ACOUSTICALLY-LINKED MOORED BUOY OBSERVATORY

WHOI Ocean Bottom Seismograph Laboratory

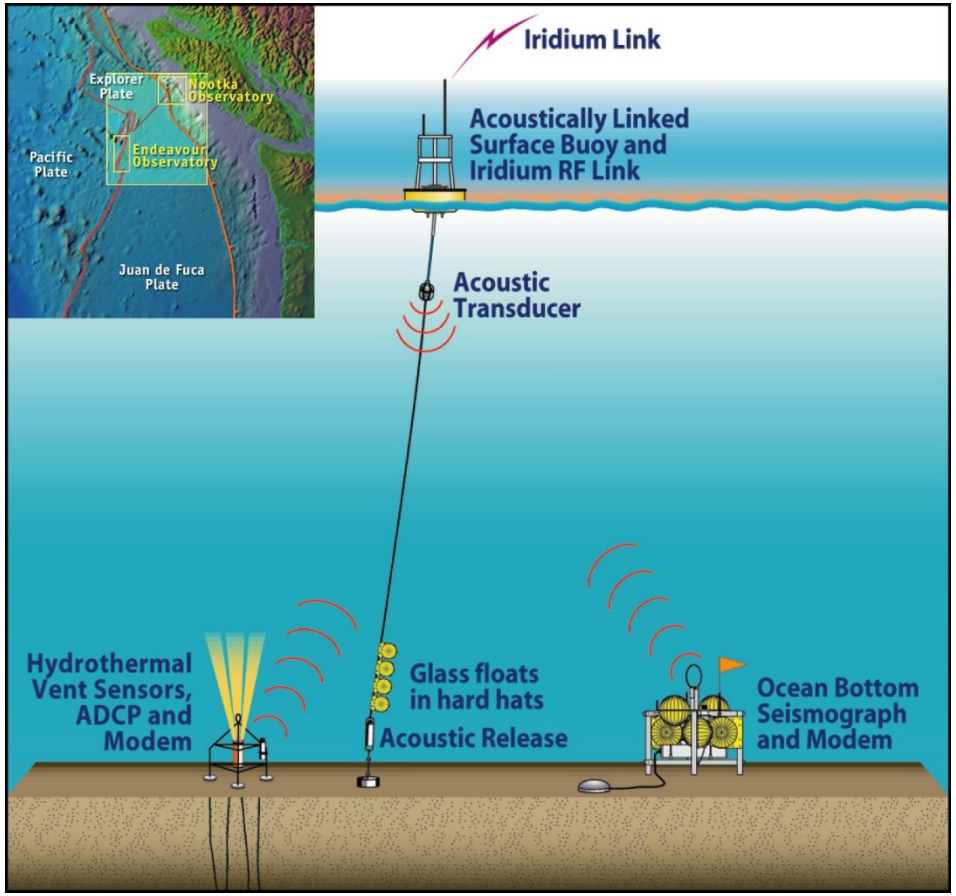
Development and Testing of a Deep-Water, Acoustically-Linked, Moored-Buoy Seafloor Observatory

In 2002, the National Science Foundation funded a group of WHOI scientists and engineers (Detrick, Frye, Freitag, and Collins) to design, construct, and deploy an acoustically-linked, moored-buoy observatory.

In collaboration with investigators from the University of Washington and Scripps Institution of Oceanography, this system was deployed in May 2004 off the coast of Vancouver Island at the Nootka fault.

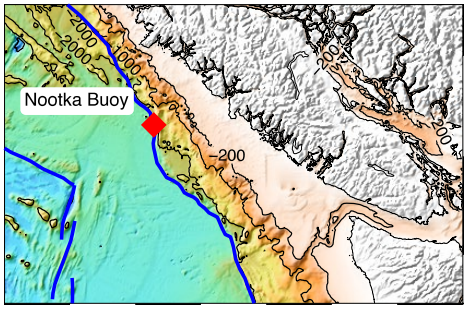
The Nootka fault is characterized by an ~50-kilometer-wide band of intense earthquake activity that extends from offshore Vancouver Island to the Juan de Fuca–Pacific plate boundary. A number of cold seep sites occur along the fault, and the Nootka observatory was located near one of these seeps in order to measure fluid expulsion along the fault and to examine the links between seismic deformation and episodic fluid flow.

