New opportunities for Near-trench Geodesy

NSF#: 1935996, 2016995, 2232639

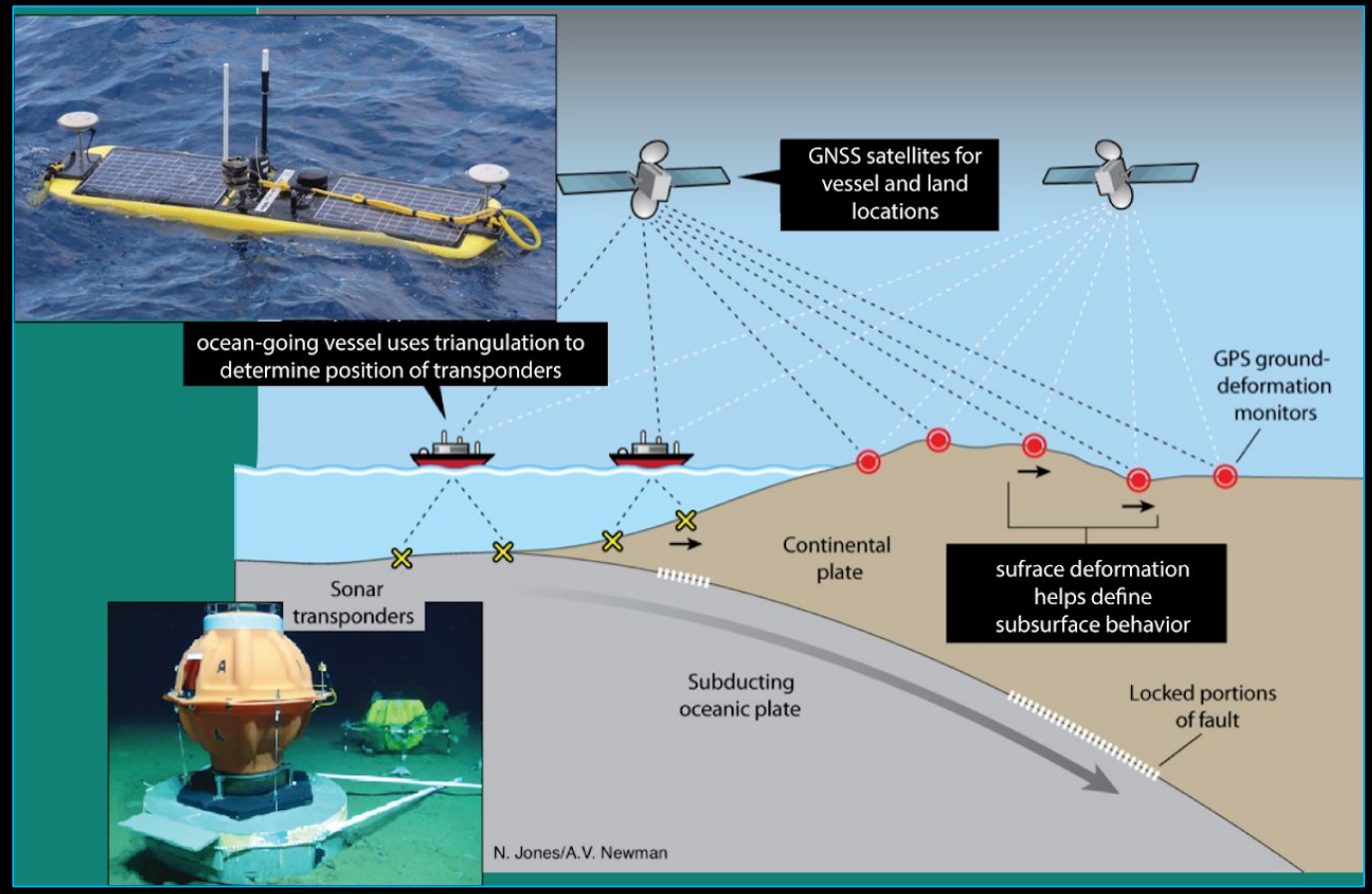
Andy Newman, Georgia Institute of Technology

Collaborators:

- **Mark Zumberge**, Scripps, UCSD
- **Noel Jackson,** Univ. of Kansas
- **Donna Charlevoix,** EarthScope
- **David Schmidt**, Univ. Washington
- **Spahr Webb**, Lamont Doherty, Columb. U.
- **Surui Xie,** Univ. Houston
- **John DeSanto,** Univ. Washington

Much thanks to:

