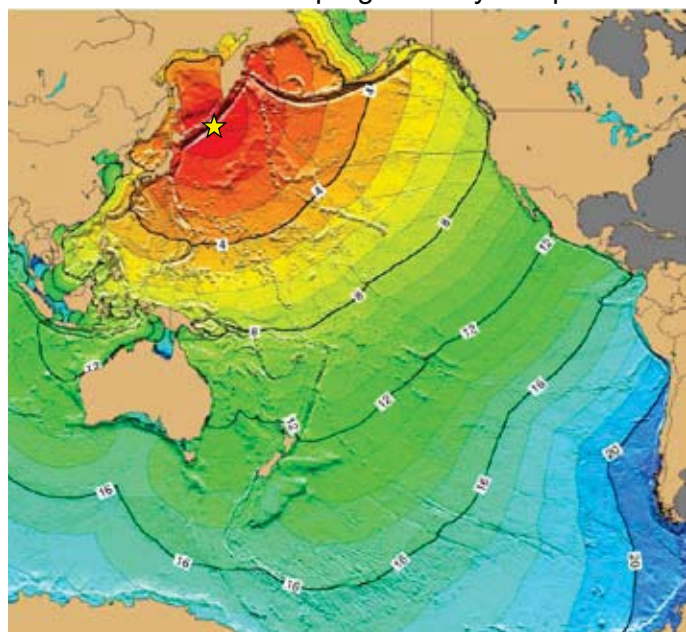


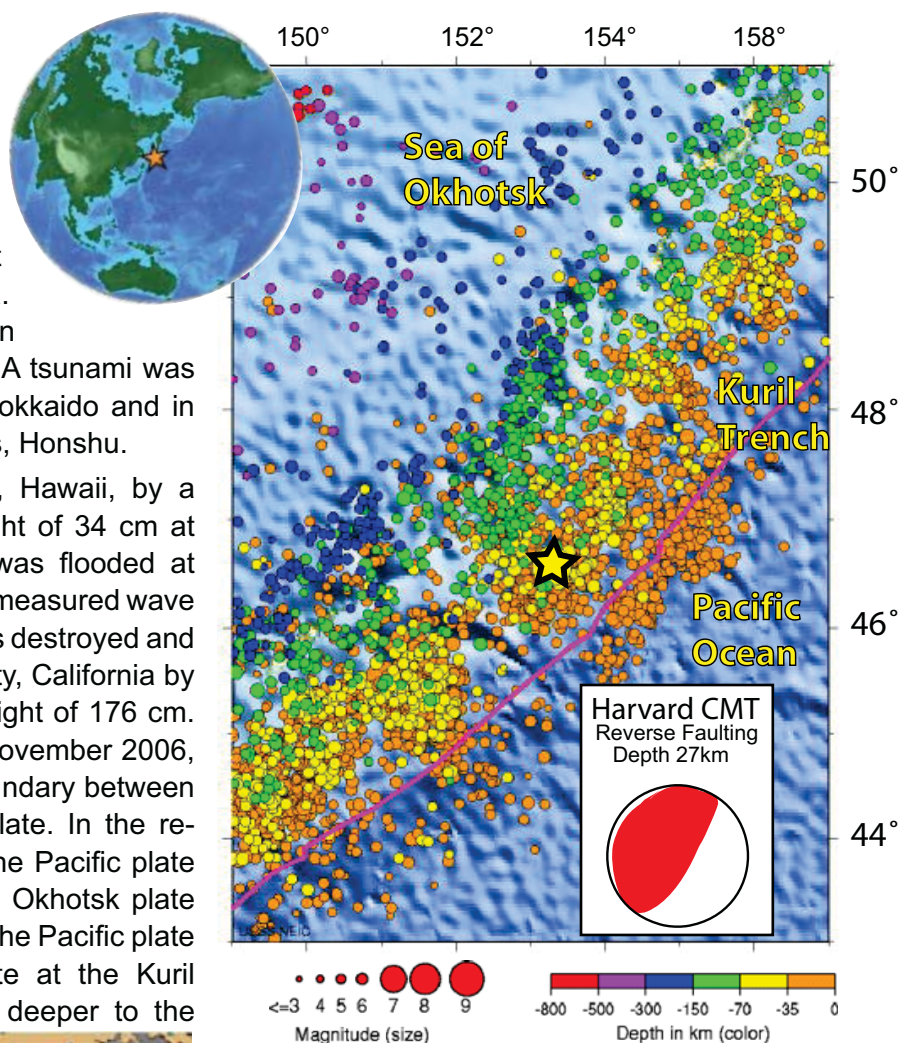
KURIL ISLANDS, 15 November 2006, 11:14 UTC, $M_W=8.1$

