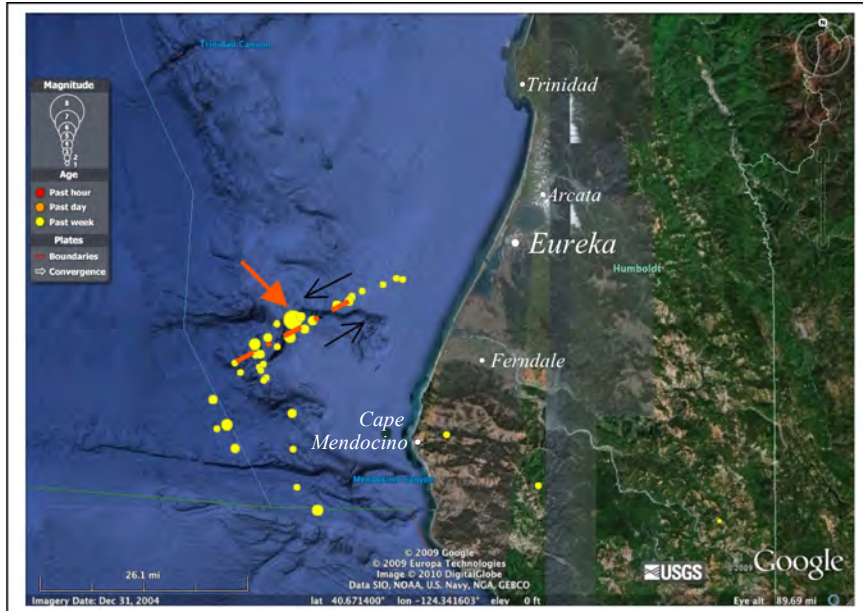


January 9, 2010 M_w 6.5 Gorda Plate Earthquake offshore of Northern California

Summary Report January 13, 2010 compiled from the USGS, Berkeley Seismological Laboratory, Times Standard, Humboldt State University, and the Redwood Coast Tsunami Work Group

The Earthquake

The earthquake occurred at 4:27 PM PST January 9, 2010 (00:27 UTC 1/10/10). It was centered at a depth of about 29 km (19 miles) beneath the earth's surface, but the depth accuracy is relatively poor for offshore earthquakes and located offshore, 21 miles NW of Cape Mendocino, 23 miles WNW of Ferndale and 29 miles WSW of Eureka. The preliminary information issued by the West Coast Alaska Tsunami Warning Center four minutes after the earthquake gave a magnitude of 6.4, which was changed to 6.5 after review by seismologists at the USGS. Analysis of the earthquake indicates that slip occurred on an unnamed, near-vertical, left-lateral fault oriented about N47E within the Gorda plate.



Google Earth image of the January 9 mainshock (arrow) and aftershocks as of 1/13. Dashed line shows the location of the probable fault source and black arrows show the direction of slip.

Inversion of seismic waveforms by the UC Berkeley Seismological Laboratory estimated a fault length of about 25 km (16 miles) and rupture proceeded unilaterally to the southwest. The peak estimated slip (offset) between the two sides of the fault was 2.4 meters (8 feet).

Tsunami

The earthquake did not cause a tsunami. Strike-slip earthquakes are generally unlikely to produce large tsunamis because they cause relatively little vertical ground displacement. The NOAA National Weather Service West Coast/Alaska Tsunami Warning Center (WCATWC) issued a Tsunami Information Statement at 4:32 PM PST, 4 minutes after the earthquake. The bulletin stated “The magnitude is such that a tsunami IS NOT EXPECTED. However, in coastal areas of intense shaking, locally generated tsunamis can be triggered by underwater landslides.” There was no evidence of any water level disturbance on the tide gauge located just inside Humboldt Bay.

Aftershocks

Thirty-nine aftershocks were detected in the first four days after the earthquake. Most were located along the 47° trend of the fault rupture (see figure above), but some were located in the SE Gorda plate south of the rupture and along the Mendocino fault. The largest was a magnitude 4.4 that occurred about an hour and a half after the mainshock. It was widely felt in the Humboldt Bay and Cape

Mendocino areas. The Did-You-Feel-It reports indicate that earthquakes larger than M3 were felt by nearby residents. None of the aftershocks to date have caused damage.

The largest aftershocks are listed below.

