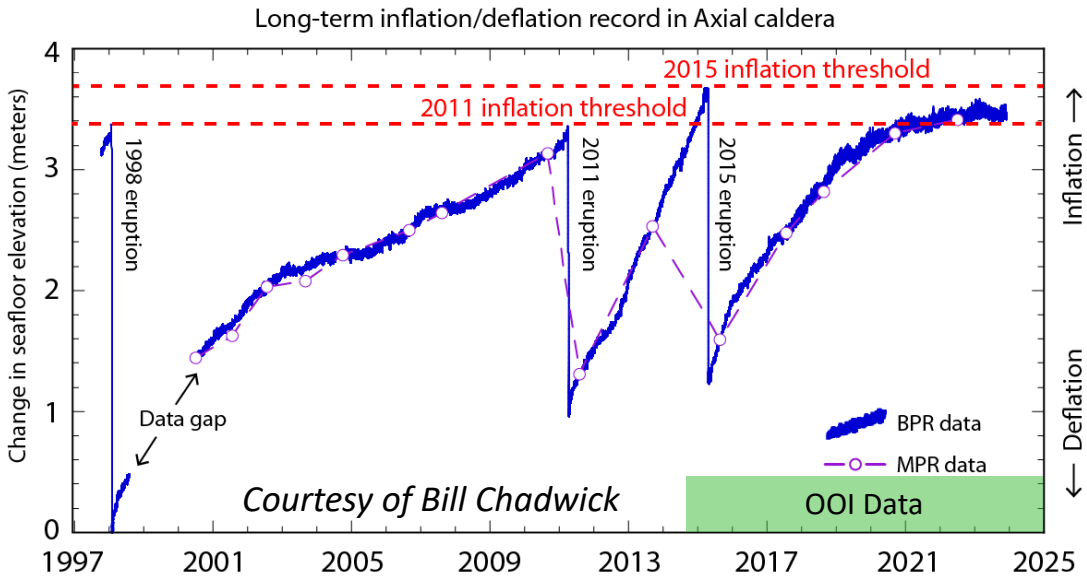
Mark Zumberge, Glenn Sasagawa (UCSD)
Project Manager: Mika Thompson

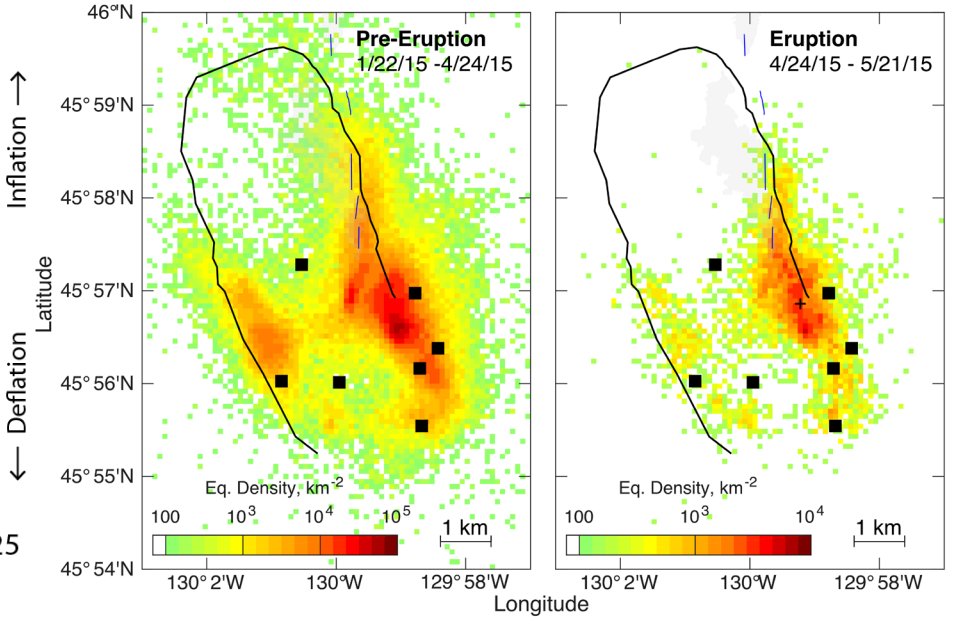
Decadal Survey of Ocean Sciences for NSF
Subduction Zone Geohazards
Wednesday, January 31, 2023

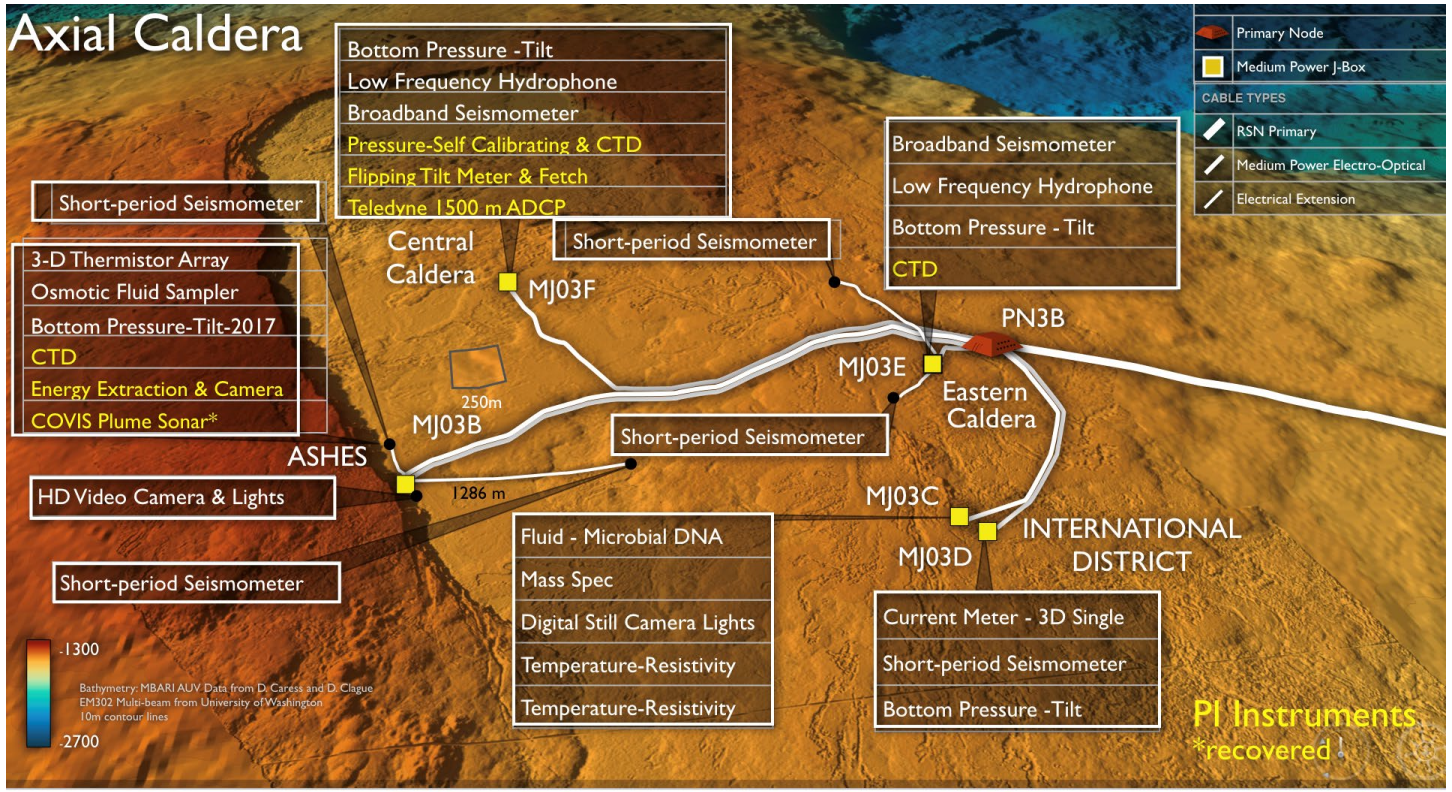

Cabled Array Primary Nodes
Ocean Networks Canada
Cabled Array Shore Station
Cabled Array Moorings
OOI Uncabled Coastal Moorings
OOI Potential Expansion Nodes
Cascadia Subduction Zone
Ocean Networks Canada
Seattle
Gigapop
Juan de Fuca Plate
Axial Seamount
PN3B
PN3A
Mid-Plate
Regional Cabled Array
Pacific City
Portland Gigapop
PNID
Slope Base
SHR
Newport
Shelf
PNIA
PNIB
PNIC
Offshore
Blanco Fracture Zone
Pacific Plate

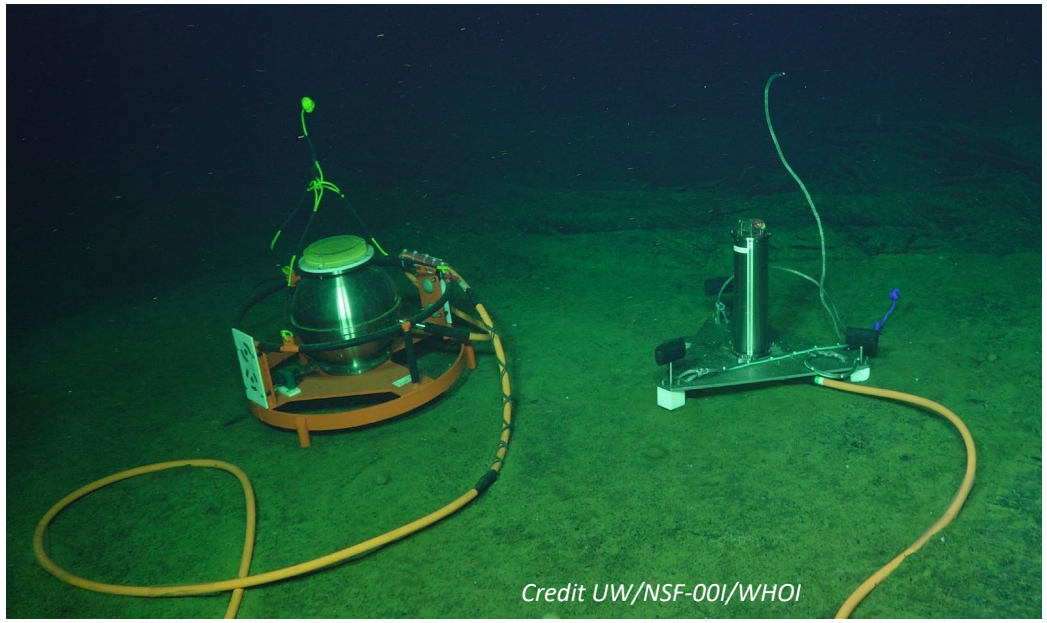
Axial Seamount

A critical mass of geophysical sensors

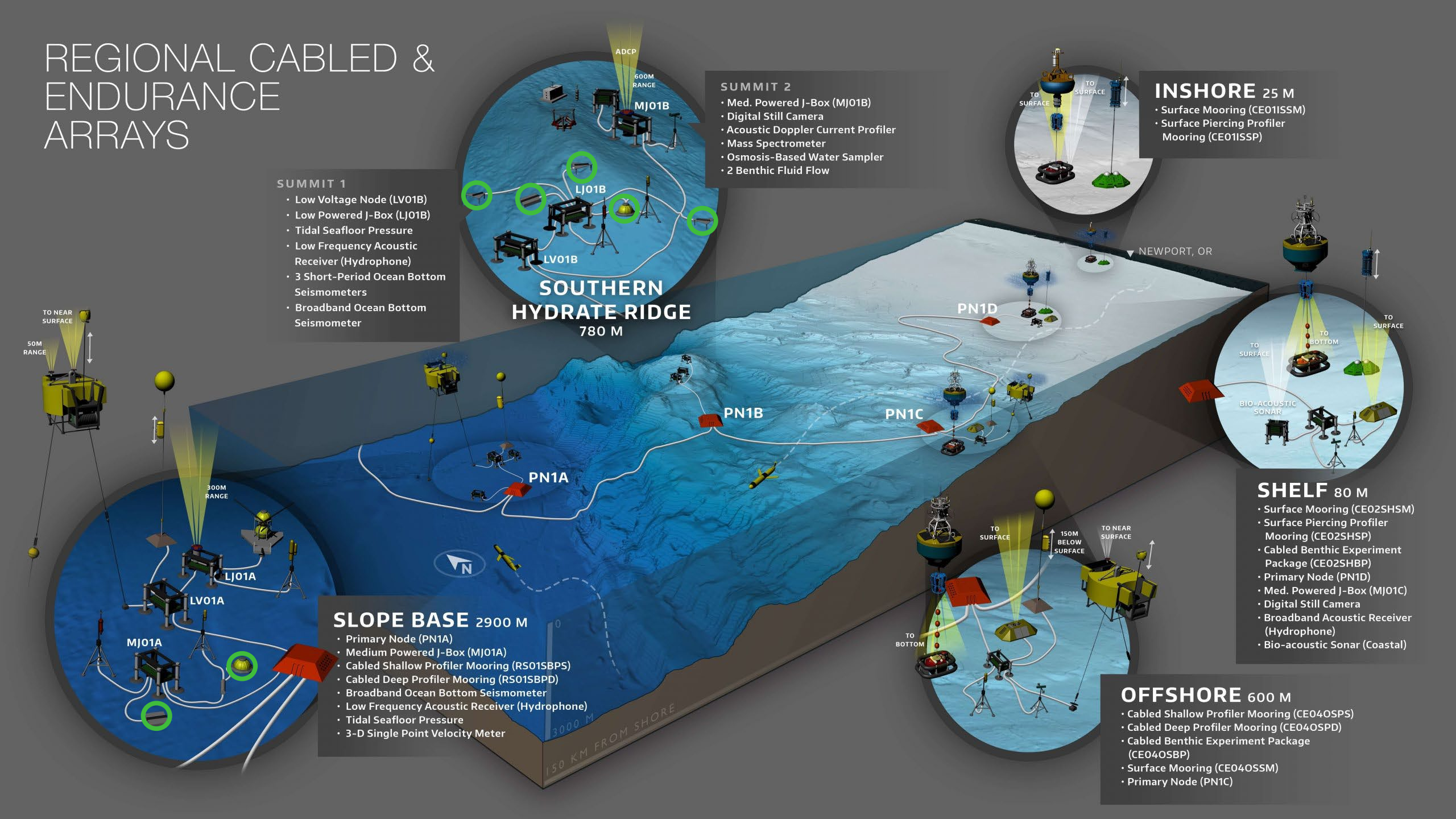








REGIONAL CABLED & ENDURANCE ARRAYS



SUMMIT 1

- Low Voltage Node (LV01B)
- Low Powered J-Box (LJ01B)
- Tidal Seafloor Pressure
- Low Frequency Acoustic Receiver (Hydrophone)
- 3 Short-Period Ocean Bottom Seismometers
- Broadband Ocean Bottom Seismometer