Dave Chadwell & Fred Speiss, Scripps UCSD



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Most geodesy is on-land

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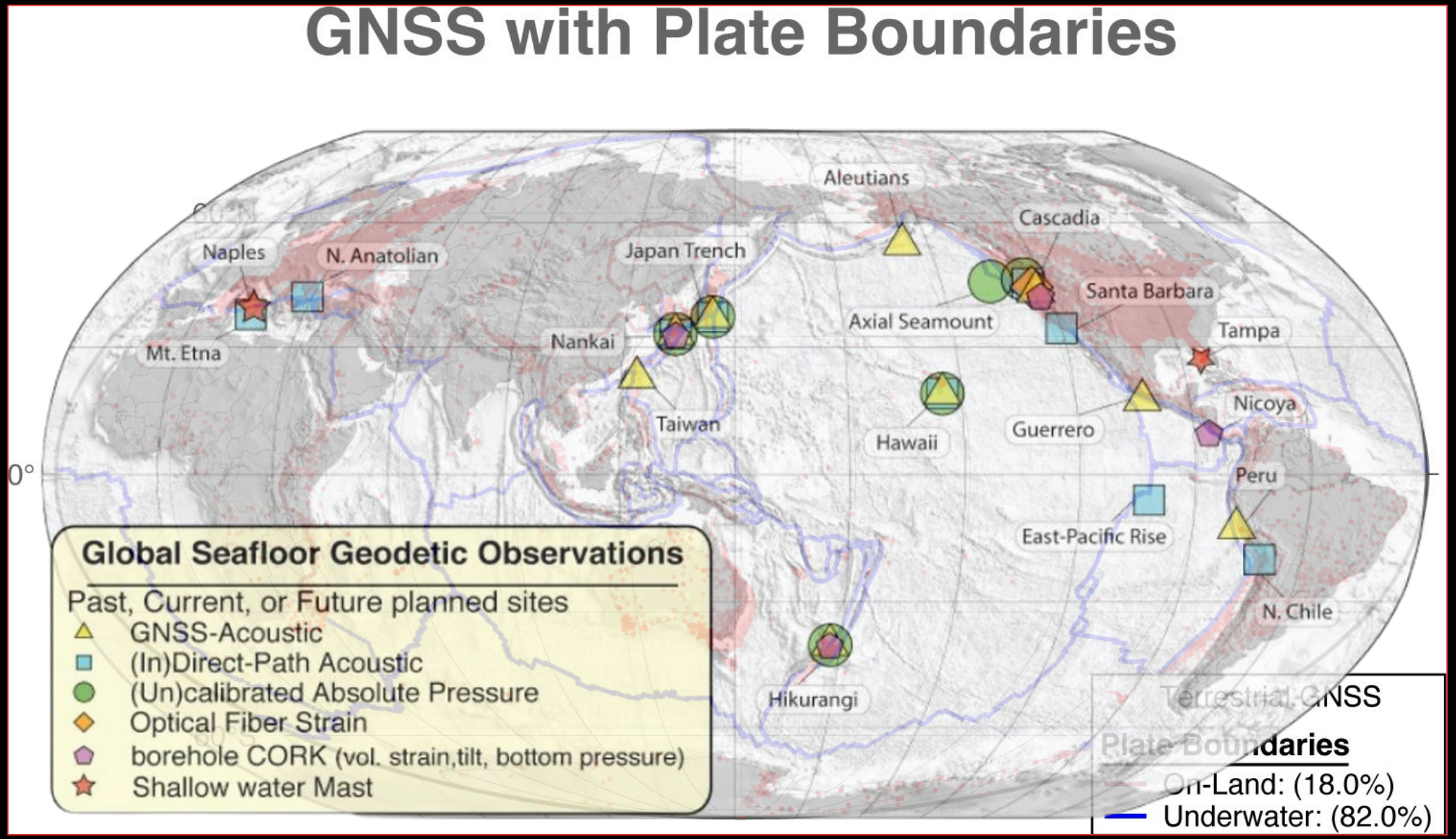
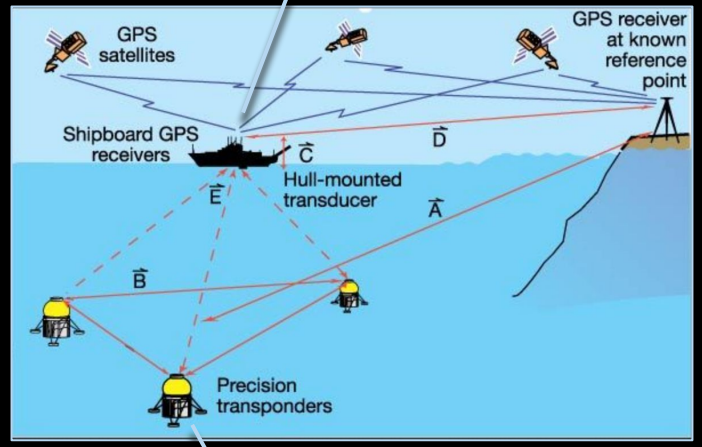


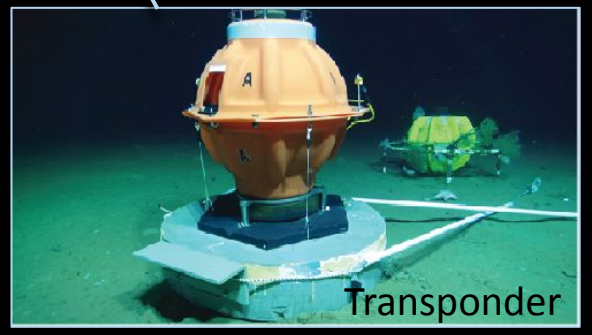
Seafloor Geodetic Instrument Pool (SGIP)

NSF#: 1935996, 2016995, 2232639

Develop Team: Chadwell, Schmidt, Newman, Jackson, Webb, Zumberge

- **51** Acoustic **transponders**, 10 yr batteries
  - ~cm/yr+ horizontal motions (long-term)
  - Rated for 3000 m water depth
- **17** Absolute Pressure Gauges (**APG**) within transp. housing
  - ~cm/mo vertical motions (short-term)
- **48** reusable kinematic **benchmarks**
- **3 Wave Glider** autonomous green-powered surface vehicles