A great earthquake occurred 495 km SSW of Severo-Kuril'sk, Kuril Islands, Russia and 1665 km NE of Tokyo, Japan at 11:14 UTC, 15 November 2006 (21:14 local time in Russia). The earthquake was felt at Misawa and Yokosuka, Japan and at Petropavlovsk-Kamchatskiy, Russia. The tsunami was recorded (2 JMA) in eastern and south-central Hokkaido. A tsunami was also recorded (1 JMA) in western Hokkaido and in Aomori, Iwate and Miyagi Prefectures, Honshu.

One person was injured at Waikiki, Hawaii, by a tsunami with a measured wave height of 34 cm at Honolulu, Hawaii. One parking lot was flooded at Nawiliwili, Hawaii by a tsunami with a measured wave height of 88 cm. There were two docks destroyed and at least one damaged at Crescent City, California by a tsunami with a measured wave height of 176 cm. The Kuril Islands earthquake of 15 November 2006, occurred as thrust-faulting on the boundary between the Pacific plate and the Okhotsk plate. In the region of the earthquake's epicenter, the Pacific plate moves northwest with respect to the Okhotsk plate with a velocity of about 90 mm/year. The Pacific plate subducts beneath the Okhotsk plate at the Kuril Trench and becomes progressively deeper to the



Tsunami travel time chart showing the theoretical time it takes to cross the Pacific from the tsunami source (assumed to be the earthquake epicentre). Color change every hour.



Map showing historical seismicity from 1990 to the present in the area surrounding the current earthquake, indicated by the yellow star. The major subduction zone is purple. Both maps courtesy of National Earthquake Information Center (NEIC).

northwest, remaining seismically active to a depth of 680 km. The 15 November mainshock occurred at shallow depth within about 80 km of the trench axis.

The 15 November earthquake is the largest earthquake to have occurred in the central Kuril Islands since the early 20th century. A central Kuril Islands earthquake in 1915 is estimated to have had a magnitude of about 8. The central Kuril Islands commonly experiences one or more shocks of magnitude 6 or greater in a decade. To the south-west, the southern Kuril Islands chain experienced a magnitude 8.5 earthquake in 1963. To the north-east, a magnitude 9 earthquake occurred offshore of Kamchatka in 1952.