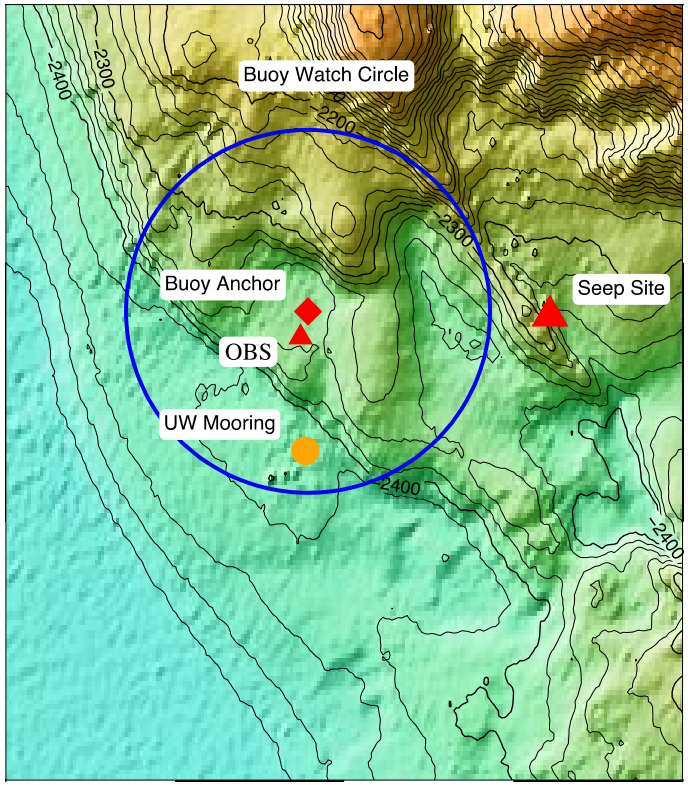
The observatory used acoustic communication to retrieve data from sensors in the water column and on the seafloor out to ranges of ~3 km from the buoy. Data telemetry to shore was provided by an Iridium satellite link.