Funding ($5.5M) in 2019 from NSF GEO Directorate, Front office, Polar Programs, and OCE

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SGIP: GNSS-Acoustic/APG

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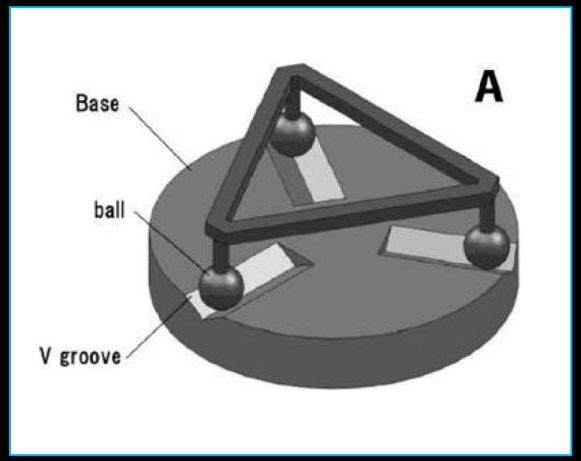
- 51 (16 sites + 3 backups) Transponders (1 in 3 with pressure sensor integrated within housing)

- 48 reusable kinematic benchmarks
  - Transponder is attached at time of deployment but can be remotely released
  - Titanium V-grooves essential for mm-level sensor replacement (for long-term monument stability)



SGIP: Wave Gliders

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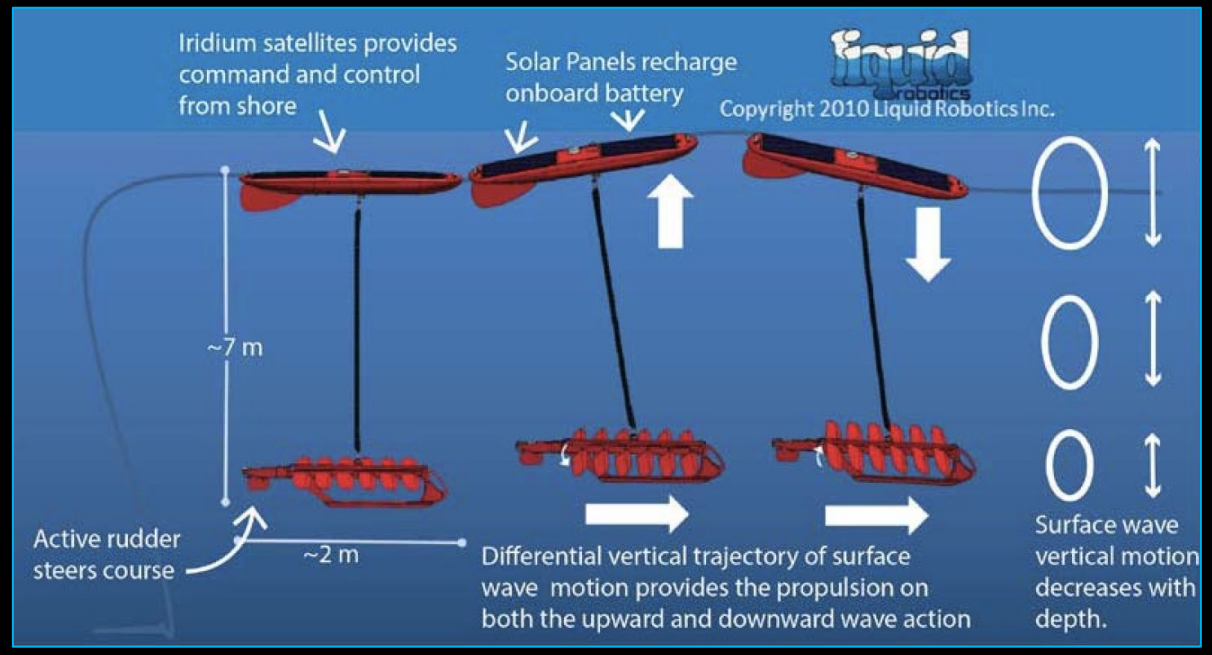
- 3 autonomous green-powered UAVs
  - Locomotion by differential vertical wave heights
  - Comms and acoustics from solar
  - Require slow current (~<2 kt), with thruster for added drive when needed (sv3)
  - Semi-autonomous (programmed nav. w/piloting for vehicle avoidance)