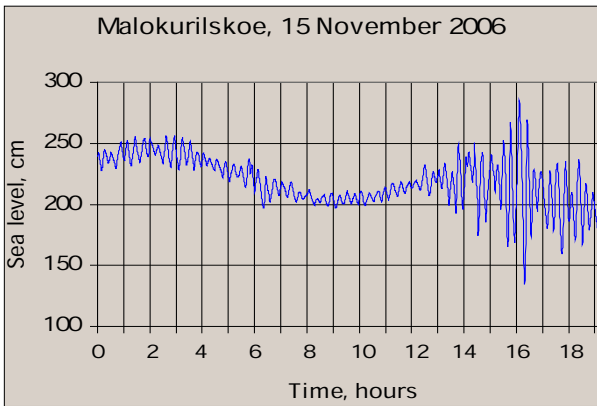
Kuril Islands, continued

Tide Station	Maximum tsunami wave height in cm (peak-to-trough)	Tide Station	Maximum tsunami wave height in cm (peak-to-trough)
Pago Pago, American Samoa	44	Niue	13
Talcahuano, Chile	97	Manus Island, PNG	13
Arica, Chile	82	Callao-La Punta	73
Caldera	76	Atico, Peru	24
Coquimbo	66	Apia, Samoa	57
Iquique	64	Honiara, Solomon Islands	7
Antofagasta	46	Betio, Tarawa	5
Juan Fernandex, Chile	40	Nuku'alofa, Tonga	9
Rarotonga, Cook Islands	18	Funafuti, Tuvalu	6
Nuku Hiva, Fr. Polynesia	88	Adak, Alaska (AK) USA	39
Rikitea, French Polynesia	11	King Cove AK	36
Santa Cruz, Ecuador	67	Nikolski AK	32
Baltra Galapagos, Ecuador	62	Sitka AK	25
Tokachi-to Japan	120	Sand Point AK	21
Chichi-jima, Japan	100	Shemya Island AK	20
Hana-saki, Japan	80	Amichitka Island, AK	8
Hachinohe, Japan	60	Arena Cove, AK	118
Hakodate, Japan	40	Santa Barbara, CA USA	79
Kushiro, Japan	40	Point Reyes, CA	62
Nemura, Japan	40	Santa Monica, CA	30
Naha, Japan	13	Los Angeles, CA	22
Shikotan, Kuril Islands	35	San Diego, CA	18
Kanton, Kiribati	6	Richmond, CA	17
Midway Island	96	Kahului, (Maui) HI USA	152
Kwajalein, Mardhall Islands	28	Hale'iwa, (Oahu) HI	115
Timaru Port	58	Wai'anae (Oahu) HI	100
Kaingarua, Chatham Island	56	Hilo (Hawaii County) HI	98
Port-Vila Vanuatu	29	Kalaupapa (Molokai) HI	88
Wake Island	22	Hanalei (Kauai) HI	85
Port Orford, OR USA	112	Kawaihae (Hawaii County) HI	65
Charelston, OR	38	Makapu'u (Oahu) HI	64
South Beach, OR	34	Lahaina (Maui) HI	45
Port Angeles, Washington USA	24	Honokohau (Hawaii County)HI	26
Lyttelton Port, New Zealand	33	Miloli'i (Hawaii County) HI	23
Sumner Head, New Zealand	33	Kapoho (Hawaii County) HI	13
Kaikoura, New Zealand	32	Mokuolo'e (Hawaii County) HI	10
Moturiki Island, New Zealand	21		

Maximum wave heights recorded for the Kuril Islands Tsunami of 15 November 2006 as recorded at Pacific Basin tide stations. Reported by the USGS in the National Earthquake Information Center's description of the event.