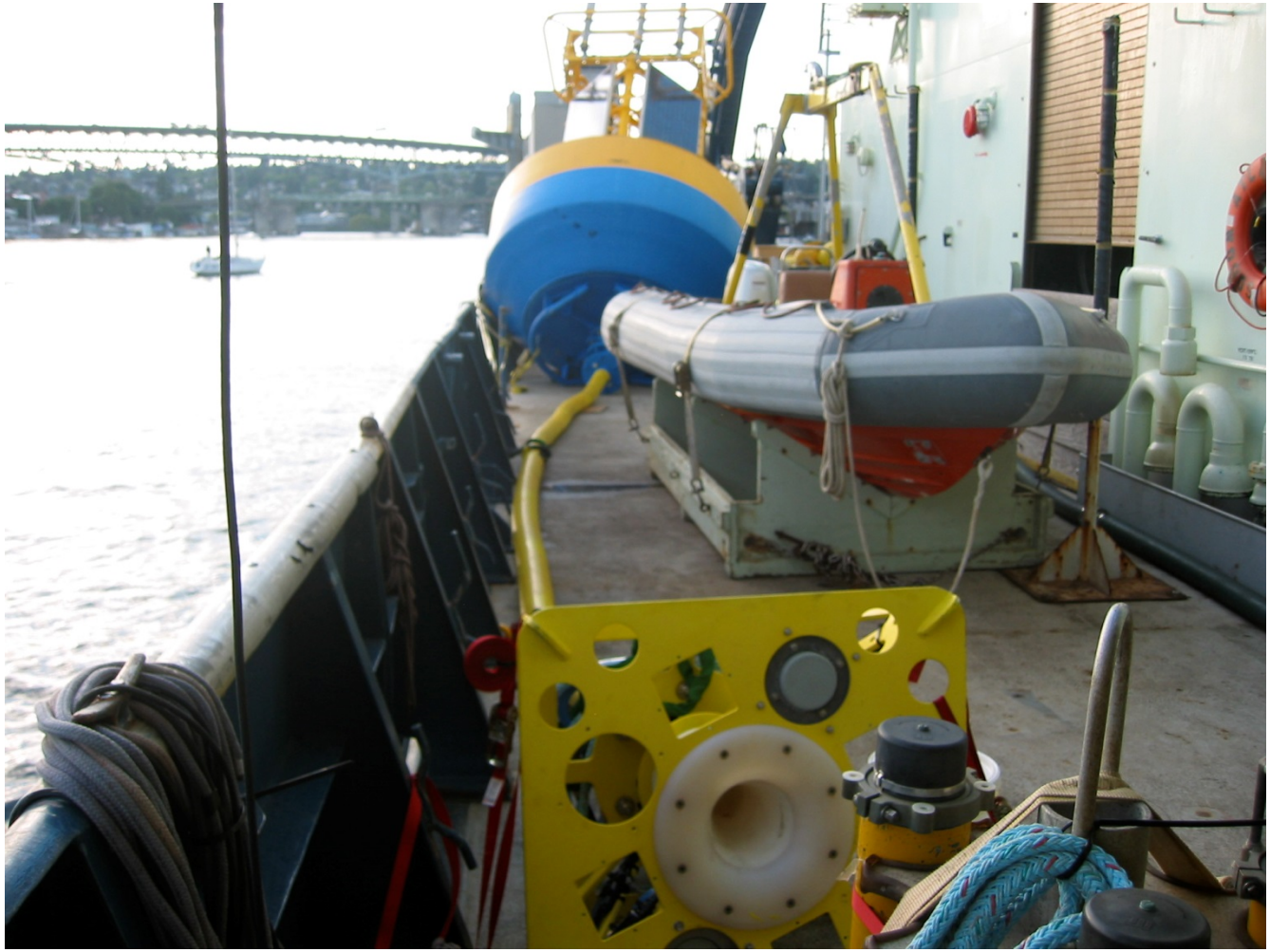
Near-Realtime Seismic Data from the Seafloor: Acoustically-Linked Buoy with Iridium Satellite Link

- The deployment site was ~80 km west of Vancouver Island. Water depth at site was 2,372 m. Deployment duration was 13 months.
- Ground-motion and pressure data recorded by the OBS was telemetered from the seafloor to the buoy (WHOI acoustic modem) and from the buoy to shore (Iridium).
- The communication link between shore and OBS was two-way.
- All of the low sample rate data (1 Hz), and operator-selected portion of the high sample rate (20-40 Hz) data were retrieved.
- Offload rates of ~1 Mbytes/day were achieved.

