A real-time cabled observatory on the Cascadia subduction zone

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The Cascadia subduction zone represents the largest potential source of seismic energy release and tsunami generation in the continental United States. Currently, the offshore component of the subduction zone is not continuously monitored, as is done onshore by established seismic and geodetic networks. Thus we have very limited monitoring capability offshore that could contribute to early warning infrastructure, and better inform models of seismogenic and tsunigenic hazards. Reducing risk to several metropolitan areas and coastal communities along the Northwest coast from a magnitude 8 or 9 earthquake provides strong motivation to extend seismic and geodetic monitoring onto the seafloor, directly over the seismogenic zone, and thereby provide earthquake early warning capabilities. Design of a cabled seismic and geodetic monitoring system offshore Cascadia would build upon progress made toward implementing land-based US EEW during the last few years, and would benefit from new insights about subduction zone processes derived from recent land-based and marine seismic experiments. Cascadia also represents one of two locations globally that is currently instrumented with cabled offshore scientific infrastructure. The OOI Regional Nodes, which are currently delivering the first continuous real-time ocean floor seismic data in the US, would both inform the design of, and facilitate expansions of, real-time seismic arrays for monitoring seismic and slip behavior into the marine environment.

Real-time information from the seafloor would enhance EEW's risk reduction mission in several ways. These include: assessing the location, geometry, and extent of faulting in progress, minimizing false alarms from earthquakes on faults more distant than the megathrust, and achieving more accurate and rapid tsunami warnings with near-source observations. Seafloor pressure sensors could also be used to monitor and characterize an incoming tsunami. An offshore early warning system would facilitate the advance of geodetic techniques with its capacity to observe strain transients, to map the megathrust coupling pattern, and to detect if the locking evolves over the earthquake cycle. These objectives would contribute significantly to improved estimation of time-dependent hazard and basic science.

Currently, two cabled array designs are being evaluated. The first is a continuous cabled system with sensors embedded in the optical-repeaters of the submarine cable, similar to the system currently being deployed by the Japanese in the Japan Trench. This approach emphasizes reliability at the expense of the flexibility to update and expand the deployed sensors. The second is node-based approach similar to the current OOI cabled array, NEPTUNE Canada cabled observatory and Japanese DONET systems around Nankai trough. This would provide the flexibility to expand the array of sensors in response to new technical developments and an improved scientific understanding of subduction zone processes and monitoring needs, but it might be less reliable. Potential hybrid designs incorporating features of these two end members that balance the requirements for reliability and flexibility are also being considered.

An offshore cabled seismic and geodetic array designed for EEW will likely be of a scale that necessitates investments from state and local governments and the private sector, whose focus would be on refining short-term warning applications. However, our ability to address basic science questions about the earthquake preparation process, stress transfer, deformation mechanisms, and the connection between structure and slip behavior would be transformed with the availability of continuous, long-term observations over the seismogenic zone. With this in mind, our research community currently utilizing land and ocean bottom seismic and geodetic tools should be the key drivers in efforts both to implement a cabled monitoring system that produces accurate short term warnings and to design an array that is optimized to gain the most important scientific insight about the subduction zone system. This effort would also be best utilized along side more 'traditional' autonomous campaign-style experiments that jointly characterize complex processes to a degree not currently possible.