Non-technical Summary

The Pacific Northwest Seismograph Network (PNSN) operates seismograph stations in Washington and Oregon, and collects, analyzes, and distributes earthquake data and information. Between Oct. 1, 2003 and Sept. 30, 2004 the PNSN analyzed 5,453 events. Of these, 4,589 were earthquakes or blasts within the network (1,471 of which were too small to locate). Within the network area, 2,267 earthquakes were located west of 120.5 degrees west longitude (including 1,182 in the general vicinity of Mount St. Helens, which began a magmatic eruption earthquake sequence on Sept. 23, 2004, just a few days before the end of this reporting period), and 375 east of 120.5 degrees west longitude. The remaining events were blasts within the network (509), regional earthquakes (291), teleseisms (573), low-frequency events (300 events, 46 locatable, including ice-quakes near the summit of Mt. Rainier, and events associated with the eruption of Mount St. Helens), and surficial events (558 events, 4 locatable, mostly rockfalls near the summits of Mt. St. Helens and Mt Rainier).

West of the Cascades, 30 earthquakes were reported felt in Washington or Oregon, ranging in magnitude from 1.6 to 4.9. The largest event was a magnitude 4.9 at a depth of about 26 km, located off the Oregon coast about 48 km southwest of Newport, on July 7 (UTC).

East of the Cascades, twenty earthquakes (magnitudes 2.5 to 4.4) were reported felt. Twelve of these, including a magnitude 4.4 quake on June 30 (UTC), were associated with swarm activity near Lakeview Oregon.

This year, several episodes of low-amplitude deep seismic tremor were observed concurrently with "silent slip" events detected with GPS. "Silent slip" events consist of very slow movement on the Cascadia Subduction Zone fault at depths of 25-45 km, and occur periodically at 13 to 16 month intervals. The "deep tremor" signals originate at similar depths. Silent slip and tremor appear to be two manifestations of the same process, which is now being called "Episodic Tremor and Slip (ETS)".
Network Operations

The Pacific Northwest Seismograph Network (PNSN) operates 187 short-period, broad-band, or strong-motion seismic stations west of 120 degrees west longitude under this agreement, and 40 additional stations under other support. Some stations include up to 7 components. PNSN stations in southern and central Oregon are maintained by the University of Oregon under Cooperative Agreement 04HQAG006. The PNSN exchanges real-time data with adjacent networks to improve our ability to locate earthquakes on the edge of our network. The PNSN records and assists with the maintenance of several short-period stations operated by the USGS, and receives real-time data from six US National Network (USNSN) stations in Washington and Oregon.

A PNSN seismologist is always available on-call, and our standard procedure is to respond to pager messages from our automatic earthquake detection process (initiated for any earthquake within our network of magnitude 2.9 or larger), or calls from Washington or Oregon emergency management agencies or the UW police. Information for well-located earthquakes is sent out automatically by the event detection process to select recipients including the national ANSS catalog. Emergency managers and other high-priority information users receive very rapid notification through the RACE pager-PC system, faxes, e-mail, and the national QDDS earthquake message system. Simultaneously, an automatic Web-site is created for the event (see http://www.pnsn.org/SEIS/EQ_Special/lasteq.html).

Final details are provided as soon as the duty seismologist analyzes the earthquake information. Final locations and magnitudes for earthquakes of M>=2.9 are also disseminated through the NOAA emergency weather notification system.

For all earthquakes, updates of information are posted to Web-pages each time the analyst finalizes a group of locations and magnitudes. In addition to ordinary phone lines, the PNSN has a radio link to the King County and City of Seattle Emergency Operations Centers and an independent direct phone link to the Washington State Dept. of Emergency Services.

The PNSN provides "Recent Earthquakes" web pages using the national "Quake Data Delivery System", "ShakeMap" pages (showing instrumental intensity, PGA, and PGV), and links to the USGS CIIM (Community Internet Intensity Maps) site, which collects, compiles, and interprets web-based felt reports from the public.
Figure 1a. Seismograph stations operated by or recorded at the PNSN at the end of September 2004. Black crosses indicate the locations of short-period seismometers, Red triangles represent the locations of three-component broad-band seismometer installations, and white squares show the locations of strong-motion stations.
Figure 1b. Detail of Fig. 1a. Puget Sound Seismograph stations operated by or recorded at the PNSN at the end of September 2004. Symbols as in Fig. 1a.
Figure 1c. Detail of Fig. 1a. Willamette Valley Seismograph stations operated by or recorded at the PNSN at the end of September 2004. Symbols as in Fig. 1a.
• The PNSN Strong Motion and CREST Programs: Since 1996, the PNSN has installed digital strong-motion instruments, mostly in the Puget Sound urban area. There are now 53 ANSS instruments, and a total of 41 other strong-motion real-time stations operated under this agreement. Six additional strong motion stations are operated by other organizations, bringing the total of strong motion stations from which we receive or retrieve data to 100. Continuous data from 95% of these stations are sent to the PNSN via Internet or lease-line modem, but the instruments also have a trigger set to record stronger events on-site. If continuous data transmission fails, the data will still be available via dial-up retrieval or site visit.