Date	Time (PST)	Magnitude	Location
1/9/10	16:42:38	3.5	29 miles WNW of Petrolia
1/9/10	16:43:15	3.7	26 miles WNW of Ferndale
1/9/10	16:48:38	3.3	18 miles WNW of Ferndale
1/9/10	16:51:00	3.2	21 miles WNW of Ferndale
1/9/10	17:06:17	3.4	27 miles WNW of Ferndale
1/9/10	17:48:47	3	17 miles WNW of Ferndale
1/9/10	18:21:39	4.4	27 miles WNW of Ferndale
1/9/10	19:07:01	4	23 miles WNW of Ferndale
1/9/10	20:31:36	3	24 miles WNW of Ferndale
1/9/10	22:32:17	4.1	31 miles WNW of Ferndale
1/10/10	3:48:31	3.9	21 miles WNW of Ferndale
1/10/10	22:44:37	4.1	31 miles WNW of Petrolia
1/11/10	3:21:30	3.1	22 miles WNW of Ferndale
1/11/10	18:53:36	3.2	33 miles WNW of Ferndale
1/13/10	17:36:27	3.6	22 miles WNW of Ferndale

The USGS issued probability estimates for strong and possibly damaging aftershocks ($M > 5$) in a seven-day window with an initial value of approximately 78% immediately after the earthquake, decreasing to 60% twenty-four hours later and 38% by the third day. Most likely, the mainshock will be the largest in the sequence, however, the USGS estimates a small chance (~5-10%) of an earthquake equal to or larger than the mainshock in the following week.

Tectonic background

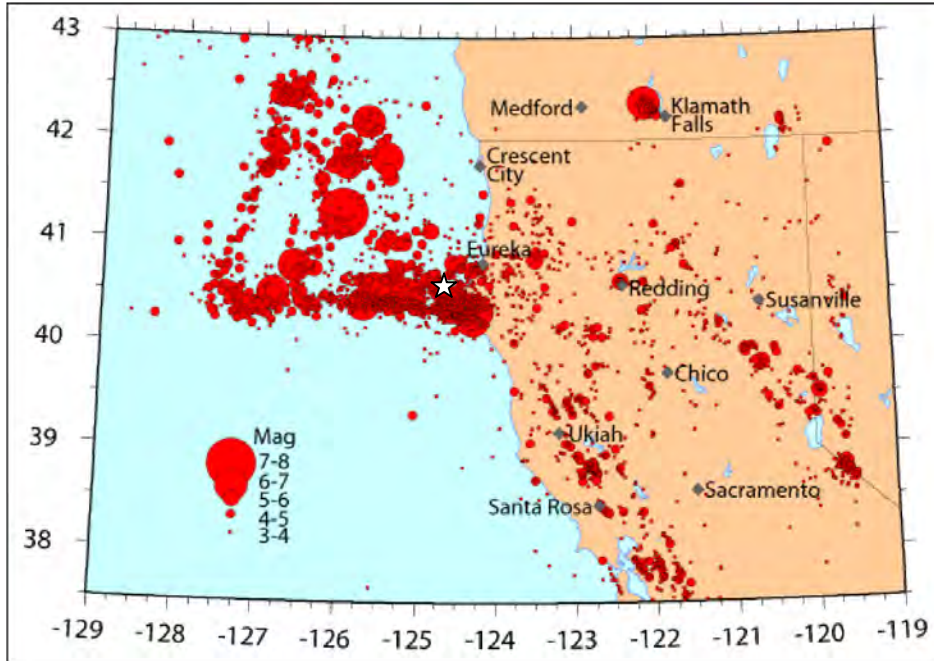
The Cape Mendocino region of Humboldt County and the adjacent offshore area is the most seismically active region of the contiguous 48 states. This magnitude-6.5 earthquake occurred in a deformation zone of the southernmost Juan de Fuca plate that is commonly referred to as the Gorda plate. The earthquake's epicenter was northwest of the Mendocino Triple Junction, which is formed by the intersection of three plates (the Gorda, Pacific, and North American) and three plate boundaries - the Mendocino fault, the San Andreas fault and the Cascadia subduction zone. The Gorda plate is subducting beneath the North America plate at about 2.5-3.0 cm/year to the northeast. The Gorda plate is also subjected to intense compressive stresses by oblique-convergence of the northwestward migrating Pacific Plate as well as localized eastward spreading at the Gorda Ridge. The resulting internal deformation of the Gorda plate is manifested primarily by intraplate strike-slip events on vertical NE-oriented, left-lateral faults. The majority of historic earthquakes have occurred in this zone or along the Mendocino fault.