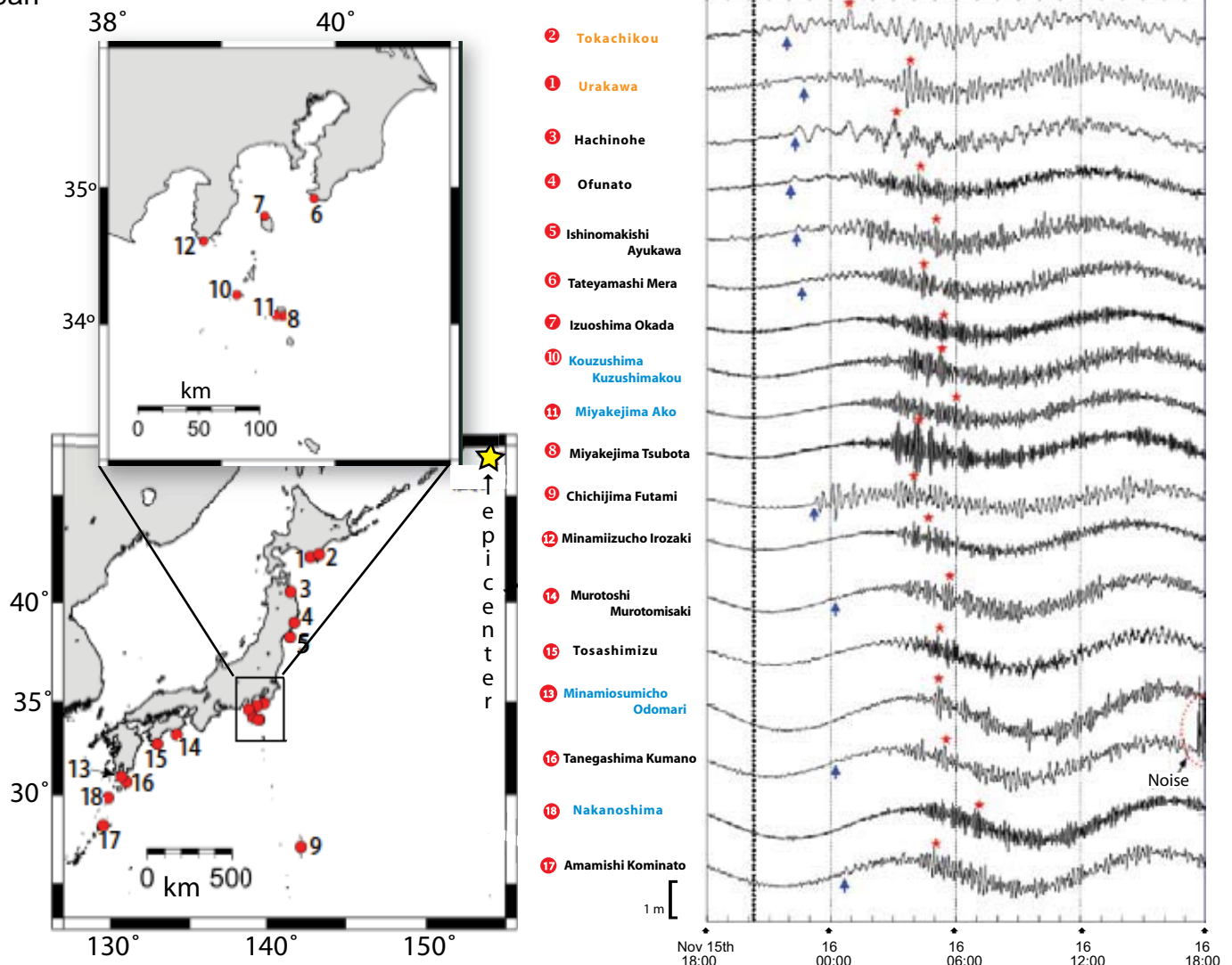
Kuril Islands, *continued*

Russia



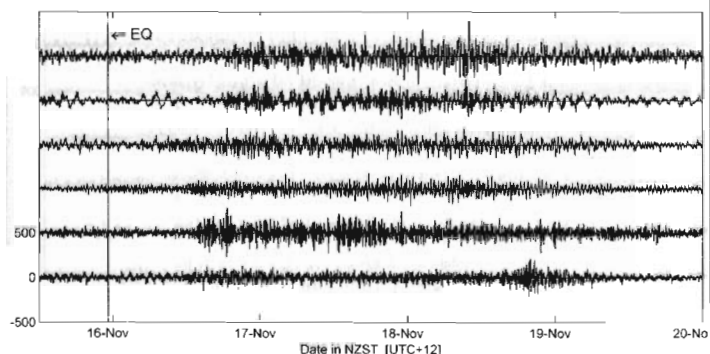
Sea level record from Malokurilskoe, Shikotan Island (left) along with an aerial view (right) of the harbor. Red dot indicates the location of the analogue gauge in the harbor. Graph indicates maximum peak-to-trough wave height in centimeters over time. Both courtesy of Tatiana Ivelskaya, Sakhalin Tsunami Warning Center.

Japan



Map and inset detail show the epicenter (yellow star) and station locations, numbered to correspond to sea level records in the graph to the right. All stations are maintained by Japan Meteorological Agency (JMA) except those named in orange belong to Hokkaido Bureau of Ministry of Land, Infrastructure and Transport Japan, and those in blue are maintained by the Japan Coast Guard. The dotted line on the graph is the earthquake origin time. Blue arrows indicate initial wave arrival times and the red stars mark when maximum amplitudes were recorded. Where there are no arrows, arrival times could not be determined. The sea-level data at Tanegashima Kumano station (#14) includes noise from 17:30 on 16th November. Courtesy of JMA.