The PNSN also operates 19 CREST (Consolidated Reporting of EarthquakeS and Tsunamis) stations, and records four additional stations operated by the northern California network.

• Data Availability: Continuous telemetry data streams from all PNSN broadband stations and the higher-quality short-period stations are recorded at the UW, and all broad-band and short-period data are provided to IRIS in near real-time via the IRIS BUD system. Complete unedited trace-data are saved for all network triggers. Edited, quality-controlled event trace-data are archived at the UW on large disks, 5 GByte exabyte tape, and on high-speed, high-capacity (15 GByte) digital linear tape (DLT) cartridges. Edited event trace-data are also archived at the IRIS Data Management Center (DMC) in SEED format, where they can be retrieved by any investigator via the standard IRIS data request mechanisms.

• Education and Outreach: Staff from the PNSN provide an educational outreach program to better inform the public, policy makers, and emergency managers about seismicity and natural
hazards. Most of the PNSN strong-motion instruments are located at public schools and monthly e-mail information and news updates are sent to teachers. We also provide information sheets, lab tours, workshops, and media interviews, and have an audio library with several tapes. Current seismic activity and other information are available via Internet on the World-Wide-Web (WWW): http://www.pnsn.org

- **Special Events:** PNSN staff participated in meetings with numerous groups, including hosting meetings of the ANSS PNW Region Advisory Committee (see www.pnsn.org/SEIS/ANSS/welcome.html), Cascadia Regional Earthquake Workgroup (CREW), and Contingency Planners and Recovery Manager (CPARM), and making presentations in other meetings, such as ANSS, IRIS and Earthscope committees, as well as numerous presentations for the general public. PNSN faculty, staff, and students authored or co-authored at least a dozen abstracts presented at the 2003 Geological Society of America meeting in Seattle.

**Seismicity**

Between Oct. 1, 2003 and Sept. 30, 2004, 30 earthquakes were reported felt in Washington or northern Oregon west of the Cascades, ranging in magnitude from 1.6 to 4.9. Twenty earthquakes (magnitudes 2.1 to 3.4) were reported felt east of the Cascades, twelve of them (ranging in magnitude from 2.5 to 4.4) as part of an earthquake swarm near Lakeview Oregon.