Historic seismicity

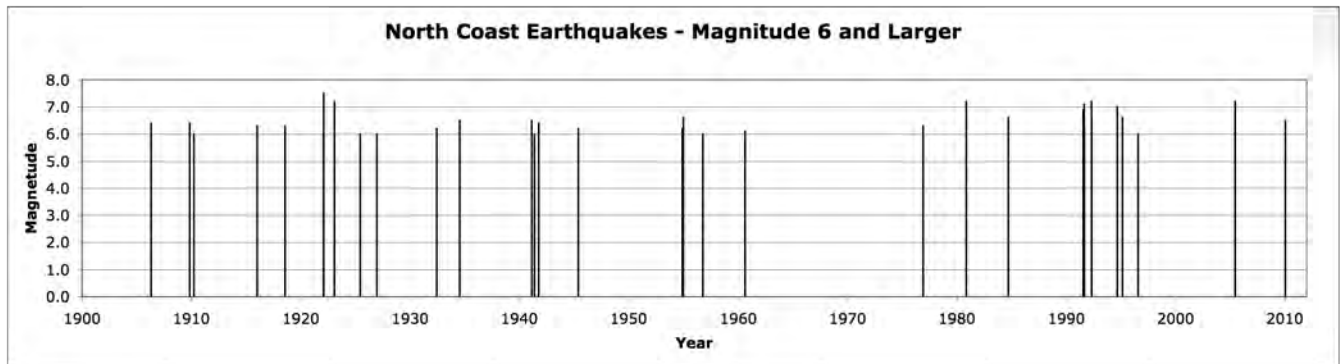
During historic times, the coastal and offshore areas of Humboldt and Del Norte Counties, California have been the single most seismically active region of the coterminous United States. On average, an earthquake with strength enough to topple items off shelves has occurred every two to three years, strong enough to topple chimneys every seven years, and cause major damage about every twenty years.

Since 1900, 25 earthquakes have caused damage to structures (Intensity VI or greater), an average recurrence of less than five years. Most of these earthquakes have been centered offshore or near Cape Mendocino, sparing the more populated Humboldt Bay region the strongest shaking levels. The 1932 and 1954 earthquakes, both in the magnitude 6 - 6.5 range and located less than 20 miles from the bay, each caused one fatality and produced significant damage in the Arcata and Eureka areas. This is the

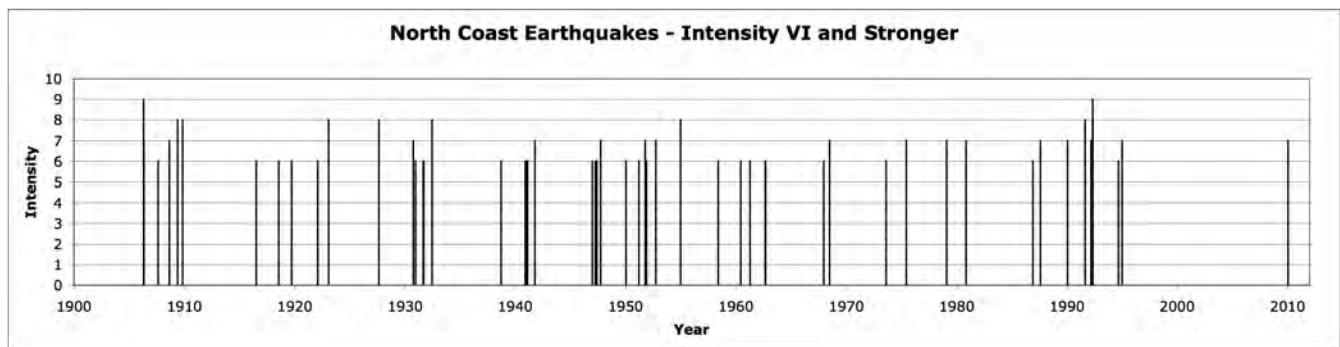
largest quake to occur in this region since the June 15, 2005 magnitude 7.2 offshore Eureka earthquake. It did trigger a tsunami warning for the entire west coast of the United States but was fortunately too far offshore to cause damage. The January 9 earthquake was the first event to cause damage since a magnitude 5.4 earthquake on December 26, 1994. The most significant recent earthquake sequence occurred on April 25-26 1992 when a magnitude 7.2 earthquake occurred onshore near Petrolia and was followed by magnitude 6.6 and 6.7 earthquakes in the following 18 hours. The sequence caused at least \$60 million in damages and resulted in a federal disaster declaration.