SUMMIT 2

- Med. Powered J-Box (MJ01B)
- Digital Still Camera
- Acoustic Doppler Current Profiler
- Mass Spectrometer
- Osmosis-Based Water Sampler
- 2 Benthic Fluid Flow

INSHORE 25 M

- Surface Mooring (CE01ISSM)
- Surface Piercing Profiler Mooring (CE01ISSP)

SHELF 80 M

- Surface Mooring (CE02SHSM)
- Surface Piercing Profiler Mooring (CE02SHSP)
- Cabled Benthic Experiment Package (CE02SHBP)
- Primary Node (PN1D)
- Med. Powered J-Box (MJ01C)
- Digital Still Camera
- Broadband Acoustic Receiver (Hydrophone)
- Bio-acoustic Sonar (Coastal)

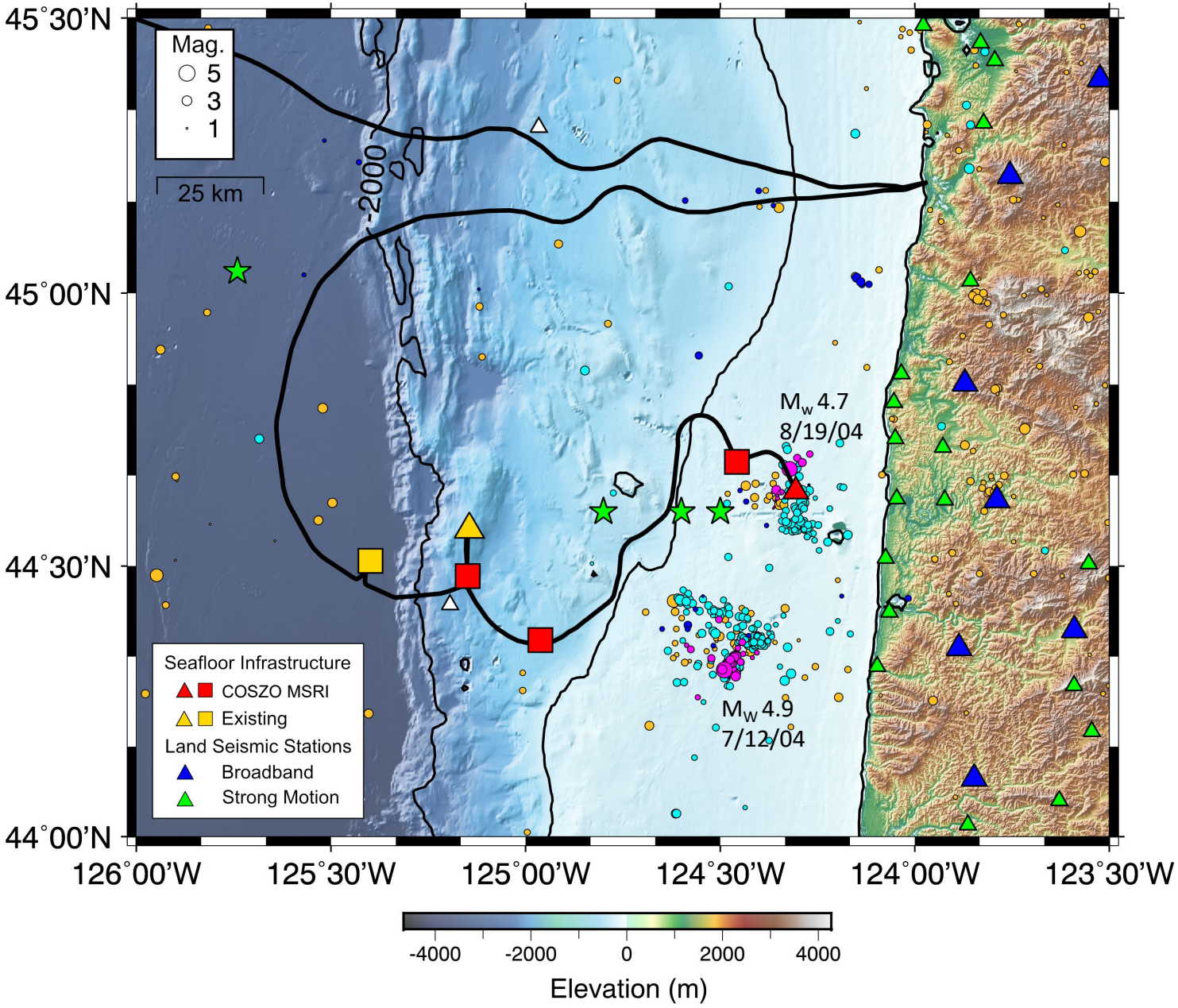
SLOPE BASE 2900 M

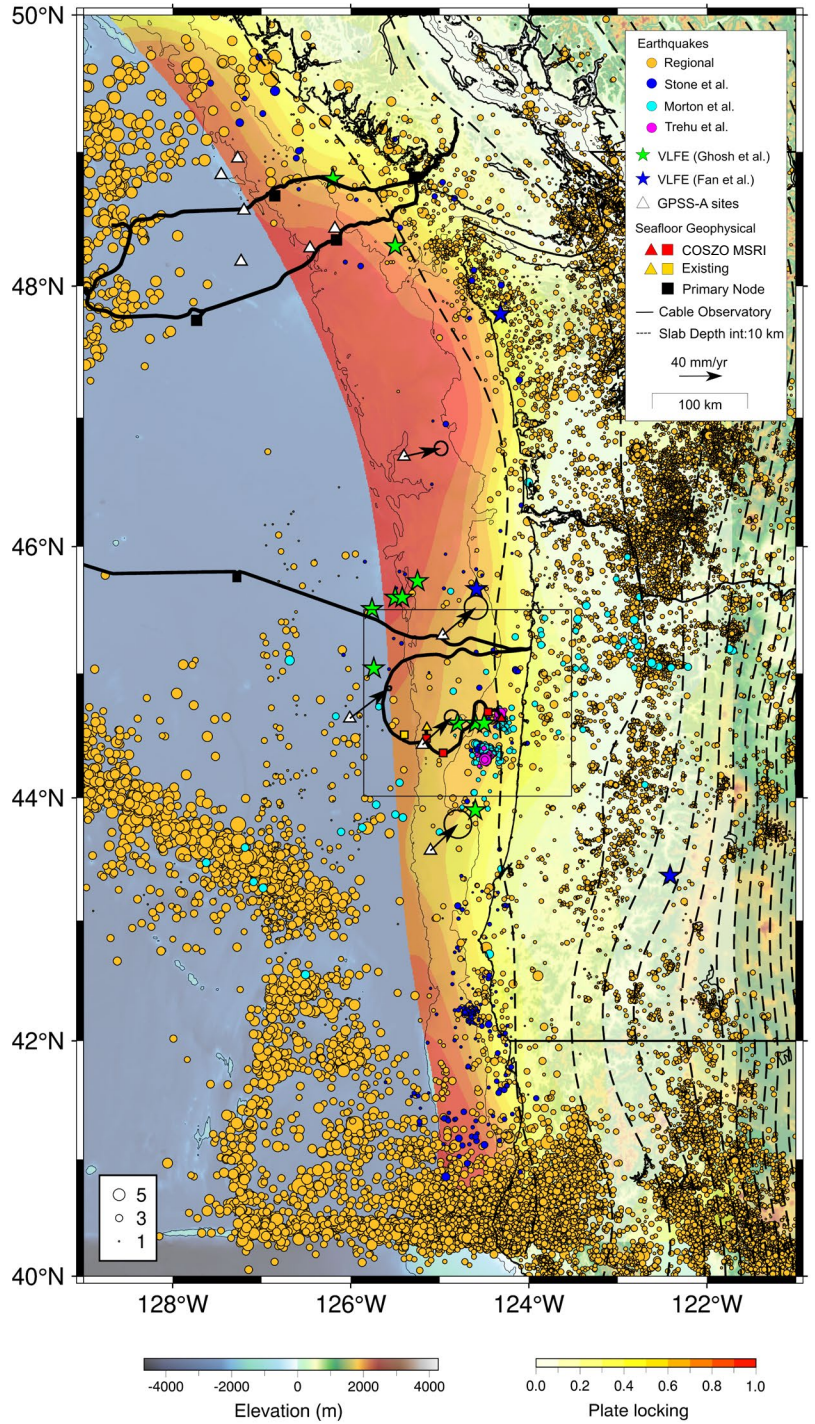
- Primary Node (PN1A)
- Medium Powered J-Box (MJ01A)
- Cabled Shallow Profiler Mooring (RS01SBPS)
- Cabled Deep Profiler Mooring (RS01SBPD)
- Broadband Ocean Bottom Seismometer
- Low Frequency Acoustic Receiver (Hydrophone)
- Tidal Seafloor Pressure
- 3-D Single Point Velocity Meter

OFFSHORE 600 M

- Cabled Shallow Profiler Mooring (CE04OSPS)
- Cabled Deep Profiler Mooring (CE04OSPD)
- Cabled Benthic Experiment Package (CE04OSBP)
- Surface Mooring (CE04OSSM)
- Primary Node (PN1C)

