

Real-time Offshore Geophysical Monitoring of the Cascadia Subduction Zone: Applications to Earthquake and Tsunami Early Warning and Scientific Research

There is a growing societal awareness in the Pacific Northwest of the hazards posed by the Cascadia subduction zone and the potential for a large megathrust earthquake in the region. Scientifically, this has helped provide motivation for extensive geophysical studies both on land and at sea. Recent offshore experiments in Cascadia have included extensive deployments of ocean bottom seismometers, the initiation of seafloor geodetic observations, and seismic and magnetotelluric imaging. In addition, both Canada and the US have installed sophisticated multidisciplinary cabled observatories, that host geophysical instrumentation and cross the subduction zone off Vancouver Island and central Oregon, respectively.

Recently there has also been interest in exploring the feasibility of a more extensive real-time offshore geophysical monitoring network that would span the full length of the subduction zone to support earthquake and tsunami early warning. Such a system could improve the reliability of earthquake early warning for offshore earthquakes, increase warning times inland by up to ~15 s and enable early warnings on the coast proximal to the epicenter of a megathrust earthquake. For tsunamis, it could support accurate warnings of the incoming wave height and forecasts for secondary arrivals. It would also enable enhanced scientific studies to better constrain the present day seismic and tsunamigenic potential of the subduction zone and search for precursory signals.

Since a large-scale offshore system would be very expensive to install, it is important to pursue strategies that would take advantage of existing infrastructure to optimize both its design and implementation. In US waters, the NSF Ocean Observatories Cable (OOI) Array presently supports geophysical observations at two sites in the subduction zone, one on the incoming plate a few kilometers west of the deformation front, and the other at Hydrate Ridge, a site of particular interest for studies of methane seeps and shallow gas hydrate deposits. The OOI Cabled Array has three additional primary nodes on the continental slope and shelf at depths of 1240 m, 620 m and 115 m. Two of these support extensive water column observations but all three remain un-instrumented for geophysics. Adding seafloor science junction boxes to these primary nodes with broadband seismometers, hydrophones, accelerometers and calibrated seafloor pressure sensors, and with spare ports for additional instrumentation would contribute substantially to studies of earthquake genesis and fault locking in a region where the plate boundary is relatively seismically active and the degree of seismic coupling uncertain. The expanded instrumentation would provide an opportunity to demonstrate the utility of offshore seismic data for the ShakeAlert early warning system and to develop a prototype early warning and monitoring system for incoming tsunamis. It would also provide a testbed to evaluate new technologies that might reduce the costs and enhance the capabilities of a future larger-scale monitoring system.