Historic North Coast Earthquakes epicenters 1975 to the present. Star shows the location of the January 9 earthquake.



Historic North Coast Earthquakes of magnitude 6 or larger. Magnitude is a measure of the relative energy release at the earthquake source. It depends on the size of the fault and the amount of fault slip. Large magnitude earthquakes don't necessarily produce damage if they are located far from population centers.



Historic North Coast Earthquakes of peak Intensity VI or larger. Intensity measures relative shaking strength at specific locations onshore. Intensity VI is considered very strong and may break windows and produce cracks in buildings. Intensity VII is severe and will topple many unreinforced brick chimneys and displace heavy furniture. Intensity VIII is described as violent and will knock unsecured structures off foundations and damage brick buildings. Intensity IX and larger is extreme and will damage even well-engineered structures.

Earthquake effects

Landslides

No large landslides have been observed. A number of small slips were seen in the Humboldt Hill area and on the bluffs adjacent to HWY 101 south of Eureka. Recent coastal bluff erosion was observed near Table Bluff south of the Eel River but it is difficult to determine whether it was an earthquake effect or due to high surf activity. Bank failure damaged the Mattole Road.

Liquefaction and spread failures

Liquefaction (sandboils) were observed on Centerville Beach and along the Eel River. The Centerville Beach features were subtle and had been overtopped by high tide washover. Small sandboils were better preserved on the banks of the Eel River and associated with spread failures ranging in length from less than a meter to 20 meters.



Liquefaction features. Left – remains of sandboils at Centerville Beach. Right – sandboil along the Eel River.

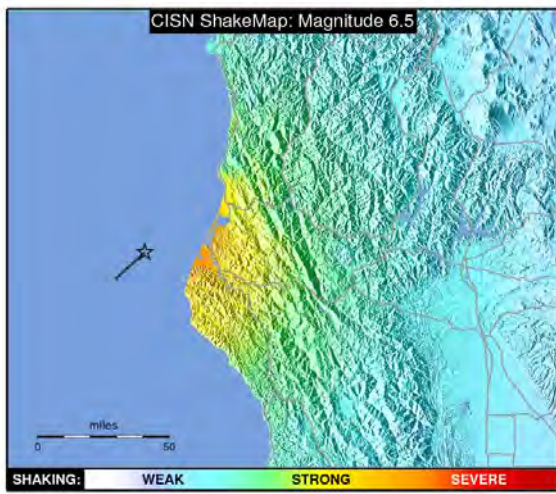
Spread failures were also observed at King Salmon.

Strong ground shaking

The maximum recorded shaking was observed in Eureka (33%g), which is sufficient to cause moderate damage. The instrumentally-computed shakemap shows a zone of strong shaking along the coast extending from the Eel River Valley to Eureka. About 20% of the vertical monuments at the Ferndale cemetery were toppled or displaced and preliminary analysis suggests an east-west alignment.