Cascadia Subduction Zone





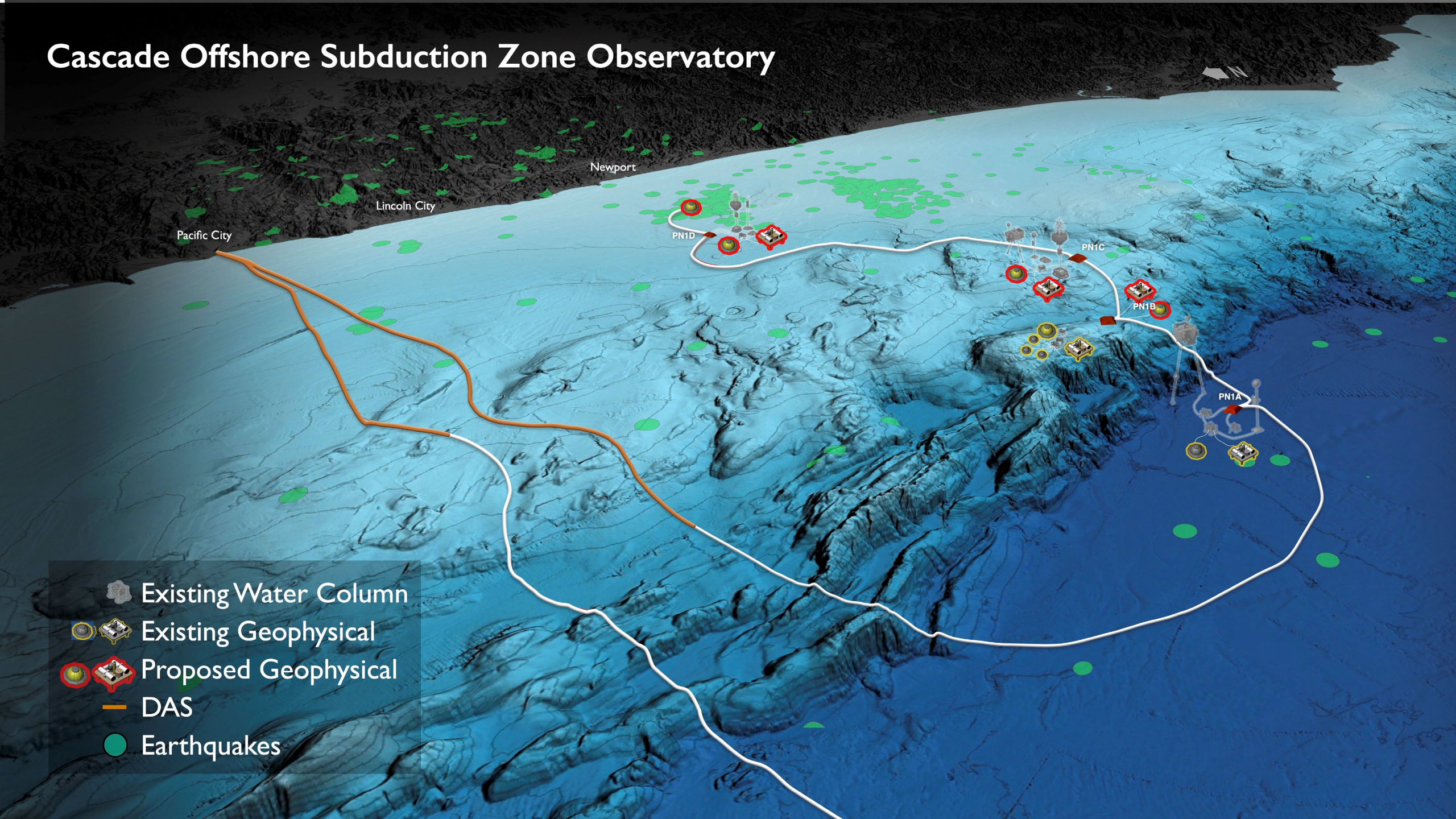
COSZO Science Questions

1. How does the locking of the Cascadia megathrust transition between the deformation front and the coastline off central Oregon?
2. Is there transient slip behavior – slow slip, tremor, and/or very low frequency earthquakes – offshore spanning the locked zone and its downdip transition? If so, might this be used to track the redistribution of stress on the megathrust, and possibly provide insight into precursory fault behavior?
3. How are the clusters of shallow earthquakes offshore linked to the megathrust?
4. What is the baseline deformation rate and fault slip behavior of the accretionary prism?

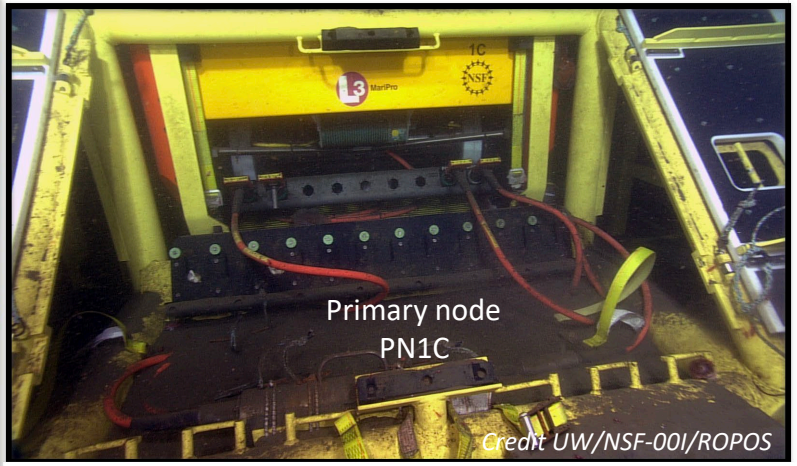
COSZO Hazards Applications

1. Contribute observations that will contribute to efforts to improve scientific understanding of the hazards of Cascadia Subduction Zone.
2. Provide a platform to prototype approaches and infrastructure for offshore real-time earthquake and tsunami early warning.

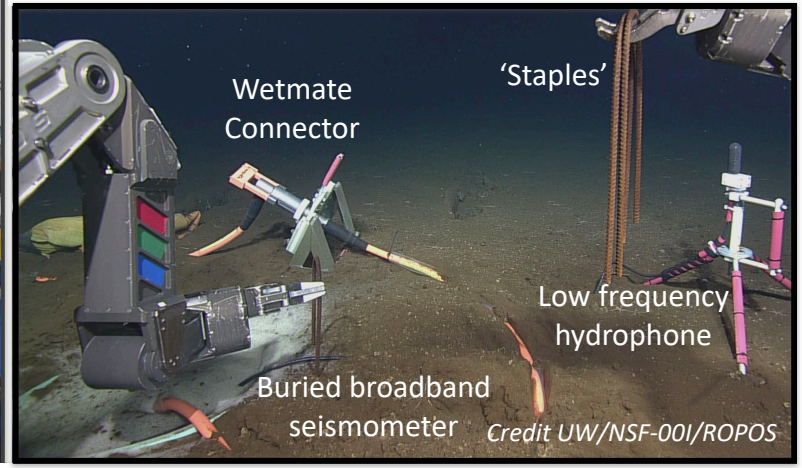
Cascade Offshore Subduction Zone Observatory

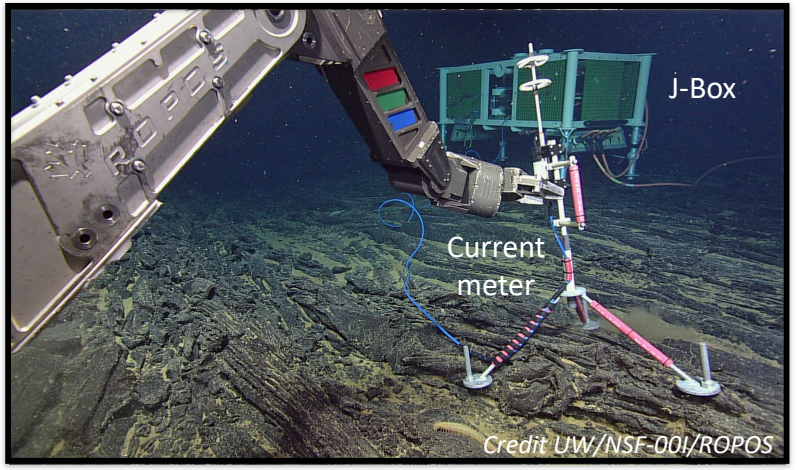


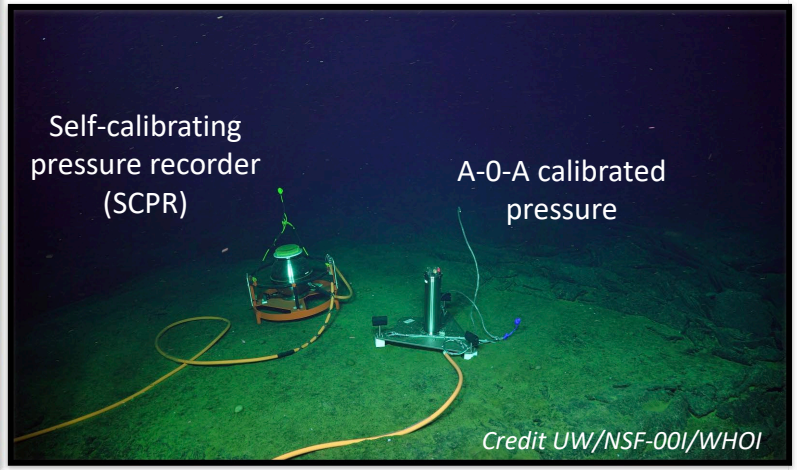

JASON
ONR
NOAA
J-Box includes spare ports for PI instruments
Credit UW/NSF-00I/WHOI

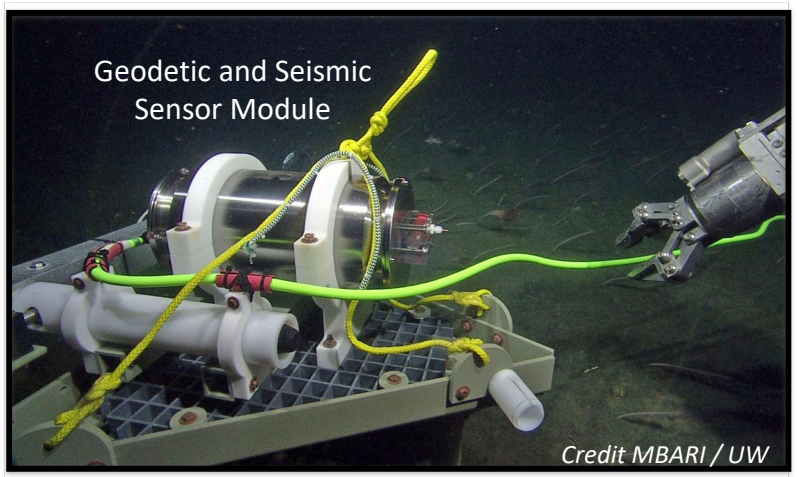

Primary node PN1C
Credit UW/NSF-00I/ROPOS


Broadband seismometer inserted in caisson
Credit UW/NSF-00I/ROPOS


Wetmate Connector
'Staples'
Low frequency hydrophone
Buried broadband seismometer
Credit UW/NSF-00I/ROPOS

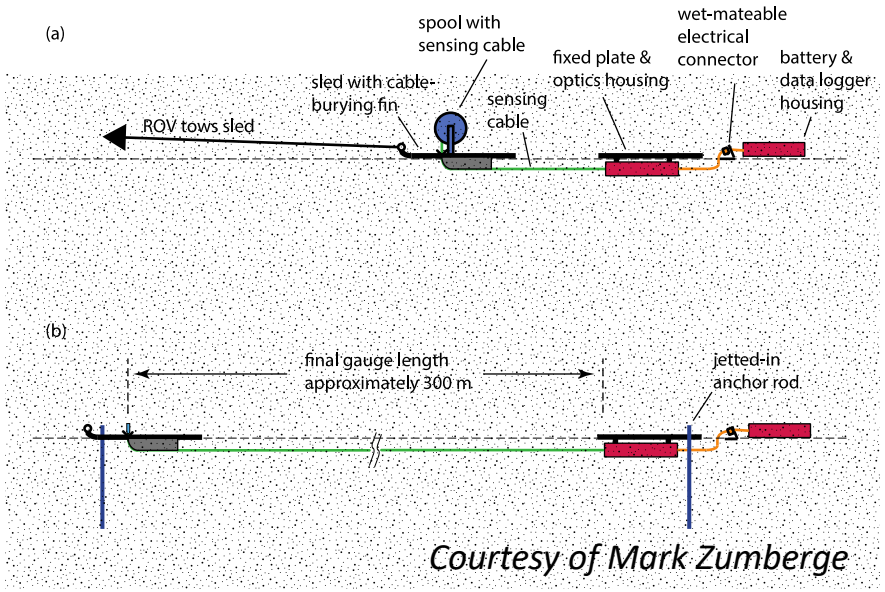

J-Box
Current meter
Credit UW/NSF-00I/ROPOS


Self-calibrating pressure recorder (SCPR)
A-0-A calibrated pressure
Credit UW/NSF-00I/WHOI

