# Seafloor Geodesy

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This project (OCE-1249876 "Constraining slip distribution of the Cascadia Subduction Zone Offshore Central Oregon with Seafloor Geodesy") initiates seafloor geodetic measurements of plate motion on the submerged continental slope of the Cascadia Subduction zone to constrain the distribution of slip on the megathrust. One site (NNP1) is located at latitude 44.6 N offshore Newport, Oregon. A second site (NGH1) is located at 46.7 N offshore Grays Harbor, Washington. A third site (JNP1) is farther offshore Newport on the incoming Juan de Fuca plate and measures the present-day convergence rate with North America.

In June 2014, using R/V Thompson and ROV Jason, site JNP1 was re-established with new transponders on permanent benchmarks placed next to old transponders, which were deployed in 2000 and where the position of JNP1 was measured in 2000, 2001, 2002 and 2003. The global position of the old transponders was transferred to the new ones with centimeter resolution. This allows us to continue the time series from 2000 to 2014 and beyond. In September 2014, the GPS-Acoustic Wave Glider was deployed at JNP1 and operated for approximately 60 hours. During that time it self-guided along a nominal circular track within approximately 30 meters of the center of the seafloor transponders. Both the GPS data and acoustic ranging data were collected for 30 of the 60 hours. These data have been processed successfully. Two important results were achieved:

(1) The GPS-Acoustic method from a Wave Glider is viable in the nominally deep waters (JNP1 site is 3000 m deep). The Wave Glider can act as a replacement for high-cost ships in Cascadia and likely other subduction zones (e.g., offshore Alaska). The Wave Glider costs a few dollars a day to operate (i.e., for status and command/control communications using Iridium) compared to several tens-of-thousands of dollars per day for a ship that has dynamic positioning, which is needed to hold station within 30 meters

(2) The re-measurement of the site JNP1 now spans 2000 to 2014, incidentally the longest seafloor position time series anywhere. Preliminary results show that the convergence velocity is comparable to the geologically predicted rate. This supports the hypothesis that creep may be occurring at the CSZ in central Oregon. Scientifically useful data can be collected from a Wave Glider based GPS-Acoustic system.

Also in September 2014, from the R/V Atlantis, the transponders were deployed at sites NNP1 and NGH1. Here, we successfully demonstrated the capability to deploy the transponder package free-fall from the sea surface. In part, the site selection was determined using results from modeling supported by project OCE-1144493 "Potential contributions of Seafloor Geodesy to understanding slip behavior along the Cascadia Subduction Zone". Support for developing the Wave-Glider-based GPS-Acoustic and benchmark is from NSF OTIC program.

As of summer 2015, the Wave Glider will be deployed from a small vessel a few miles offshore Newport and

then directed to sites NNP1, JNP1 and NGH1 to collect the next epoch of positions in the time series.

This project is the first implementation of an autonomous approach to collecting GPS-Acoustic data greatly reducing costs of data collection by no longer relying upon research ships, permanent seafloor benchmarks for horizontal positioning that ensures the time series of positions can be continued into the future, and reuse of commercial seafloor transponders. These three changes in methodology are transformative for GPS-Acoustic seafloor geodesy.

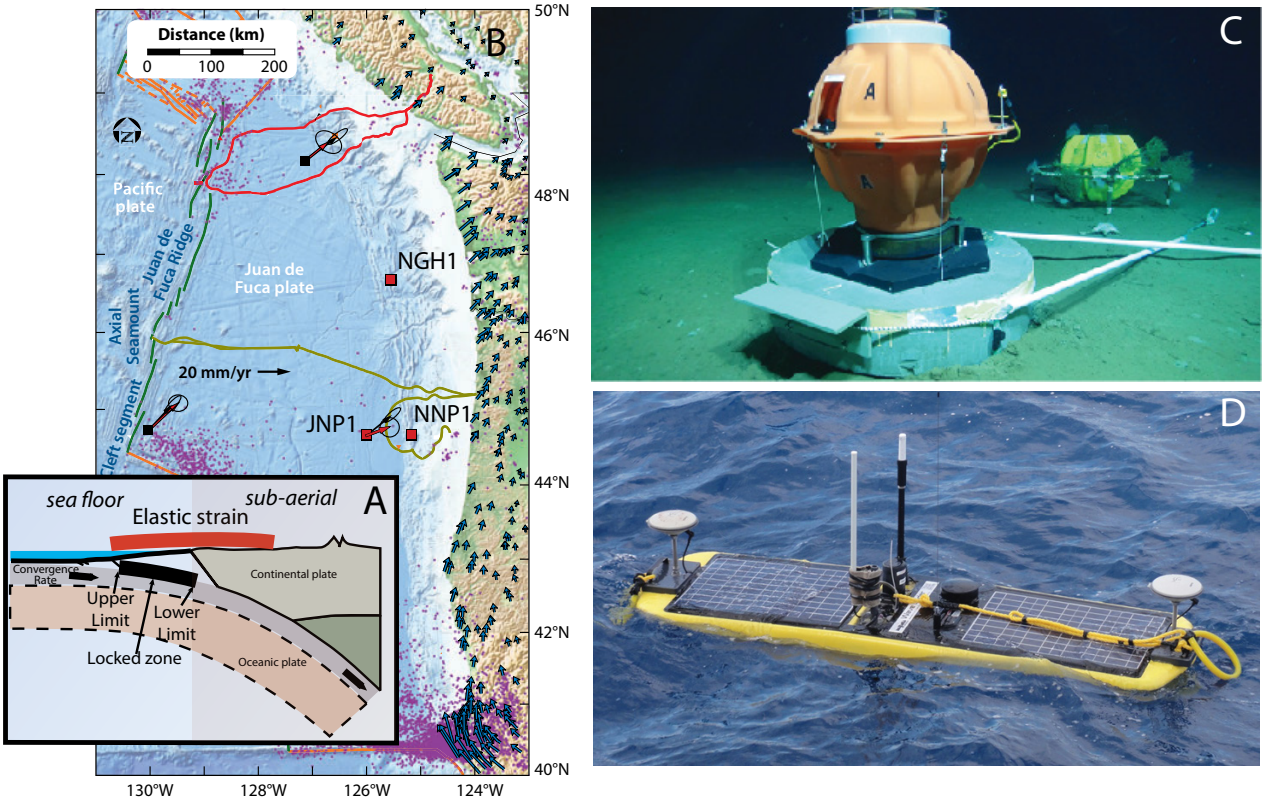


Figure 1. (A) Subduction process showing incoming plate in contact along interface with upper plate which accumulates elastic strain as uplift and contraction. Much of the deformation occurs offshore, highlighting the significance of seafloor measurements in a space geodetic frame to bridge the sub-aerial and marine regions. (B) In 2014, two sites NNP1 and NGH1 were established, the first sites on the seaward slope of Cascadia subduction zone. Also in 2014, site JNP1 offshore Newport was reestablished and its position re-measured. Two earlier GPS-Acoustic sites (black squares) are also shown. Red and black arrows show the GPS-Acoustic and geomagnetically-derived plate motions relative to North America, respectively. (C) Foreground shows new seafloor benchmark with commercial transponder placed approximately 2 m from old (circa 2000) transponder at site offshore Oregon. In June 2014, successfully demonstrated ROV Jason removing and replacing the transponders with millimeter-level repeatability. (D) Wave Glider conFig.d for GPS-Acoustic operations underway at sea. (Note: recovery line has since been rerouted around solar panel.)