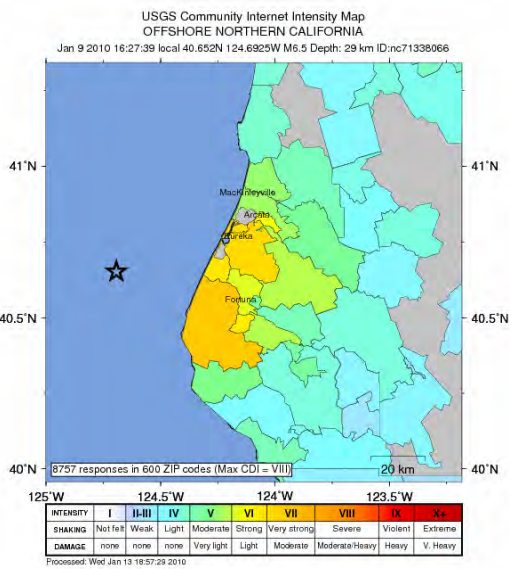
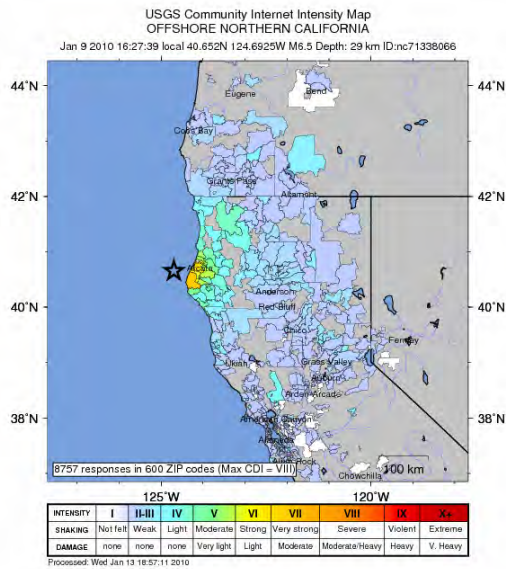
Toppled monuments at the Ferndale Cemetery. Both of these monuments have collapsed to the west.



Map Version 16 Processed Mon Jan 11, 2010 08:04:57 PM PST, NOT REVIEWED BY HUMAN

Shakemap - Instrument-determined ground shaking. Star shows epicenter and line is the approximate extent of rupture.

Shaking was strongest near the coast line between Petrolia and Eureka, CA, although felt reports for this event extend from as far south and north as Capitola, CA and Eugene, OR, respectively, and as far east as Reno, NV. USGS has received 8757 “Did You Feel It?” reports from 529 zip codes as of January 13.



Did You Feel it – individual responses to the USGS Intensity online survey

Impacts (from newspaper accounts and government assessments)
 The Humboldt County (CA) Office of Emergency Services and the Humboldt County Emergency Operations Center were activated and conducted assessments and information gathering. The CA State EOC was not activated. About 30 people visited hospitals for minor injuries, and one report of a major injury (an elderly man with a broken hip). Damage was greatest in Eureka. In Eureka there were 219 reports of damage to homes and commercial buildings (foundation damage, damaged parapets, cracked walls, toppled chimneys and driveways). Damage estimates as of January 12 exceed \$20 million in the county. The largest losses to structures (all in Eureka):

Bayshore Mall (Broadway)	\$6,000,000
US Post Office (5 th & H St.)	\$1,000,000
Lloyd Building (211 5 th St.)	\$1,000,000
Reflections Gallery (417 2 nd St.)	\$1,000,000
Eureka Marina Dock B (Marina Way)	\$750,000
Old Town Bar & Grill (325 2 nd St.)	\$700,000
Arkley Center (5 th & G St.)	\$300,000
The Pearl (507 2 nd St.)	\$200,000
Ray's Food Place (Broadway)	\$200,000
1200 W. Del Norte	\$200,000
Carson Block Building (231 F St.)	\$200,000



State Highways and bridges survived the earthquake with minimal damage. The initial estimate of losses to County roads was \$2.5 million. A number of culverts suffered damage and a bank on the Mattole Road collapsed.

More than 36,000 people were initially without power, but electricity was restored to everyone shortly after 6 AM Sunday January 10. There were 75 reported residential gas line breaks and Pacific Gas & Electric power and gas crews responded. According to the Division of Drinking Water and Environmental Management, no drinking water systems were affected. PG&E reported no damage at its gas-powered Humboldt Bay Power Plant, where a batch of spent nuclear fuel rods has been stored for years.

Damage to structures was also observed in Ferndale, Loleta, and Fields Landing. Humboldt County Red Cross is currently supporting shelter for 14 people displaced from their homes. Governor Schwarzenegger declared a State of Emergency for Humboldt County on January 12.

Human behavior

Numerous security cameras and home videos captured the January 9 event and the most striking observation is that the majority of people did not drop-cover-hold on, but walked or ran outdoors during the strong ground shaking. An important lesson from this event is to improve outreach efforts for drop, cover and hold on response.

Many people were aware of the potential tsunami hazard and recognized the ground shaking as a natural warning sign. In Samoa, at least a dozen people evacuated by foot to the evacuation site. However, many more people chose to evacuate by car, causing significant traffic problems and in some cases, gridlock. Outreach efforts need to emphasize that tsunami evacuation should be by foot.