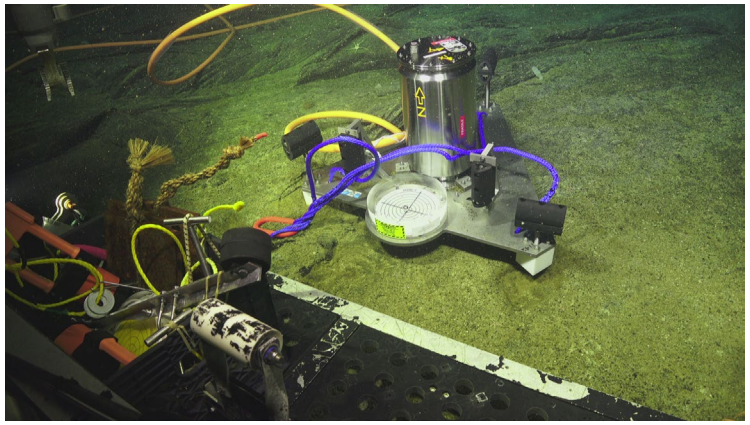

Geodetic and Seismic Sensor Module
Credit MBARI / UW

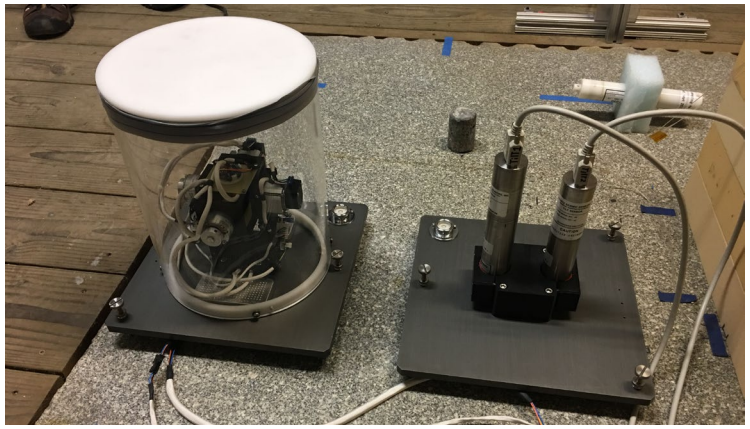
Possible PI Instruments for spare ports

Optical Fiber Strainmeter

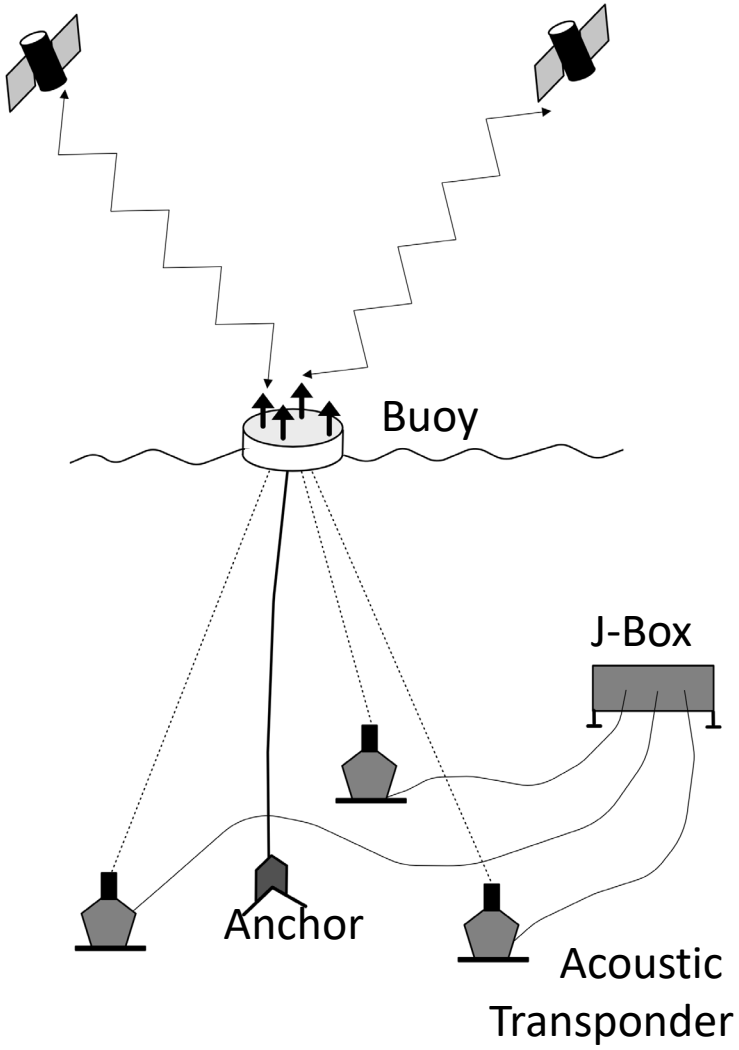


Quartz Crystal Tiltmeters

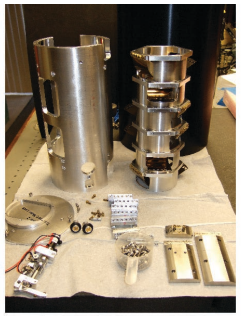




Continuous GNSS-Acoustic



Optical seismometers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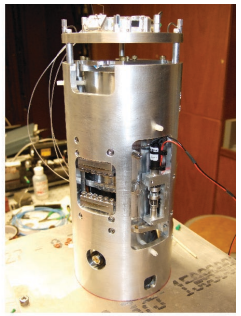
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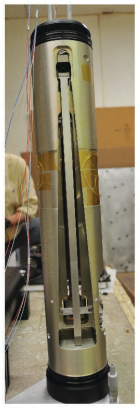
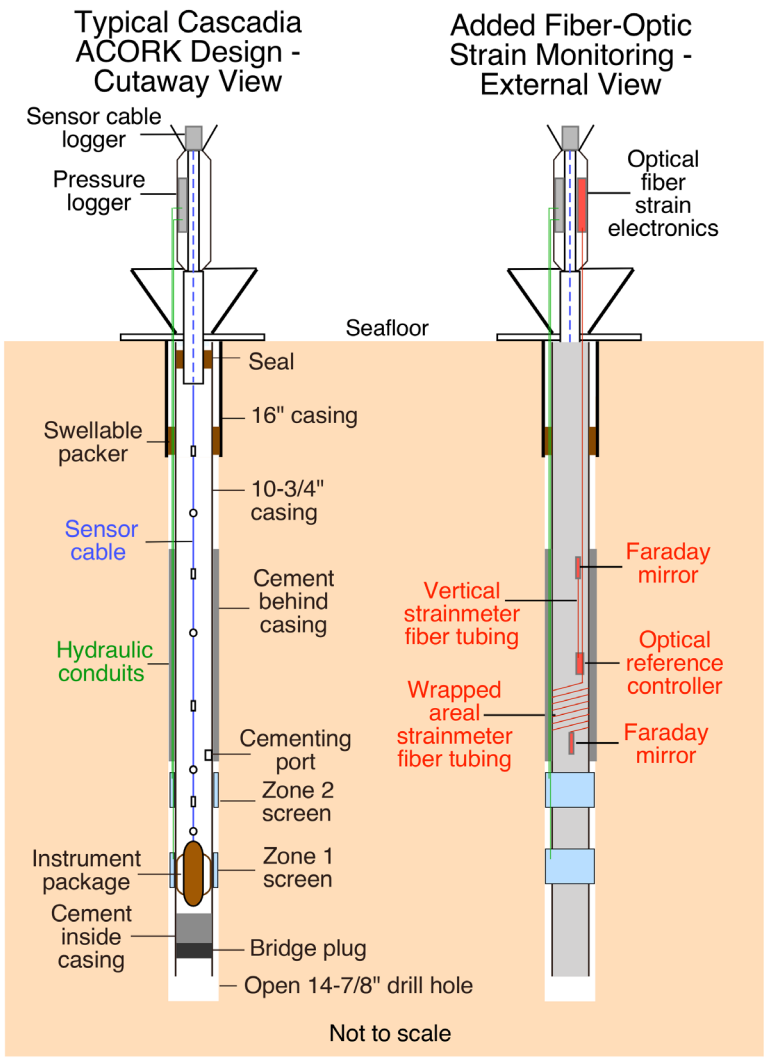
Courtesy of Mark Zumberge


3

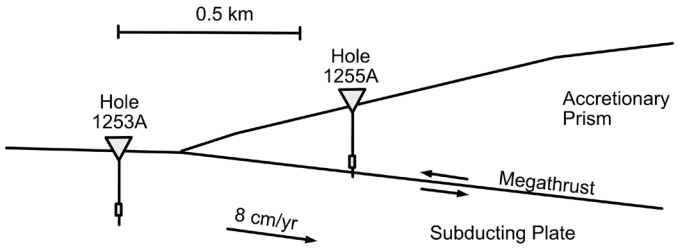

4

Cabled Borehole Observatories

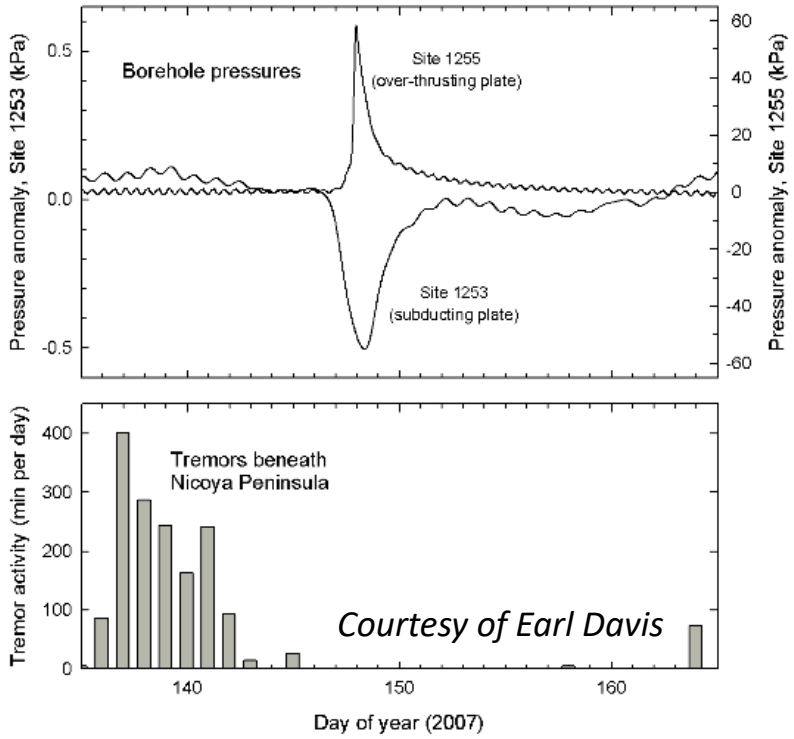
Cascadia ACORK Design



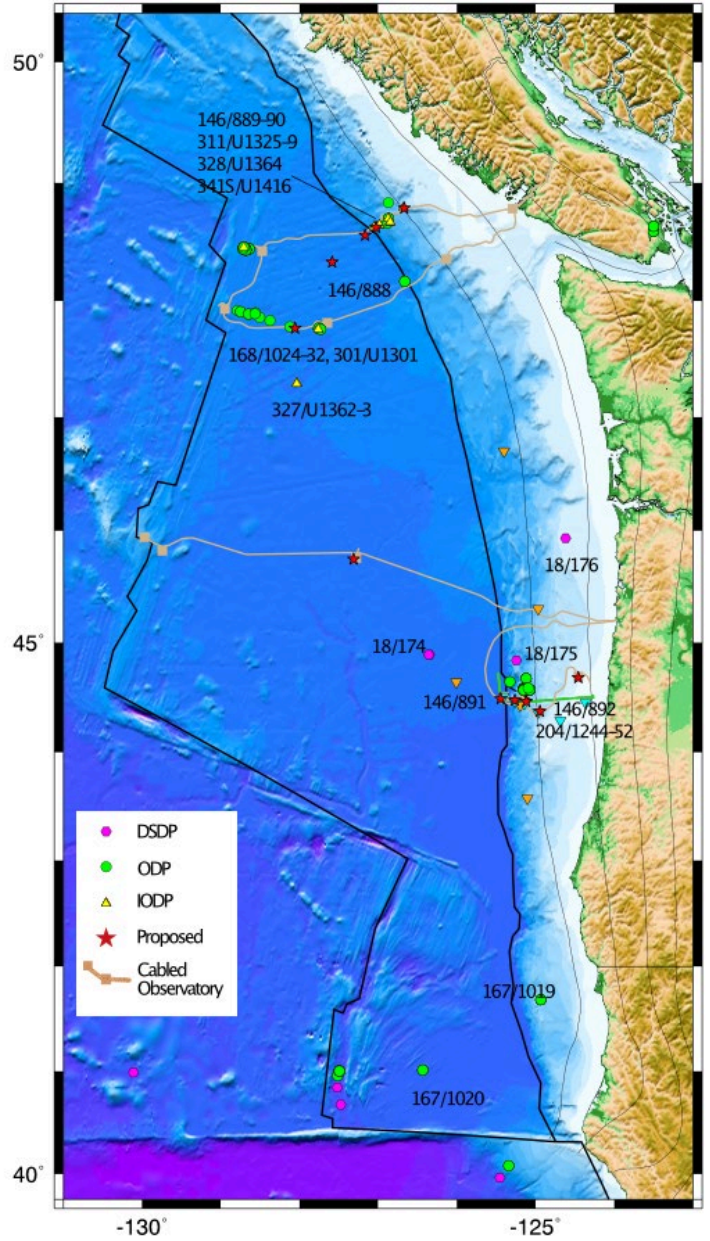
Costa Rica Example



Based on figure in Davis et al. (2011)