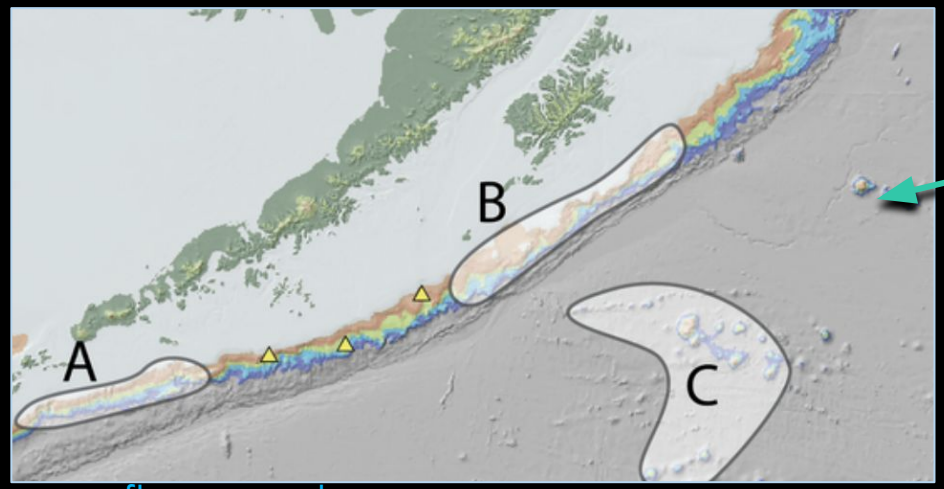


Near-Trench Community Geodetic Experiment

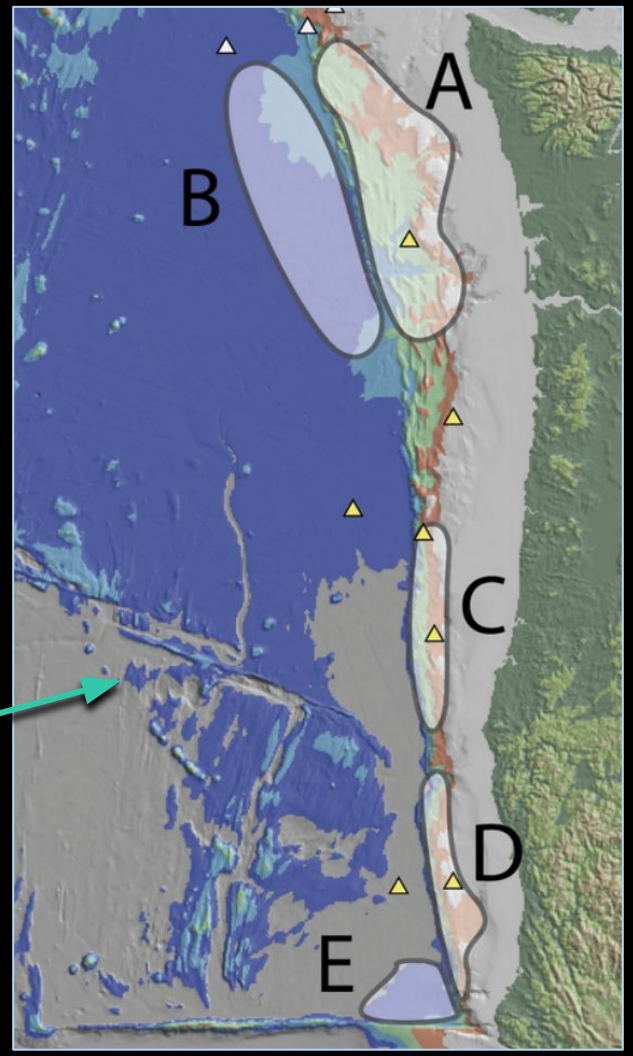
Funded August 2022

NSF#: 1935996, 2016995, 2232639

- Prompted by Community-wide seafloor geodesy (2021) and regionally-focused (2022) workshops
- Project period: 2023-2027 (from NSF-OCE: 5 yr, $5.5M)
- 12 sites (36 transponders) across Cascadia and Alaska
  - Guided by community science questions and deployment constraints



Primary regions of interests for science questions



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▲ -- *Existing GNSS-A sites*