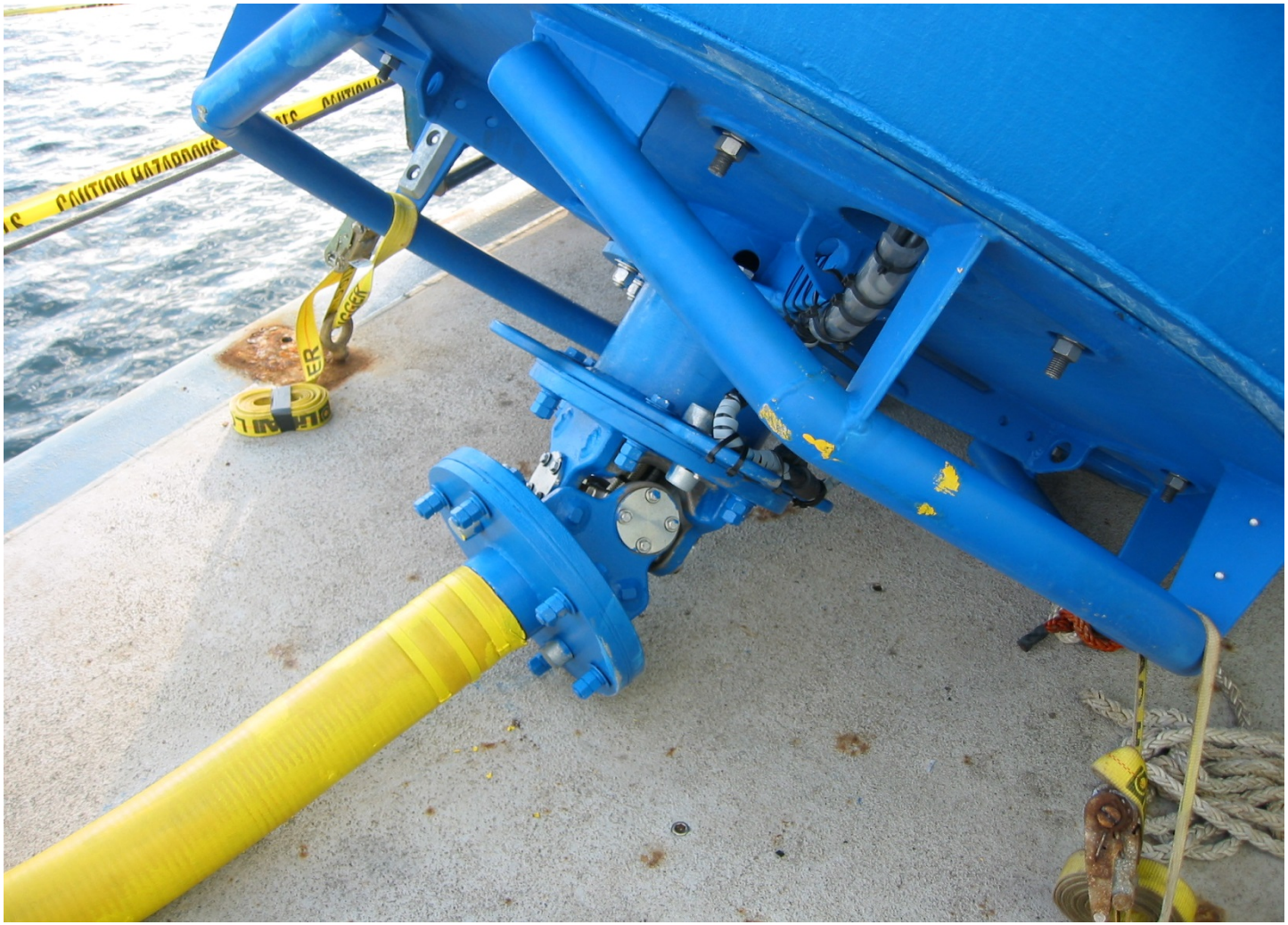




The surface buoy consisted of a 2.7-m diameter Surlyn float with 6800 kg of net buoyancy. The aluminum structure mounted atop the float includes a tower for securing instruments and antennas as well as four 150-watt solar panels. The buoy's average 5 watt/day power consumption was provided by a rechargeable bank of lead-acid cells augmented by a backup battery capable of providing power for up to three months.



A 10 m chain-urethane composite around which are coiled 12 conductors connects two acoustic-modem transducers mounted on an aluminum plate to electronics in the surface buoy. The purpose of this component is to protect the conductors from the bending strains produced by the motion of the buoy in severe sea states.