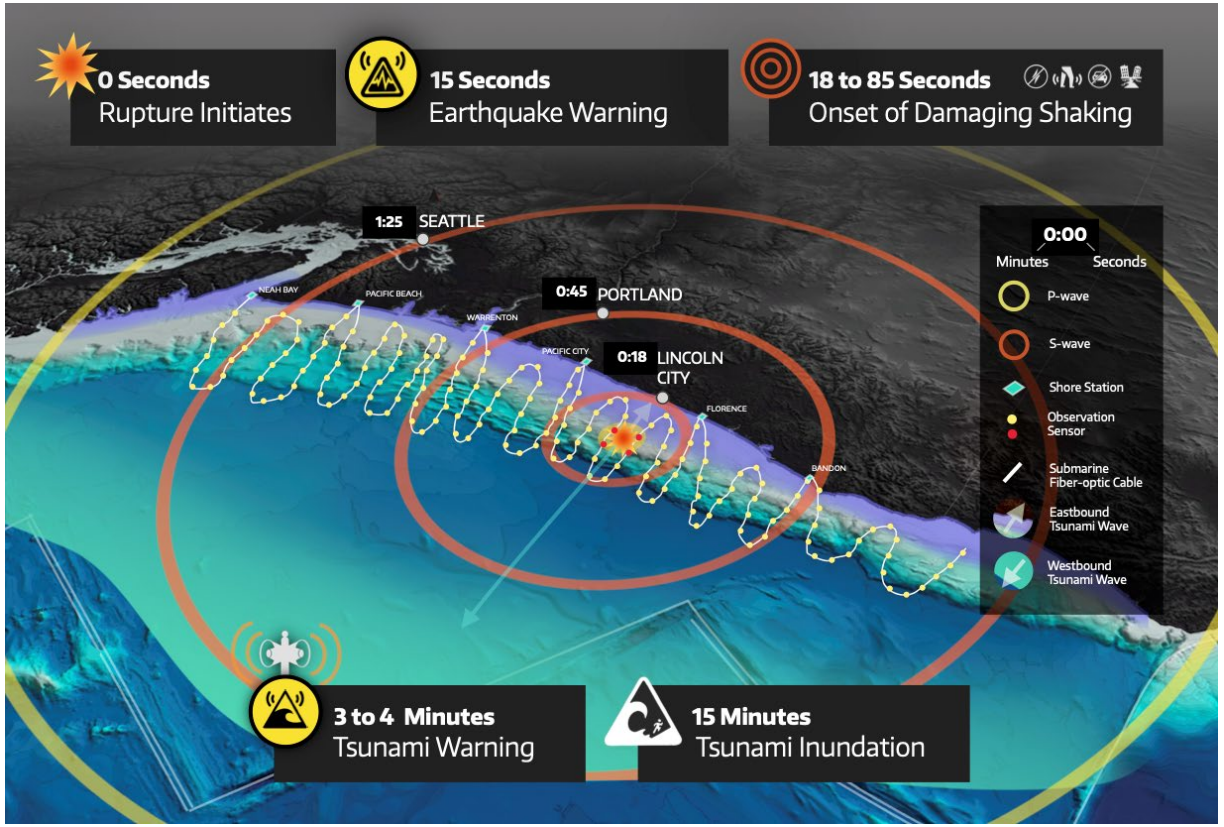


Proposed Borehole Observatories

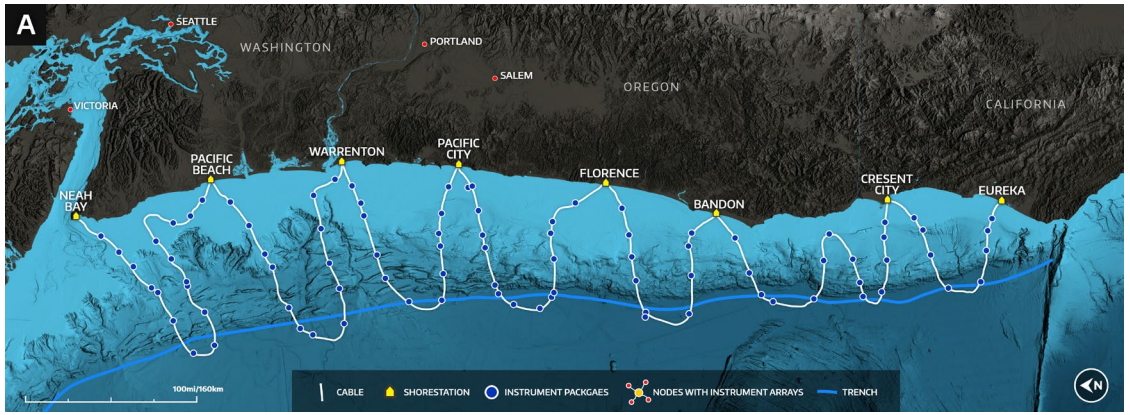


Offshore Earthquake & Tsunami Early Warning

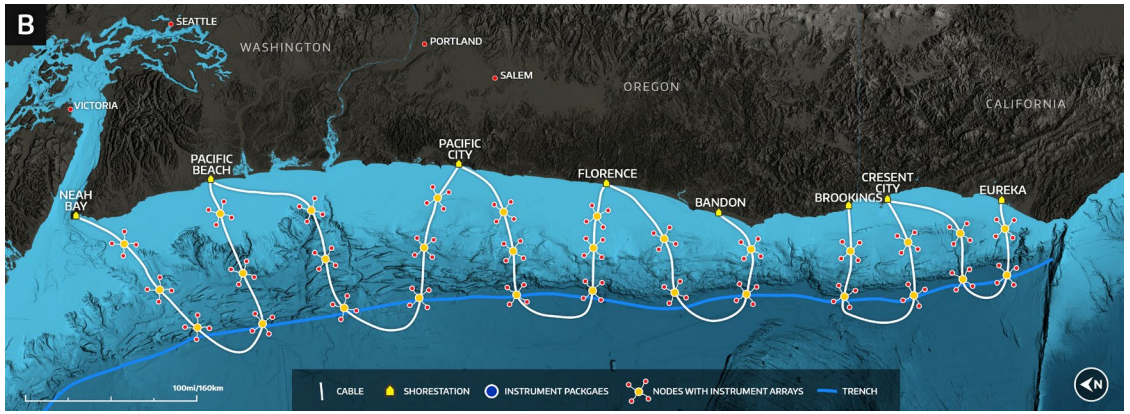
A feasibility study for Cascadia – Schmidt et al. (2019) http://hdl.handle.net/1773/50968



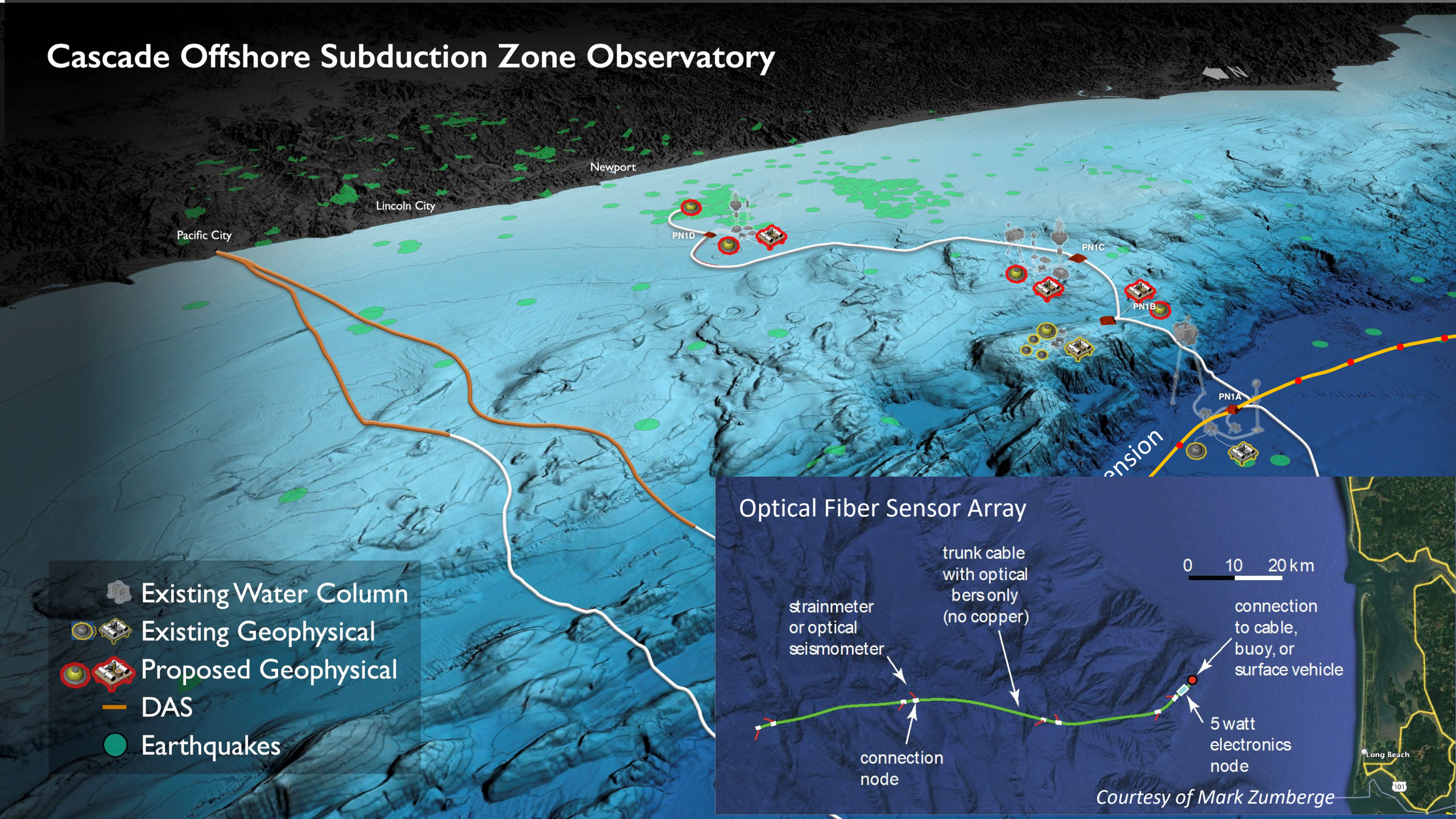
Inline System



Connectorized System

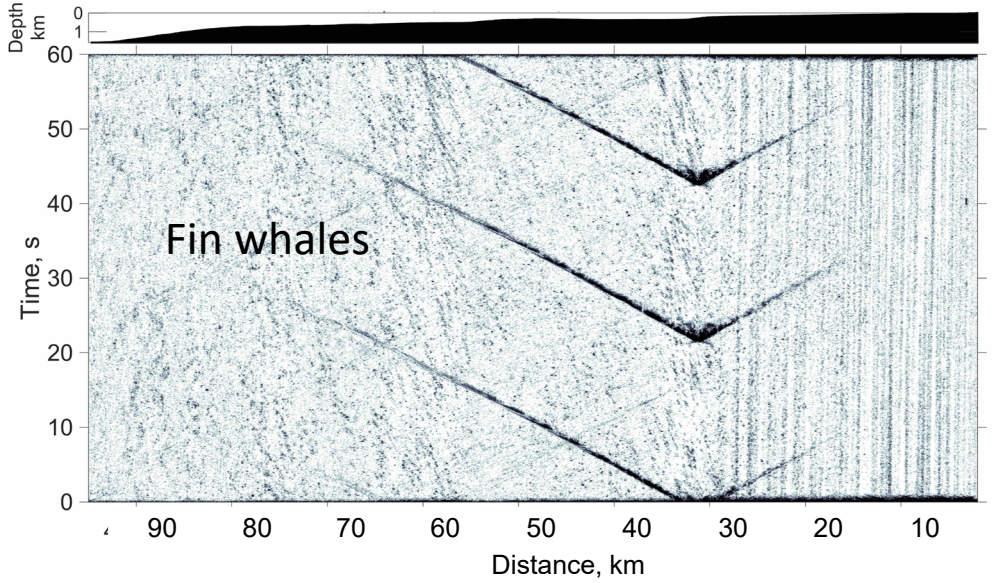


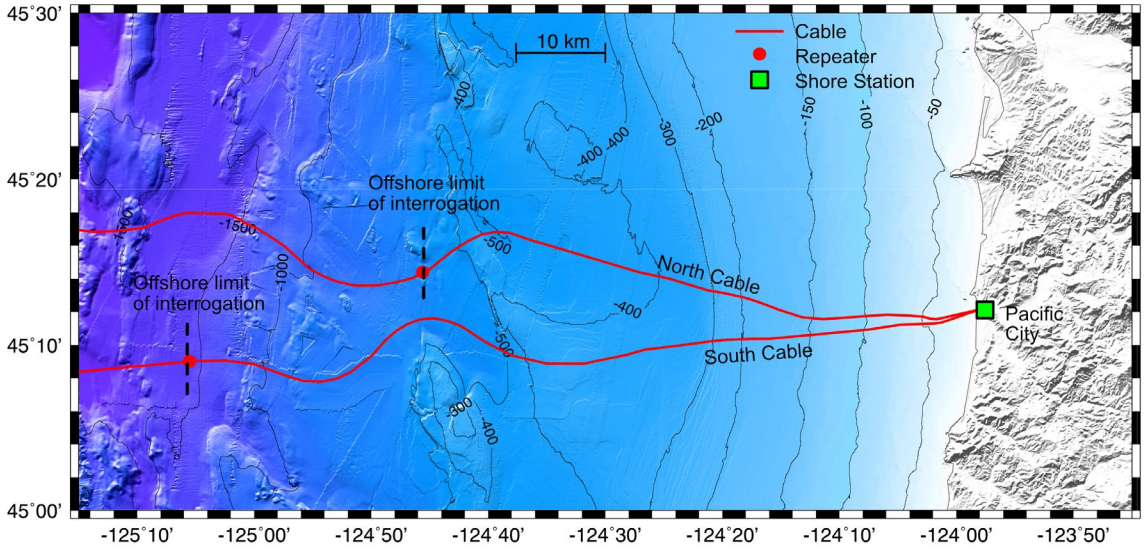
Cascade Offshore Subduction Zone Observatory