New Zealand



Tide Gauge	Arrival Time 16 Nov (NZST)	Arrival Time 16 Nov (UTC)	Periods of waves (min)	Maximum peak-to-trough wave height	Time of peak wave height	Peak wave amplitude above mean (cm)	Time of highest peak above mean
◀Timaru Port, NZ 44.392 S 171.254 E	18:03	06:03	9-19	58	09:52 18 Nov	40	10:00 16 Nov
◀Lyttelton Port, NZ 43.606 N 172.722 E	14:50	02:50	10-18	33	01:11 17 Nov	25	09:27 18 Nov
◀Sumner Head, NZ 43.570 S 172.773 E	14:45	02:45	12-21	33	18:34 16 Nov	20	18:38
◀Kaikoura, NZ 42.415 S 172.703 E	14:00	02:00	10-20	32	17:36 17 Nov	19	
◀Kaingaroa, Chatham Is. 43.732 S 183.733 E	13:42	01:42	9-12	56	18:35 16 Nov	28	
◀Moturiki Is, NZ 37.633 S 176.193 E	13:20	01:20	9-15	21	20:29 16 Nov	13	

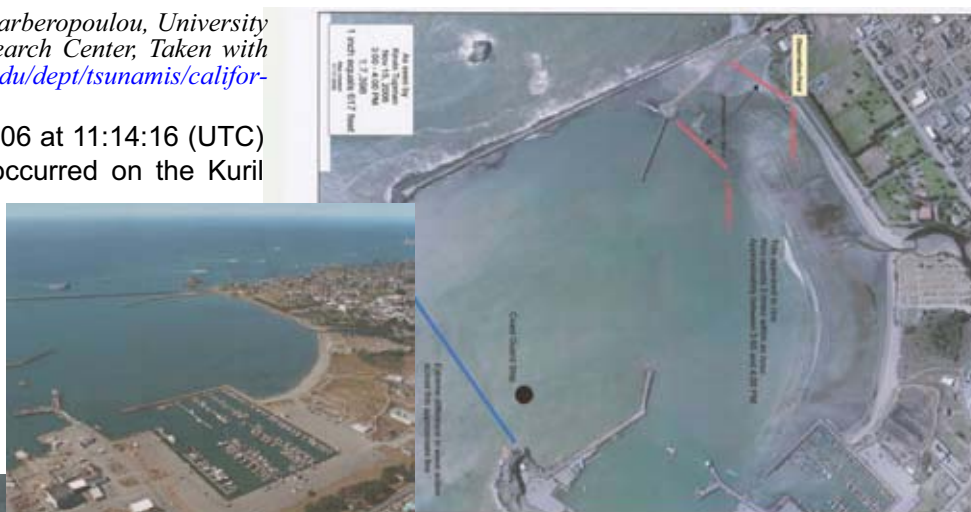
Sea level data supplied by Port of Lyttelton Ltd. and Prime-Port, Timaru and New Zealand National Institute for Water and Atmospheric Research or NIWA, Taihoro Nukurangi (Moturiki, Kaingaroa, Kaikoura, Sumner Head).

Kuril Island Tsunami Impact in Crescent City, California 15 November 2006

By Mr. Burak Uslu and Dr. Aggeliki Barberopoulou, University of Southern California, Tsunami Research Center; Taken with approval from URL: http://www.usc.edu/dept/tsunamis/california/Kuril_2006.

On Wednesday, 15 November 2006 at 11:14:16 (UTC) a large ($M_w = 8.3$) earthquake occurred on the Kuril Islands Subduction Zone. The event caused a Pacific wide tsunami which was expected to reach Japan in 64 minutes and California in 8 hours and 20 minutes.