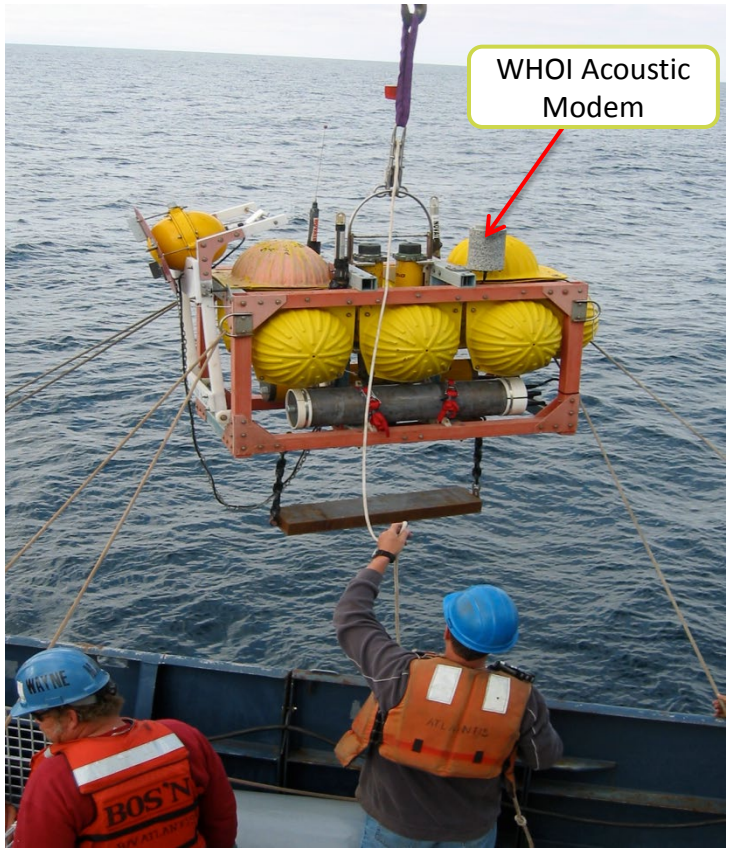
Unique features of the buoy and mooring include a universal joint between the buoy and the mooring that provides for up to about 60 degrees of motion in two planes. A central hole in the universal provides an unbending pathway for conductors that pass through the universal.

Nootka OBS