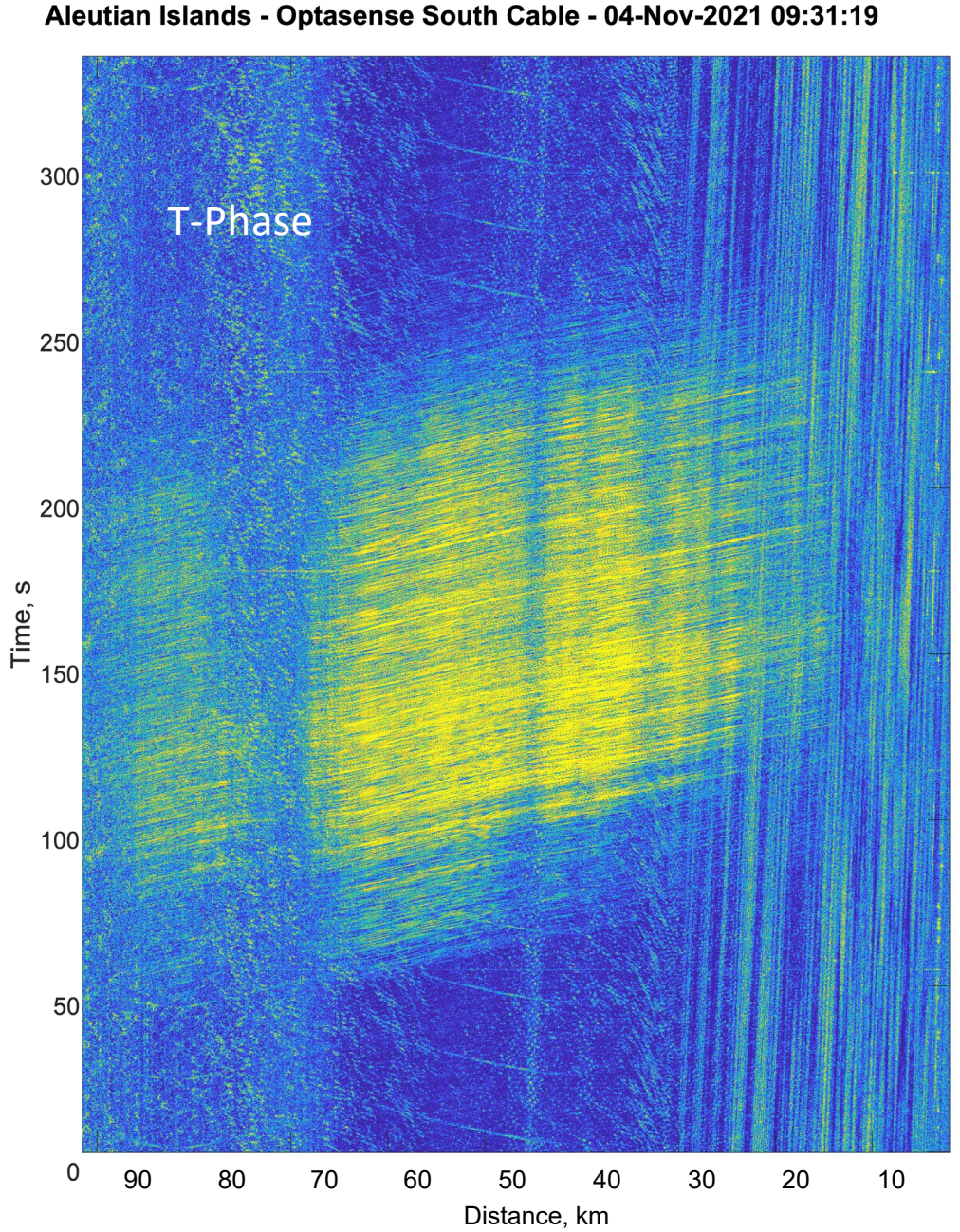


OOI RCA DAS Experiment

- 4-days in November 2021 during shutdown.
- Continuous DAS on the live observatory now appears feasible.

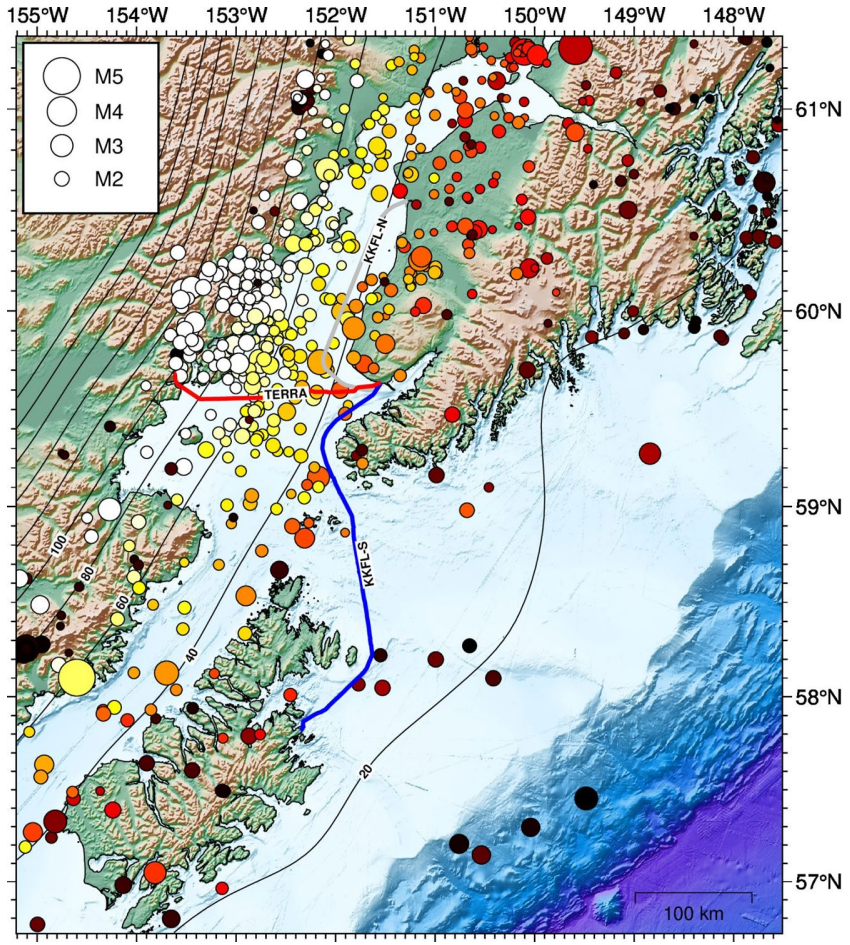






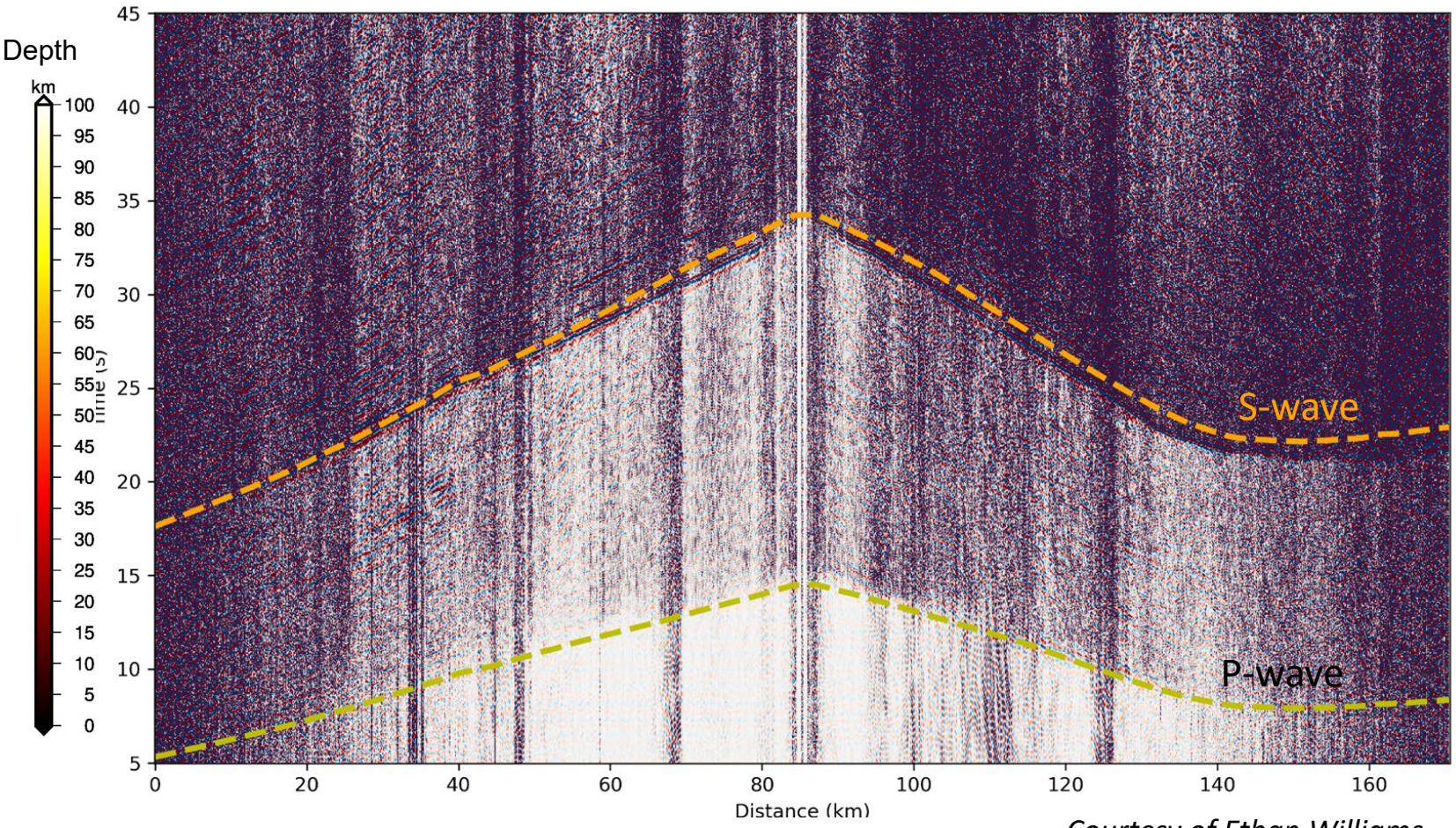
GCI submarine telecommunication cables out of Homer, AK

Seismicity, June 9– July 3, 2023



Courtesy of Ethan Williams

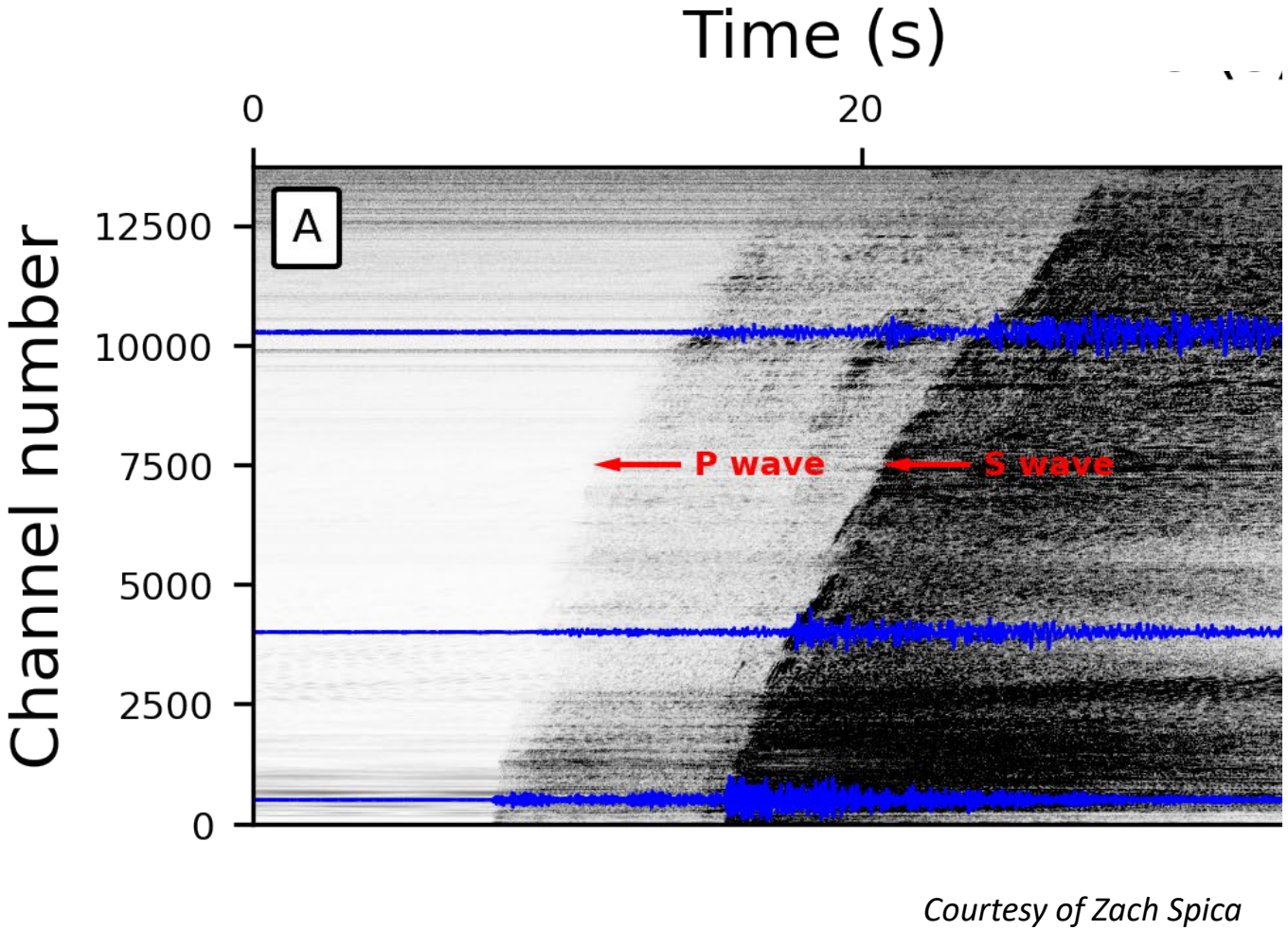
July 31, 2023, M_L 3.60, 80 km SE of Kokhanok, Alaska 9.6 km depth