AK-CASC Community SFG Experiment Report, 2022

Experiment Design: Cascadia

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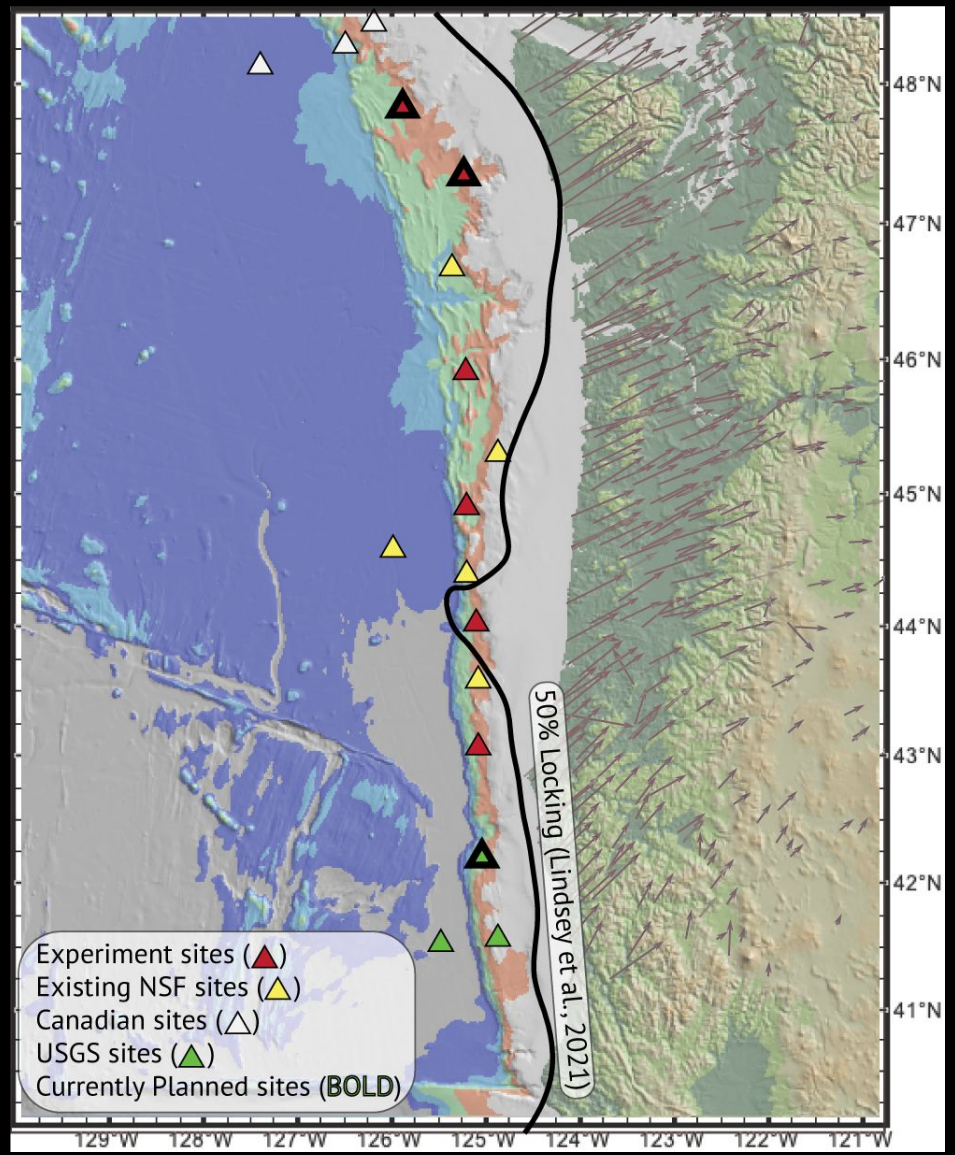
Deployment period: 2023-2027

Cascadia sites (Focus on):

1. **Offshore locking** in relation to observations on-land
2. Off-shore **behavior around apparent slow aseismic slip**

- **Four sites** were deployed in Aug 2022 as a part of the "commissioning" of the SGIP, with first WG interrogations.
- Remaining **2 new sites** deployed in July 2023 with an "Apply-to-Sail" program

- In 2024, **2 existing sites** will have their transponders replaced with new 10-year batteries



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▲ -- *Existing GNSS-A sites*

Apply-to-Sail 2023: Cascadia

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9 Participants

- from US, Chile, UK, and Singapore
- Grad students, postdocs, and assistant professors

Experiment Design: Alaska

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2016995, 2232639

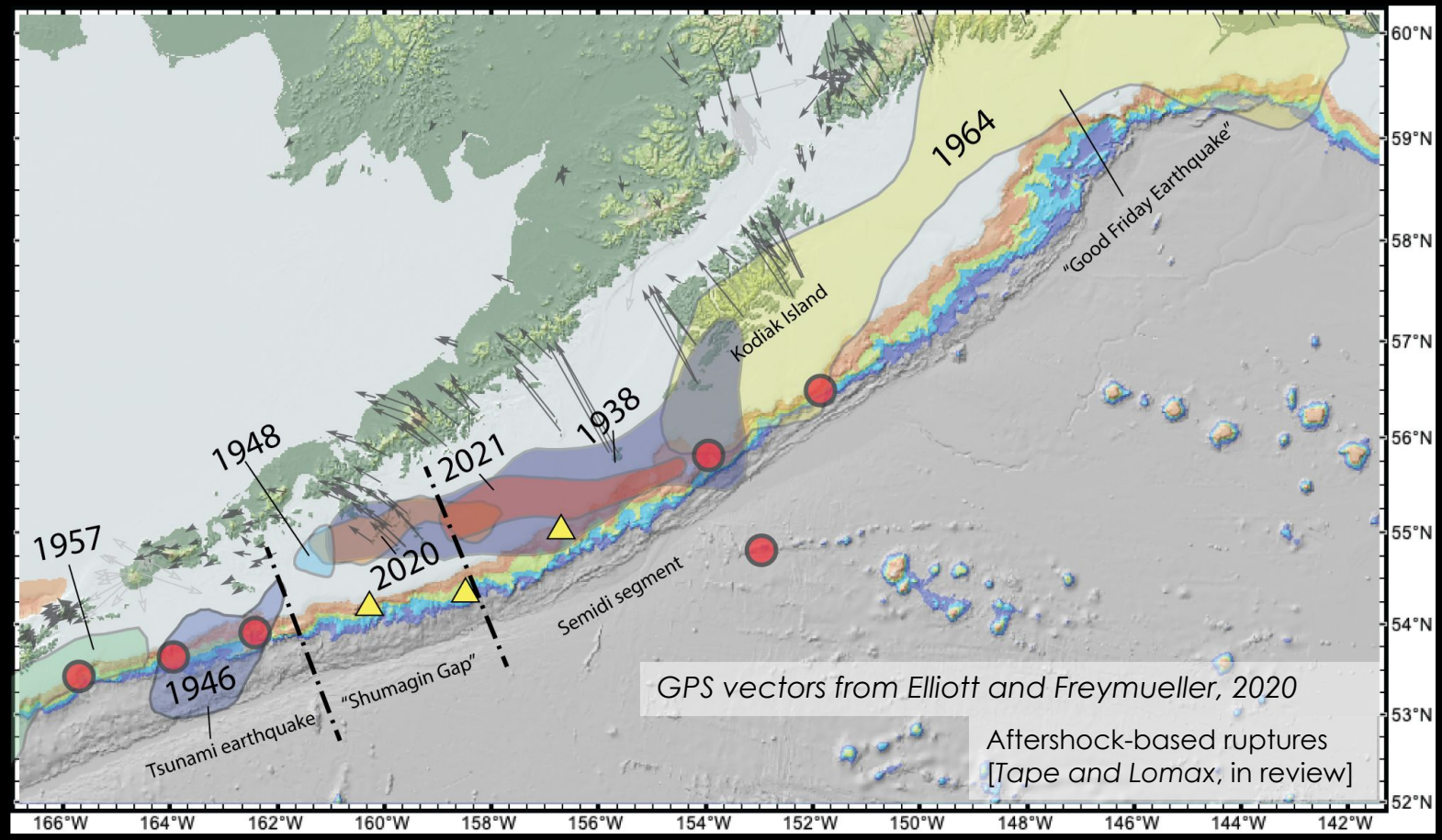
Deployment period: 2023~~X~~4 - 2027 (~~X~~4 yrs)