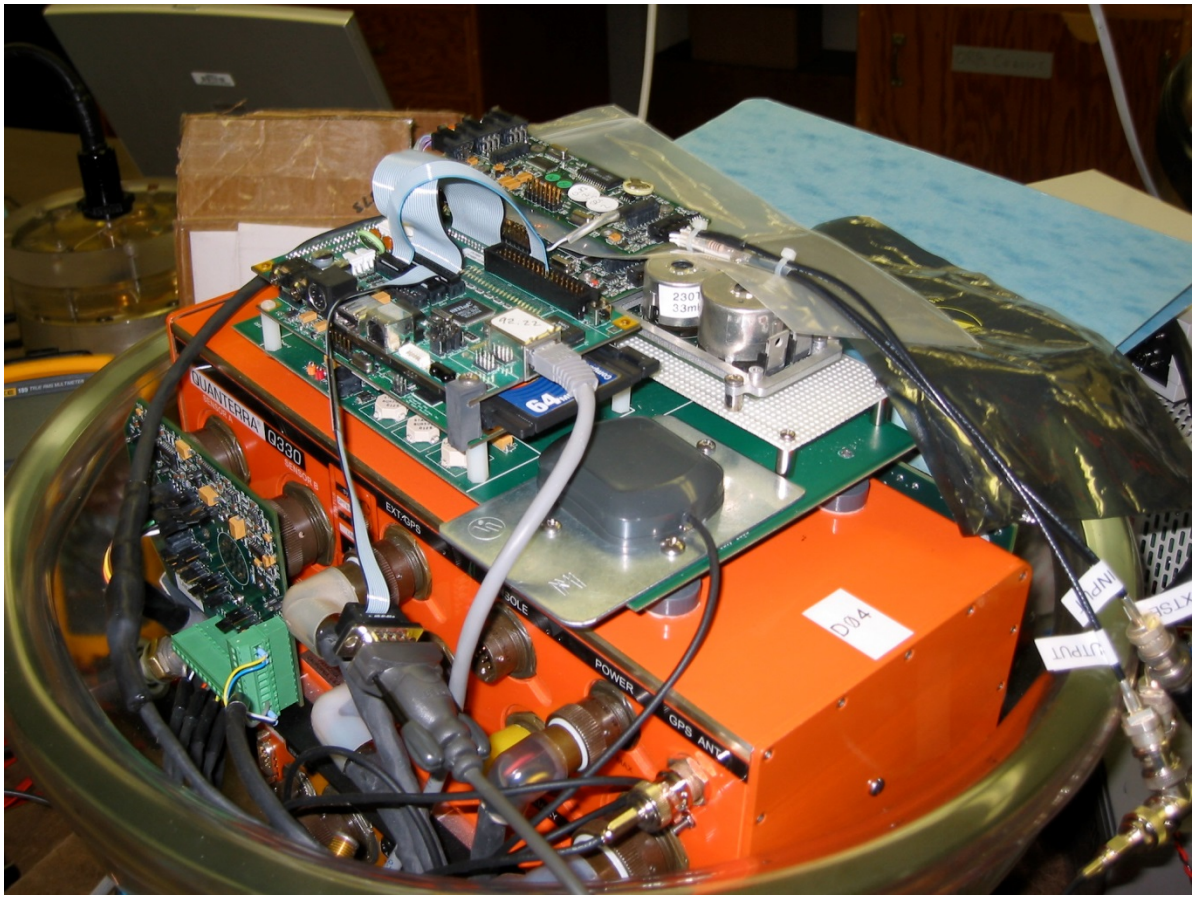
- At the time of the deployment of the Nootka experiment, the WHOI OBS group did not yet have a complete broadband OBS available. Instead we used a short-period seismometer (1 Hz natural frequency) and a mechanical frame from an older generation of OBS. The data-logger was a Quanterra Q330.