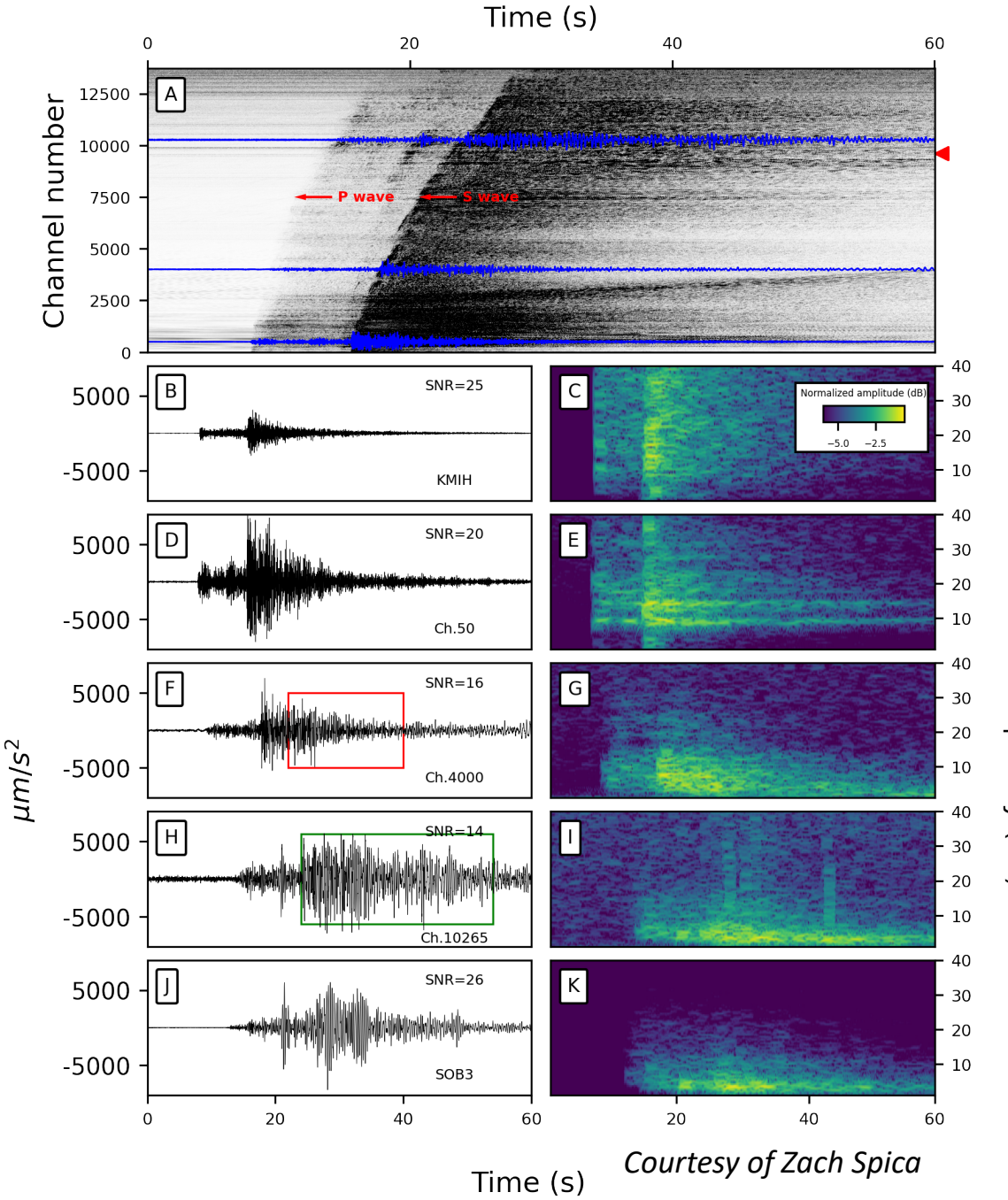
Courtesy of Ethan Williams

DAS Offshore Sanriku, Japan

2019-11-23T16:22:03 UTC, 66 km depth, M 3.3

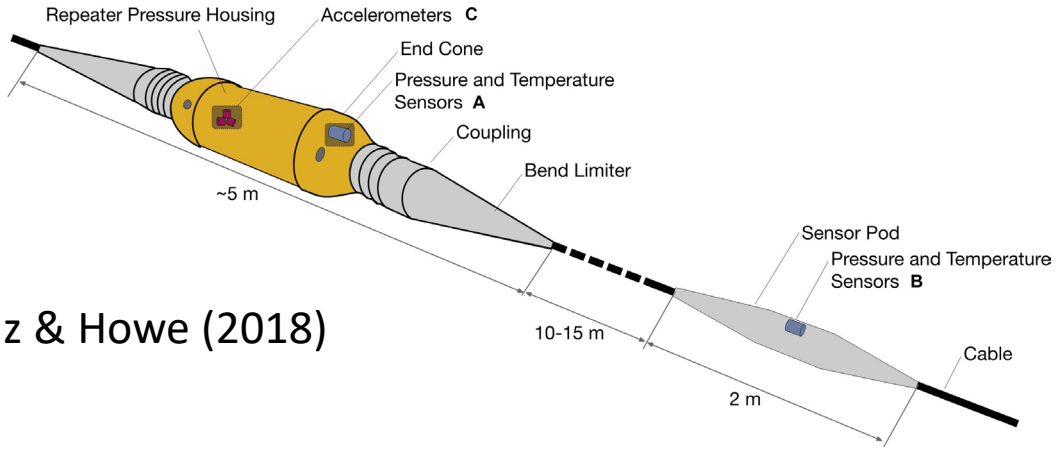


Courtesy of Zach Spica

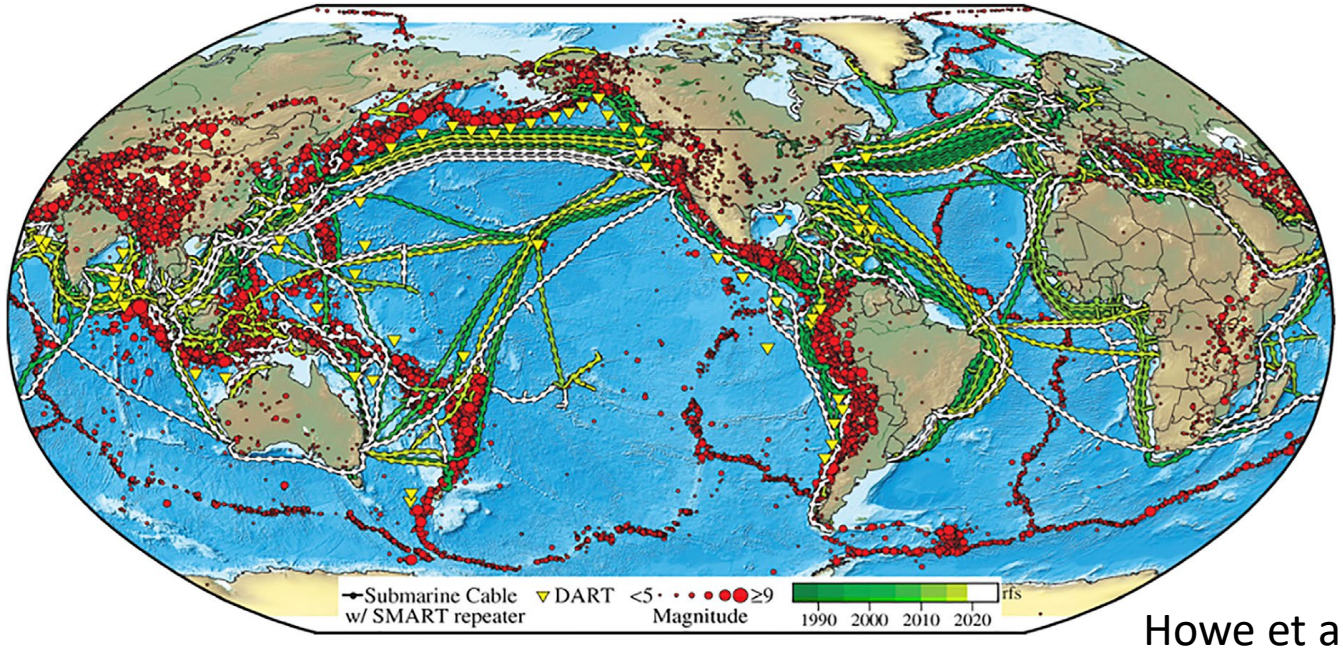


Courtesy of Zach Spica

SMART Cables

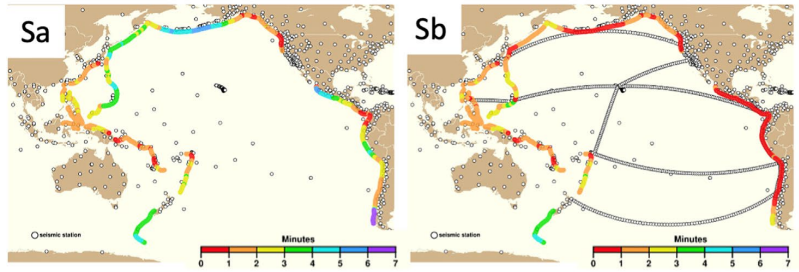


Lenz & Howe (2018)

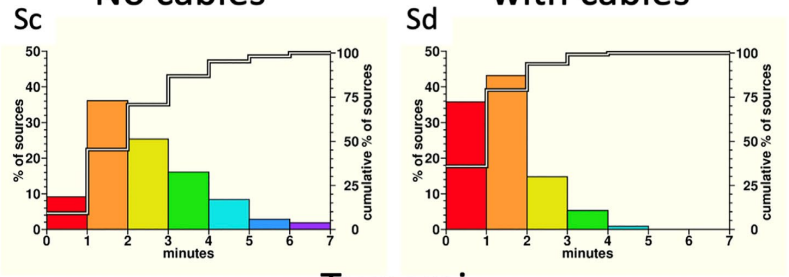


Howe et al (2022)