Proposed new sites are approximated from workshop input. Final siting is depends on coordinated working group decisions (Spring 2024)

Alaska sites (Focus on):

1. **Offshore locking** in relation to observations on-land
2. Coupling around 1946 slow "**tsunami earthquake**"
3. Constraining near-trench **postseismic deformation**

Deployment will occur in 2024 with another Apply-to-Sail opportunity



▲ -- *Existing GNSS-A sites*

Other Community-Funded Activities:

NSF#: 1935996, 2016995, 2232639

Apply-to-Sail

- **Seagoing opportunities** are planned for students, post-docs, and early-career scientists along each of the deployment, recovery and any repair legs where instruments are going to the seafloor. Announcements will appear shortly after determination of follow-year ship schedules.
- **Watch for emails for 2024 opportunities:** Prioritizing grad students and early career scientists.

Software Development

- **Open-source code** for the processing of GNSS-Acoustic data for seafloor horizontal positioning. First Beta release announced (Dec. 2023; See AGU presentation by J. DeSanto et al., T51A-05)

Short-Courses

- Two **"Future PIs"** courses (2024, 2026) to develop understanding of opportunities and limitations of current tools, ship-time requests, network design, and cooperation with local and international partners.
- Two **"Data Processing"** courses will utilize the newly developed software for working with available community data. Courses planned for 2025, 2027 will prioritize graduate students and postdocs.

Community Archive

- All community experiment data will be openly available and following **FAIR** standards through the GAGE facility to be operated by the EarthScope Consortium.
- Cooperation with IAG for development of standards for GNSS-Acoustic data

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Dear Colleague Letter: Seafloor Geodesy 2024

NSF#: 1935996, 2016995, 2232639

Colleagues:

A new NSF Dear Colleague Letter (NSF DCL 24-016 https://www.nsf.gov/pubs/2024/nsf24016/nsf24016.jsp) has been posted inviting proposals for seafloor geodesy field campaigns to deploy transponders from an existing instrument pool for **4 sites** at tectonic settings consistent with priorities as identified in the 2021 Community Workshop report on Seafloor Geodesy (https://www.seafloorgeodesy.org/post/future-directions-in-seafloor-geodesy-2021-community-workshop). Of particular interest are proposals that **target volcanic processes, transform processes, plate motions, or polar regions**. The geodetic instruments have a depth limit of 3000 m and a multi-year deployment is envisioned with requisite wave glider surveys. Projects can be PI-driven or Community-driven.

Proposers should contact program officers Gail Christeson gchriste@nsf.gov or Michael Jackson mejackso@nsf.gov early in the proposal development process for seafloor geodetic facility budget preparation guidance. Proposals should be submitted by **February 15, 2024** for full consideration.

Sincerely,

James McManus
Director, Division of Ocean Sciences
National Science Foundation

2021 Future Direction Workshop Report

NSF#: 1935996, 2016995, 2232639

Summary Recommendations:

Community and Organization:

- Seafloor geodesy is critical to improving our understanding of offshore plate boundary processes and hazards (i.e. subduction zones, transform faults, and ridges), as well as constraining the deformation of subsea volcanoes.
- The formation of a seafloor geodetic facility is necessary to support the operations, maintenance, deployment, and recovery of instrumentation on PI-driven and community projects.
- The establishment of a steering committee for seafloor geodesy will help to guide the development of a facility, training, data standards, community engagement, and communications with funding agencies and stakeholders.
- Seafloor geodetic data should be readily accessible and follow FAIR principles. Greater data access will increase participation from young investigators. Data products should be provided to the community with various levels of processing (both raw and processed data). Standardized data and metadata formats are needed.
- Thoughtful usage of the current seafloor geodetic instrument pool provides opportunities to develop an active and participating community through conscientious and equitable workforce development, including groups underrepresented in earth sciences. Strong community participation will drive innovation in seafloor geodetic technologies and techniques.
- New collaborations with the oceanography community will provide opportunities for reducing noise sources and for providing new constraints that are beneficial to both disciplines.