Between Oct. 1, 2003 and Sept. 30, 2004 the PNSN analyzed 5,453 events. Of these, 4,589 were earthquakes or blasts within the network (1,471 of which were too small to locate). Within the network area, 2,267 earthquakes were located west of 120.5 degrees west longitude (including 1182 in the general vicinity of Mount St. Helens, which began a magmatic eruption at on Sept. 23, 2004, just a few days before the end of this reporting period), and 375 east of 120.5 degrees west longitude. The remaining events were blasts within the network (509), regional earthquakes (291), teleseisms (573), low-frequency events (300 events, 46 locatable, including ice-quakes near the summit of Mt. Rainier, and events associated with the eruption of Mount St. Helens), and surficial events (558 events, 4 locatable, mostly rockfalls near the summits of Mt. St. Helens and Mt Rainier).
Figure 2. Earthquakes magnitude 2.0 or larger between Oct. 1, 2003 and Sept. 30, 2004. Locations of a few cities are shown as white-filled diamonds. Earthquakes are indicated by red circles or green squares; red circles represent earthquakes at depths shallower than 30 km, and green squares represent earthquakes at 30 km or deeper.
<table>
<thead>
<tr>
<th>DATE-(UTC)-TIME</th>
<th>LAT (N)</th>
<th>LON (W)</th>
<th>DEP</th>
<th>MAG</th>
<th>QUAL</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/10/01 13:27:36</td>
<td>44.73N</td>
<td>117.48W</td>
<td>22.1</td>
<td>3.1</td>
<td>DD</td>
<td>E of Baker, OR</td>
</tr>
<tr>
<td>03/10/13 01:11:58</td>
<td>47.58N</td>
<td>121.86W</td>
<td>7.7</td>
<td>1.6</td>
<td>BB</td>
<td>NE of Fall City, WA</td>
</tr>
<tr>
<td>03/10/25 23:35:21</td>
<td>47.53N</td>
<td>121.89W</td>
<td>18.6</td>
<td>2.3</td>
<td>BA</td>
<td>S of Fall City, WA</td>
</tr>
<tr>
<td>03/11/13 00:57:54</td>
<td>46.58N</td>
<td>122.45W</td>
<td>4.9</td>
<td>1.8</td>
<td>AC</td>
<td>WNW of Goat Rocks, WA</td>
</tr>
<tr>
<td>03/12/14 04:59:47</td>
<td>45.63N</td>
<td>122.76W</td>
<td>17.4</td>
<td>2.1</td>
<td>AA</td>
<td>NW of Portland, OR</td>
</tr>
<tr>
<td>03/15/13 00:11:51</td>
<td>48.64N</td>
<td>122.44W</td>
<td>0.7</td>
<td>2.1</td>
<td>CC</td>
<td>SW of Enumclaw, WA</td>
</tr>
<tr>
<td>03/16/17 01:34:27</td>
<td>48.44N</td>
<td>122.62W</td>
<td>0.1</td>
<td>3.8</td>
<td>CC</td>
<td>E of Mount Vernon, WA</td>
</tr>
<tr>
<td>04/01/06 22:45:51</td>
<td>46.58N</td>
<td>122.57W</td>
<td>16.8</td>
<td>2.1</td>
<td>BA</td>
<td>WNW of Mt McLoughlin, OR</td>
</tr>
<tr>
<td>04/01/07 00:11:51</td>
<td>47.63N</td>
<td>122.45W</td>
<td>0.0</td>
<td>3.1</td>
<td>BC</td>
<td>SSE of Kennewick, WA</td>
</tr>
<tr>
<td>04/01/26 16:43:10</td>
<td>47.10N</td>
<td>122.20W</td>
<td>10.7</td>
<td>1.8</td>
<td>AA</td>
<td>E of Entiat, WA</td>
</tr>
<tr>
<td>04/02/10 13:22:59</td>
<td>47.67N</td>
<td>120.27W</td>
<td>8.7</td>
<td>2.5</td>
<td>BA</td>
<td>ESE of Monroe, WA</td>
</tr>
<tr>
<td>04/02/25 01:41:32</td>
<td>42.04N</td>
<td>120.23W</td>
<td>14.3</td>
<td>2.7</td>
<td>DB</td>
<td>NE of Lakeview, WA</td>
</tr>
<tr>
<td>04/03/17 11:34:27</td>
<td>42.05N</td>
<td>120.23W</td>
<td>10.9</td>
<td>4.4</td>
<td>BB</td>
<td>NE of Mount Vernon, WA</td>
</tr>
<tr>
<td>04/03/20 07:00:14</td>
<td>42.09N</td>
<td>120.23W</td>
<td>11.6</td>
<td>3.9</td>
<td>BB</td>
<td>E of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 07:03:16</td>
<td>42.07N</td>
<td>120.23W</td>
<td>10.4</td>
<td>3.2</td>
<td>BB</td>
<td>E of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 11:32:37</td>
<td>42.07N</td>
<td>120.23W</td>
<td>6.9</td>
<td>3.0</td>
<td>BB</td>
<td>E of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 11:40:37</td>
<td>42.07N</td>
<td>120.23W</td>
<td>10.4</td>
<td>3.2</td>
<td>BB</td>
<td>E of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 12:21:45</td>
<td>42.07N</td>
<td>120.23W</td>
<td>10.9</td>
<td>4.4</td>
<td>BB</td>
<td>E of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 18:59:45</td>
<td>42.07N</td>
<td>120.23W</td>
<td>3.6</td>
<td>2.5</td>
<td>CD</td>
<td>E of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 06:06:03</td>
<td>42.09N</td>
<td>120.23W</td>
<td>2.9</td>
<td>4.7</td>
<td>BB</td>
<td>W of Newport, OR</td>
</tr>
<tr>
<td>04/03/20 16:58:00</td>
<td>42.07N</td>
<td>120.23W</td>
<td>7.4</td>
<td>2.2</td>
<td>AA</td>
<td>SW of Mt Rainier, WA</td>
</tr>
</tbody>
</table>
Publications

Quarterly bulletins from the PNSN (http://www.pnsn.org/REPTS/quarterly.html) provide operational details and descriptions of seismic activity in Washington and Oregon. These are available from 1984 through the third quarter of 2004. Final published catalogs are available from 1970, when the network began operation, though 1989.

• Reports and Articles


Caruso, F., S. Viciguerra, V. Latora, A. Rapisara, S. Malone, (in preparation), Multifractal analysis of Mount St. Helens seismicity as a quantitative characterization of the eruptive activity


Ranf, R.T., M.O. Eberhard, S. Malone, (in press), Post-Earthquake Prioritization of Bridge Inspections, Earthquake Spectra, EERI


• Abstracts


Crosson, R.S., 2004, High resolution 3-D travel-time tomography using controlled sources and earthquakes: application to the Cascadia subduction zone (abstract), AGU Fall Meeting.