- The OBS recorded three data streams sampled at 1, 20, and 40 Hz on 4 channels (3 seismometer and 1 long-period pressure). All of the 1 Hz data were telemetered to shore daily and used, along with shore-based seismic data, to identify events of interest. Selected portions of the 20 Hz or 40 Hz data streams were retrieved as needed.

- During the thirteen-month deployment, 151 Mbytes of data were transferred to shore. Average data throughput for each transfer ranged between 220 and 240 bytes/sec depending on file length. Typically, about 544 Kbytes of data were transmitted to shore each day. Maximum data throughput of more than 1.6 Mbytes/day was achieved during the deployment.



Seismometer Data Extraction

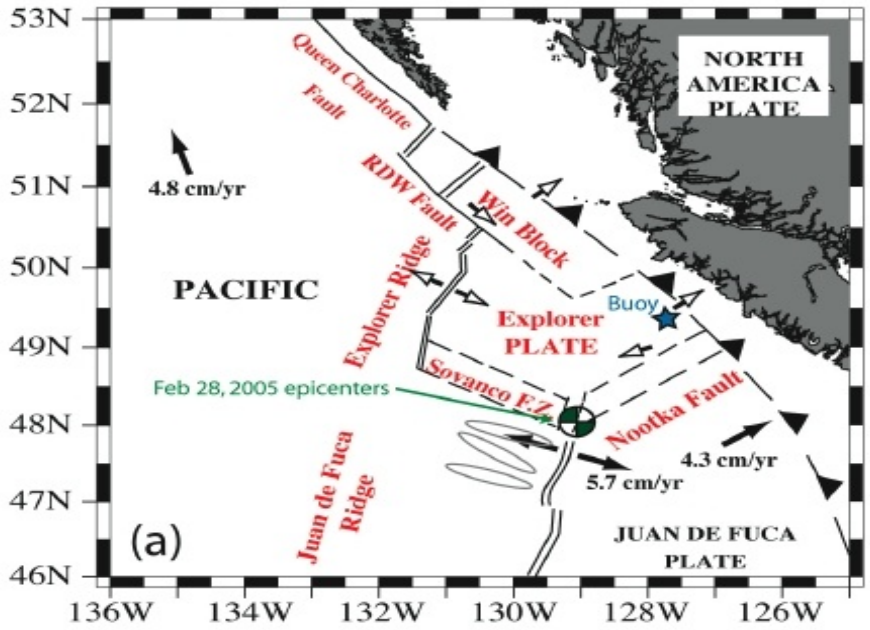


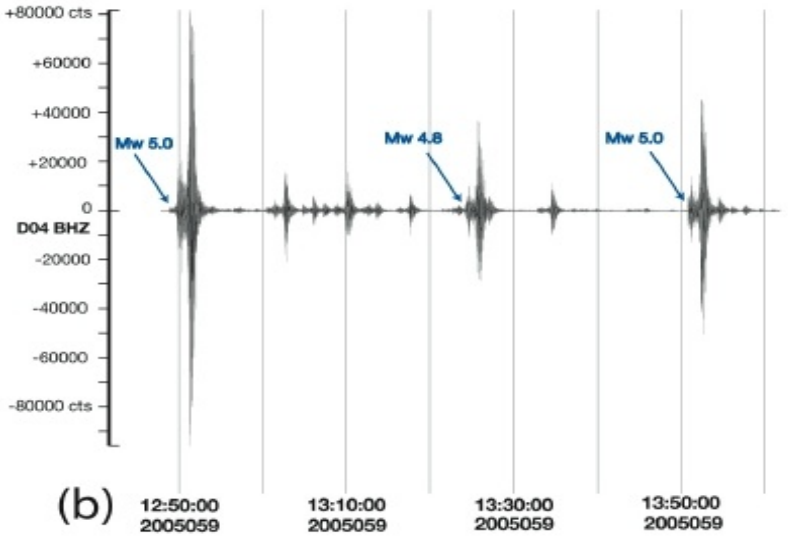
Linux, single-board “Bitsy®” computer and acoustic modem electronics mounted on top of a Quanterra Q330 data-logger. A Quanterra Baler (storage device) sits below the Q330, and the whole assembly sits in the lower hemisphere of a Nautilus glass-ball pressure housing. Either on a pre-defined schedule or on a “pull” request from the buoy, the Bitsy controller commanded the Q330 to flush the contents of its RAM buffer to the Baler. The desired time slice of data was then requested from the Baler and written to the Bitsy’s storage device, and then telemetered to the buoy.