The first wave arrived at Hana-saki, Hokkaido with an amplitude



Left: Aerial photograph of the Crescent City Harbor. Photo provided by Harbor Master Richard Young (taken by Rick Hiser). Right: GIS measurement of inundation distance between high and low water levels during the tsunami. Information provided by Mr. Kevin Tupman.

expected to be relatively minor, a full evacuation was not ordered, but rather targeted verbal warnings were issued for people in the harbor. Mr. Erik Macee from the fishing vessel *Resolution* confirmed that he was warned by the harbor control at around 11:10 am PST.

The first wave arrived as expected but it was not noticed by the harbor control. Mr. Macee said he was in his boat when he first noticed the withdrawal. He was able to watch the tsunami from his boat looking at the water elevation change at the piling and breakwater.

The tsunami surges did not cause any damage until after 2 pm. Mr. Macee said the largest waves arrived around 2 or 2:30 pm. The second in the series of larger waves did the most damage when mooring lines from

of 30 cm. After the observation of this minor tsunami in Japan, a large tsunami was not expected in Alaska or along the US west coast.

However, around 11:00 am Pacific Standard Time (PST), the Crescent City, California Harbor Control and Emergency offices received a warning for possible strong tsunami surges which were expected to arrive around 11:30 am. Because the tsunami effect was

Crescent City, *continued*

vessels berthed at Dock H were severed. Dock H had three boats, including the biggest boat in the harbor, 'Delana'. The 'Delana' was connected directly to the piling, while the other two vessels were connected to the exposed dock. The dock could not resist the strong current and the pull coming from the boats and failed.

The current was so strong, harbor facilities manager Pual McAndrews reported that a white buoy at the entrance of the harbor was buried under water as the current flowed out of the harbor. He also noted that harbor seals and sea lions were not able to swim against the current.



Aerial view showing the areas where major damage occurred to the docks of Crescent City Harbor. URL:http://www.usc.edu/dept/tsunamis/california/Kuril_2006 Permission granted to download from the USC Tsunami Research Center website. Photo credit to Professor Lori Dengler.



Boats damage in Crescent City Harbor. Photo provided by Professor Lori Dengler, Humboldt State University.

Other witnesses described the tsunami in the harbor as 'flowing like a river'. It caused a whirlpool effect and it was flowing in clockwise direction. Dock H was the first dock in the flow direction and could not resist the flow.

After the Dock H, it was just a matter of time before Dock G failed. The loose boats carried pieces of Dock H when they crashed into Dock G and later into Dock F. A large portion of Dock F was also damaged, but it did not move around as did Docks G and H.

Docks E, F and G are used for small craft and sail boats. *Windrose* and *Allarion* are two of the sail boats that use Dock G. Robert Nunneley and Jim Herriott, owners



Boat lifted out of the water onto a pier. Photo provided by Professor Lori Dengler, Humboldt State University.

of the vessels, learned about the tsunami and arrived at the harbor around 3:40 pm. They noticed that the currents were still very strong. Their boats *Windrose* and *Allarion* were pushed on to the other boats at Dock C. The Coast Guard helped them to move the boats from Dock C to F.

Sam and Kathleen Burke, who work at a local RV camp, returned to the campground around 2:30 pm. They noticed that the tide level was different than what would be expected for that time. They also observed several water level changes. Mrs. Burke measured the time between wave crests to be 12 minutes. She repeated this for three more waves to confirm her observation.

Public works technician Kevin Tupman came to north harbor around 2:40 pm. He also observed the changes in water level due to the tsunami. Mr. Tupman estimated the distance from the low water mark to the high water mark was some 850 ft. He was at the north harbor from 3 until 4 pm and he saw three full wave cycles, which confirms Mrs. Burke's observation.

Fortunately it was low tide when the tsunami surges first arrived around 11:30 am. Total damage in the harbor is expected to be between \$500,000 to \$1,000,000. Had the tide been high at the time of tsunami arrival the damage could have been more severe.



Pier damage photo taken by Emergency Services Coordinator Allen Winoogradov following the tsunami in Crescent City.