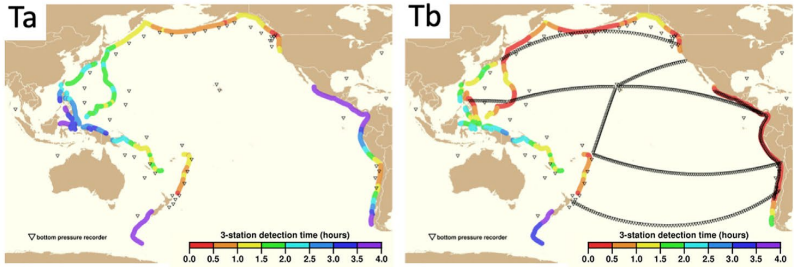
Seismic



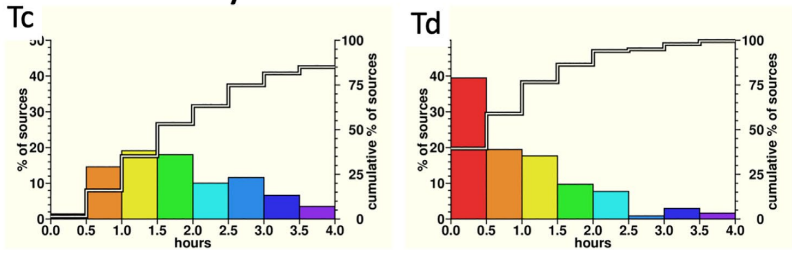
No cables | with cables



Tsunami



BPR only | with cables

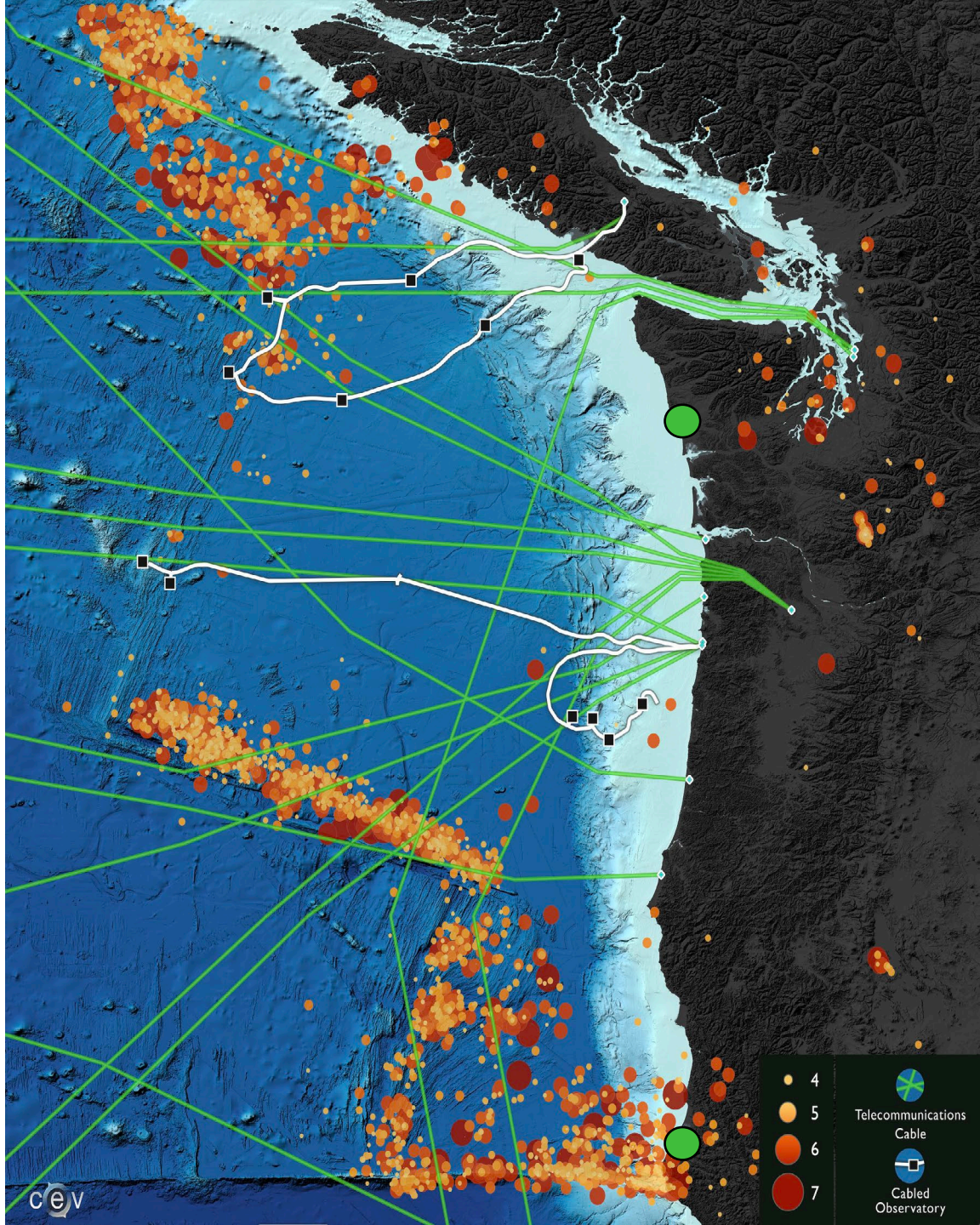


All figures courtesy of Bruce Howe

created by Nate Becker and Stu Weinstein

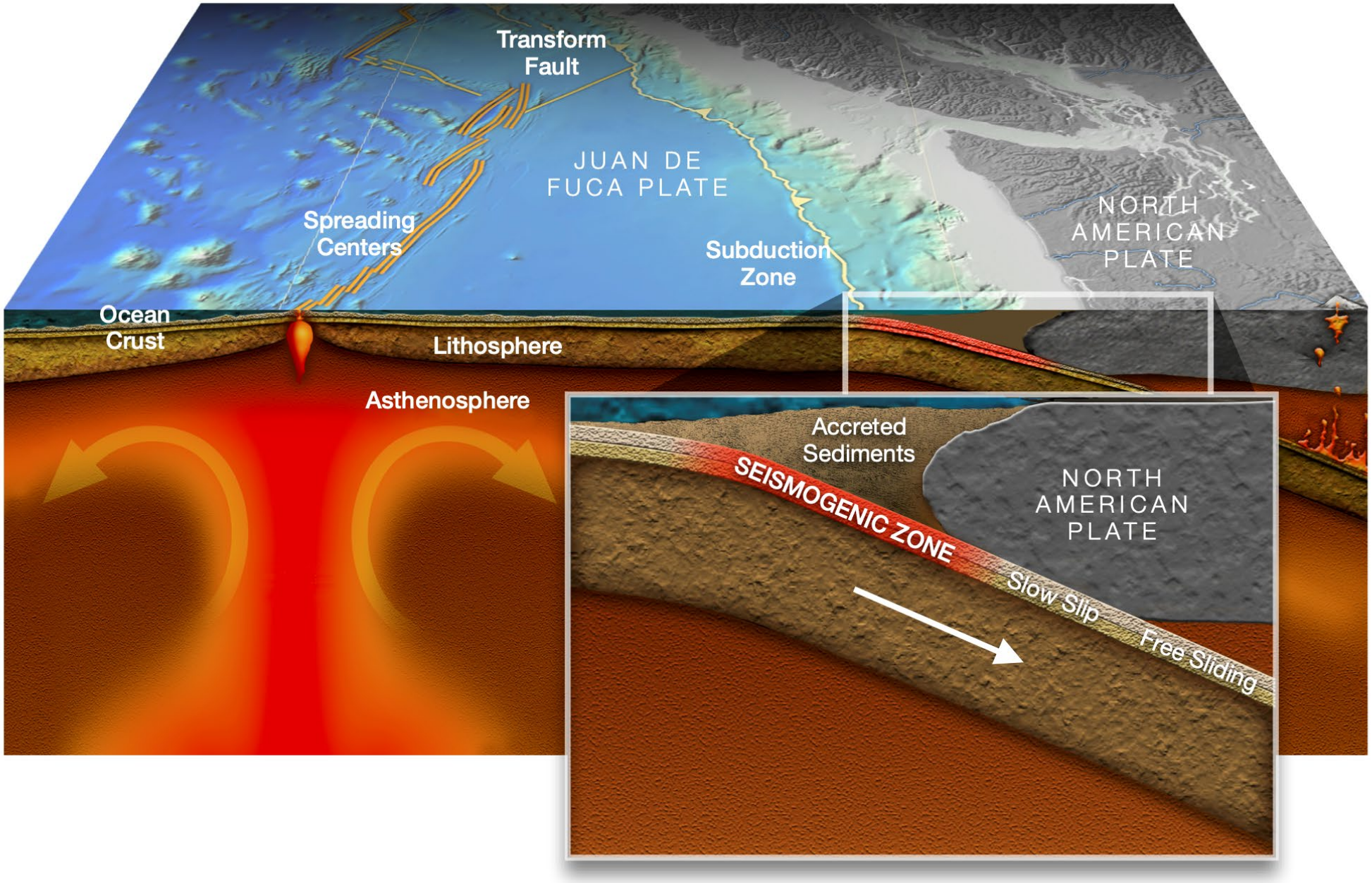
Telecommunication Cables in Cascadia

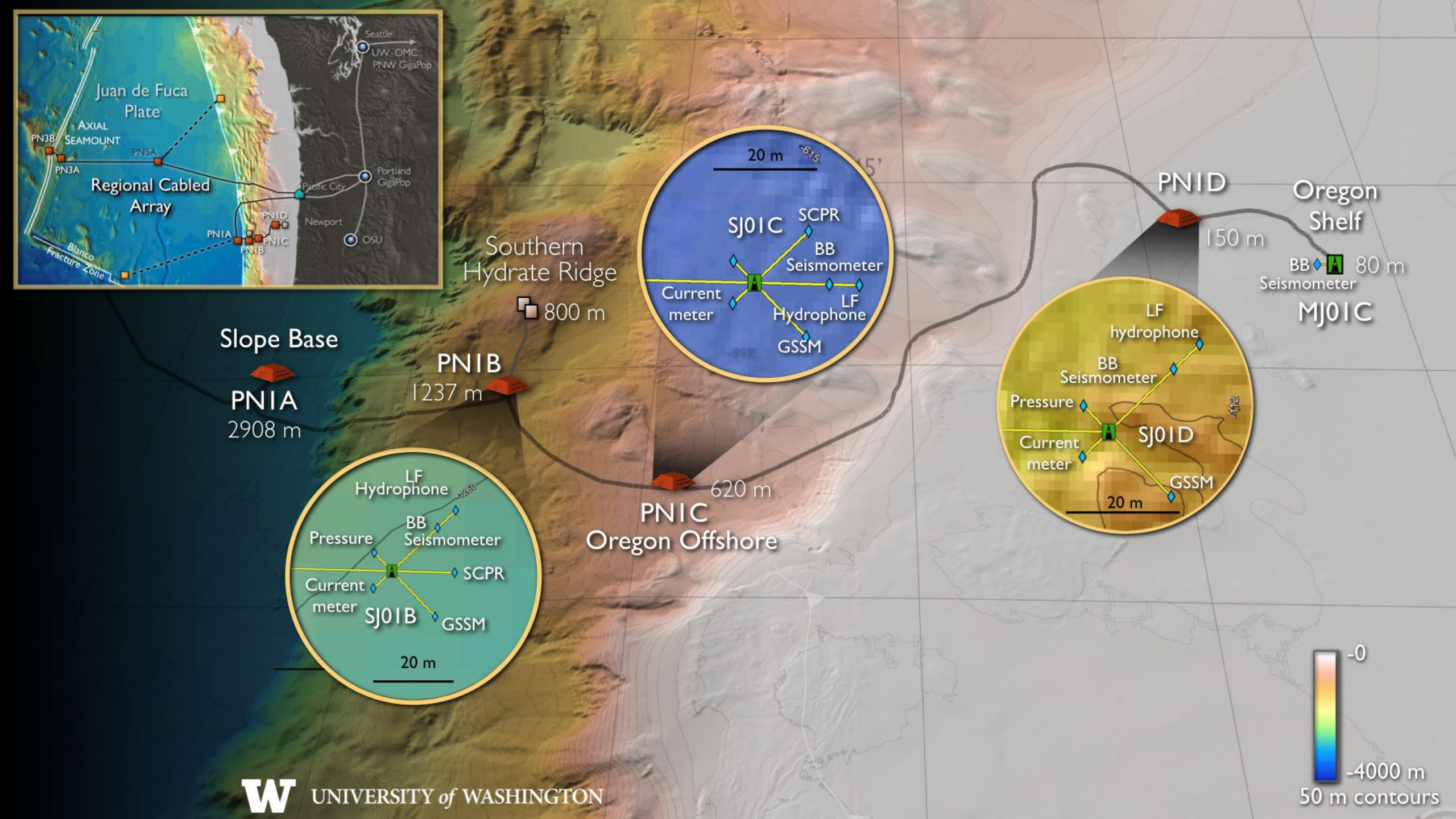
- Idealized routes (at this scale) from https://www.submarinecablemap.com as of 2 years ago
- Systems have a design lifetime of 25 years
- Network is constantly evolving with new cables added an old cables retired
- Opportunities for science and early warning.



2025-2035: What COSZO would like

- A robust remotely operated vehicle and global ship capability.
- Healthy OTIC & core MG&G programs.
- CRESCENT & SZ4D.
- A pathway to install borehole observatories in Cascadia.
- GEO / CISE partnerships to handle the fiber sensing data flood.
- Support for OPP to push the envelope in fiber sensing, branching units and SMART repeaters on the Antarctica to Australia / New Zealand cable.
- Ongoing partnerships with Federal agencies responsible for mitigating hazards.
- New partnerships with submarine telecommunication companies.


Transform Fault
JUAN DE FUCA PLATE
Spreading Centers
Subduction Zone
NORTH AMERICAN PLATE
Ocean Crust
Lithosphere
Asthenosphere
Accreted Sediments
SEISMOGENIC ZONE
NORTH AMERICAN PLATE
Slow Slip
Free Sliding


Seattle
UW OMC
PNW GigaPop
Juan de Fuca
Plate
AXIAL
SEAMOUNT
PN3B
PN5A
PN3A
Regional Cabled
Array
Portland
GigaPop
Pacific City
PNID
Newport
PN1A
PN1B
PN1C
OSU
Blanco
Fracture Zone
Southern
Hydrate Ridge
800 m
Slope Base
PN1A
2908 m
PN1B
1237 m
620 m
PN1C
Oregon Offshore
20 m
SJ01C
SCPR
BB
Seismometer
Current
meter
LF
Hydrophone
GSSM
LF
Hydrophone
BB
Seismometer
Pressure
Current
meter
SJ01B
SCPR
GSSM
20 m
PN1D
150 m
Oregon
Shelf
BB
Seismometer
80 m
MJ01C
LF
hydrophone
BB
Seismometer
Pressure
Current
meter
SJ01D
GSSM
20 m
-0
-4000 m
50 m contours
UNIVERSITY of WASHINGTON

Instruments

- Buried broadband seismometer w/ strong motion accelerometer and hydrophone
- Pressure gauge
- Current meter
- In situ calibrated pressure
  - SIO Cabled Self-Calibrating Pressure Recorder (CSCPR)
  - Geodetic and Seismic Sensor Module (GSSM) – A-0-A calibrated pressure and acceleration with quartz crystal sensors.