Instrument Pool:

- Community experiments are favored for the majority of the current pool. Such experiments are best conducted by (facility) staff who are adequately trained, can maintain the equipment, and can collect the data with consistent standards. Community participation will be important for training and workforce development. Smaller projects (using limited instrumentation) may be better conducted by PI-led efforts.
- The current pool could support up to two community experiments, There was strong interest in using the pool to establish for 8-12 sites in a subduction megathrust like Cascadia; with support too for 4-8 sites at a subsea volcano, such as Kilauea
- The instrument pool will need to grow to meet the community needs. Coordination with international partners may be a mechanism to leverage limited resources and achieve more science goals. The current pool is only sufficient for 2-3 focus areas
- Cascadia and Alaska were the highest priority subduction zones for the initial deployment of instrument pool assets, followed by New Zealand, Central America, and South America (in that order).
- Leading candidates for which subsea volcanism include the flank of Kilauea and Axial Seamount (in that order). In some cases, absolute pressure gauges, direct-path acoustic ranging might be a better instrumental solution than GNSS-A.
- Two oceanic transforms were identified for using seafloor geodesy to address scientific and hazard questions; Fairweather-Que Charlotte, and Gofar and Discovery systems.

Instrumentation:

- Absolute pressure gauges (APG) provide the most mature technology for vertical deformation of the seafloor. Gravity and tiltmeters provide additional constraints.
- GNSS-A and direct path acoustics are the most mature technologies for horizontal observations. Fiber optic strainmeters and D show promise but need further development.
- A subsea test-bed is necessary to facilitate instrument development and to benchmark and calibrate new technologies.

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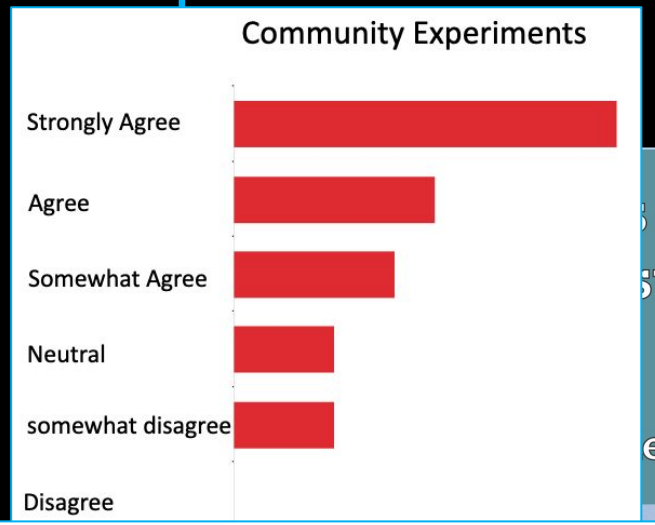
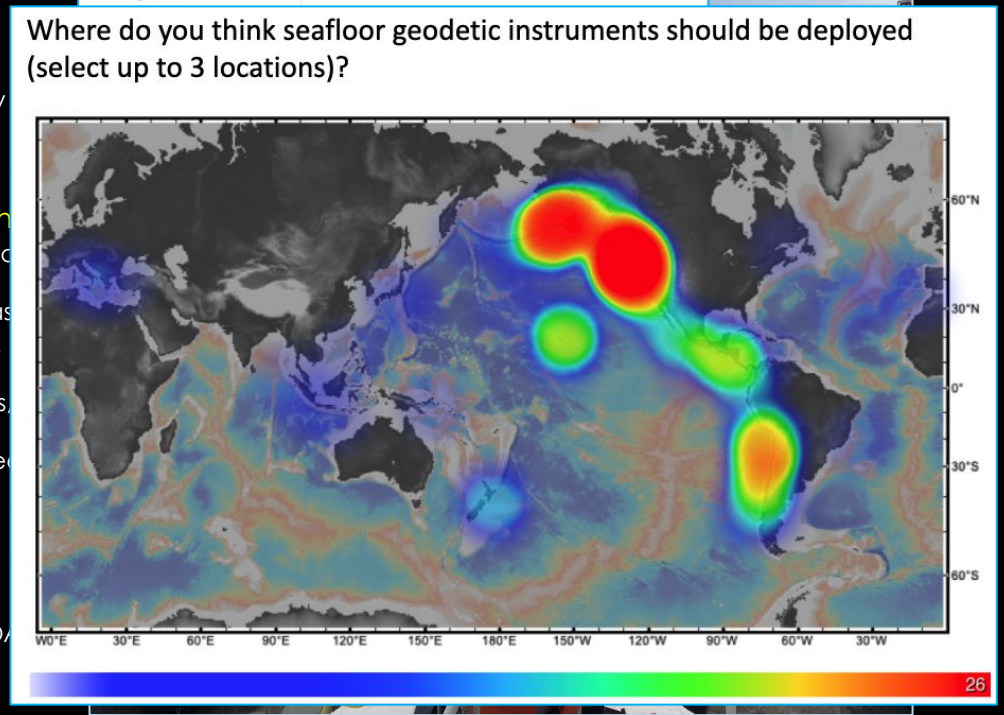