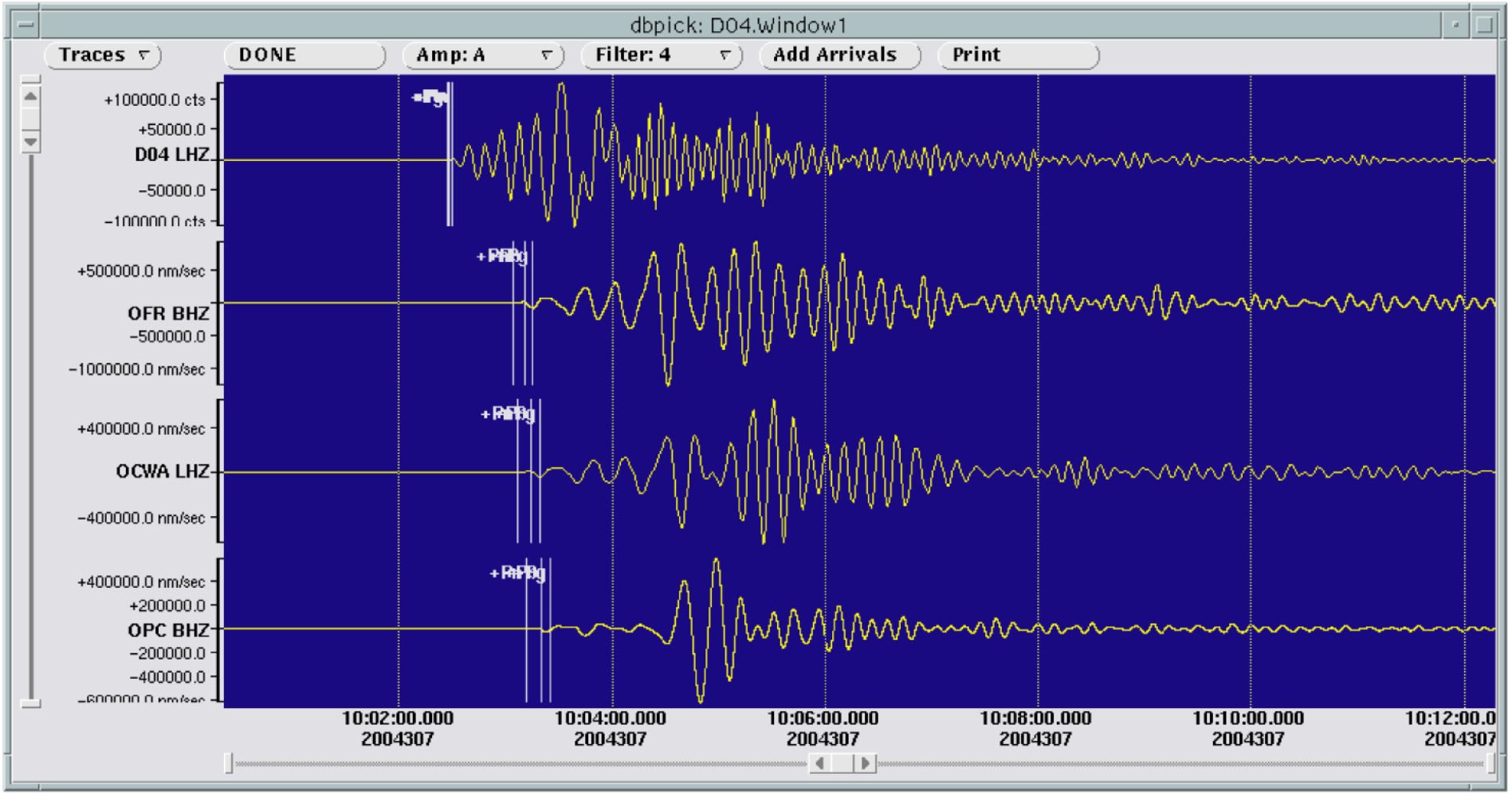
High-Rate Seismic Data from a Seismic Swarm at the Nootka Fault

On February 28, 2005 a cluster of moderate (Mw 4.8 – 5.0) earthquakes occurred near the intersection of the Nootka fault and the Sovanco fracture zone ~200 km south-southwest of the Nootka observatory. We retrieved both OBS and fluid flow data for this period within hours of the event.

Vertical-component, ground-motion data show arrivals from three moderate-sized, strike-slip earthquakes and from other smaller events. The high-rate data shown here were not part of the regularly scheduled 1-Hz data, but were requested from shore on the basis of anticipated seismic arrival times.







Vertical-component seismograms for the 2004-11-02 Mw 6.6 Vancouver Island event. Station D04 is the acoustically-linked WHOI OBS at an epicentral distance of ~0.8° from the epicenter. These data were telemetered to shore in near real-time. Seismograms from 3 nearby land stations are shown for comparison, and are located at distances of 3.2° (OFA), 3.5° (OCWA), and 3.8° (OPC).

Publications

Frye, D., L. Freitag, R. Detrick, J. Collins, J. Delaney, D. Kelley, A. LaBonte, and K. Brown (2006), An acoustically linked moored-buoy observatory, *Eos Trans. AGU, 87(22), 213*, doi:10.1029/2006EO220002.

Frye, D., J. Ware, M. Grund, J. Partan, P. Koski, S. Singh, L. Freitag, J. Collins, and R. Detrick (2005), An acoustically-linked deep-ocean observatory, *Oceans '05 – Europe*, *2,* 969-974.

Detrick, R.S., J.A. Collins, and D.E. Frye (2000), Seafloor to surface to satellite to shore, *Oceanus, 42*, 12–13.