Future Directions for Seafloor Geodesy Report, 2021

2022 Alaska-Cascadia Community Seafloor Geodetic Experiment Workshop

NSF#: 1935996, 2016995, 2232639

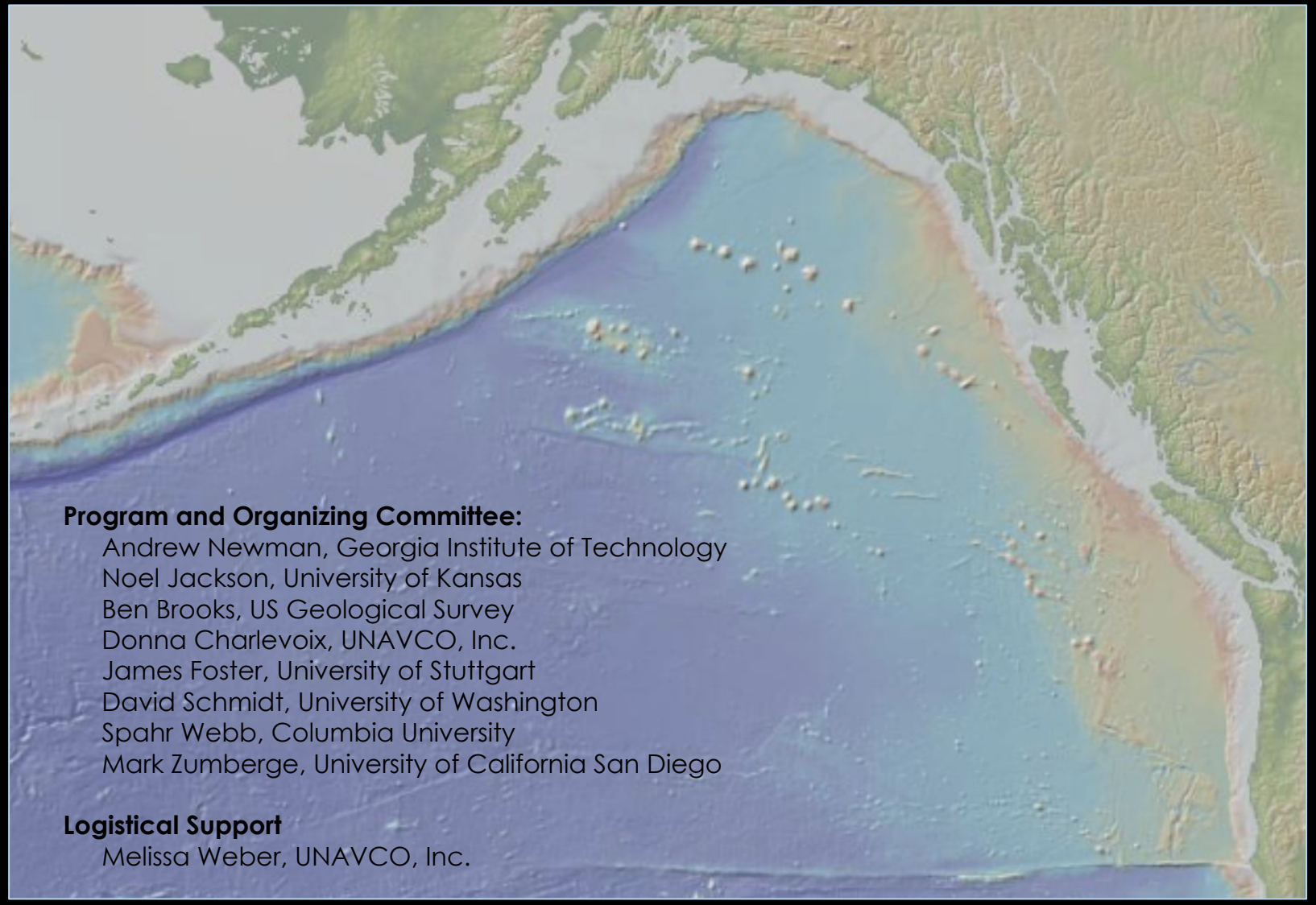
May 2-6, 2022 online

- *73 registrants*

Workshop Goals:

Identify:

- **science**, **data**, & **training needs**
- **siting** using about 2/3 current pool



Program and Organizing Committee:

Andrew Newman, Georgia Institute of Technology
Noel Jackson, University of Kansas
Ben Brooks, US Geological Survey
Donna Charlevoix, UNAVCO, Inc.
James Foster, University of Stuttgart
David Schmidt, University of Washington
Spahr Webb, Columbia University
Mark Zumberge, University of California San Diego

Logistical Support

Melissa Weber, UNAVCO, Inc.

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Alaska-Cascadia Near-Trench Community Geodetic Experiment

NSF#: 1935996, 2016995, 2232639

June 2022: Proposal 4 to NSF-OCE for Alaska-Cascadia Near-Trench Community Geodetic Experiment

- Deployment of **12 SGIP sites across Alaska and Cascadia**
- Maintain and **reoccupy sites over 5 years**
- Develop Open-Source **software for GNSS-Acoustic processing**
- Develop and hold **Short Courses for data processing and "Future PI"** training
- Develop **FAIR archive** for data at ~~UNAVCO~~ EarthScope Consortium

EarthScope Consortium