

## TSUNAMI HISTORY OF SAN DIEGO

by

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The purpose of this paper is to list the available records of tsunamis at San Diego. For remote tsunamis the historical record is quite extensive; for local tsunamis data are essentially nonexistent.

A remote tsunami is one observed more than a few wavelengths from its point of generation. Large runup from remote tsunamis usually occurs when the offshore topography concentrates the tsunami energy. This does not seem to have happened at San Diego. Tide gauge records for San Diego bay extend from 1854 to 1872 and from 1906 to the present. In the 92 years of record, at least 19 tsunamis have been recorded. Most have been only a few tenths of a meter in height; for comparison, the diurnal range of tide at San Diego is 1.7 meters. The largest one was caused by the Chilean earthquake of May 1960. In San Diego it had a maximum range (peak-to-trough) of 1.5 meters, and produced strong currents which caused some damage to piers and which temporarily halted ferry service to Coronado.

In its recorded history (since the late 1700's) San Diego has experienced only one tsunami caused by a local earthquake. It was associated with the earthquake of May 27, 1862, which caused the most intense shaking known for San Diego (Legg and Agnew, this volume). Because the tide gauge was being repaired at the time, there is no quantitative record of the event, but an eyewitness account by the tidal observer, Andrew Cassidy, has been preserved\*. At the time of the

\*In a memorandum dated May 27, 1862, pasted on page 711 of the "Emigrant Notes" compiled by Benjamin Hayes (manuscript CE 62, Bancroft Library, Berkeley).

earthquake Cassidy was on the beach at La Playa, about 2 kilometers north of Ballast Point, on the east side of Point Loma. He wrote that, "The water in the Bay did not appear to be much agitated notwithstanding the sea run up on the beach between 3 and 4 feet, and immediately returned to its usual level." The value of 3 to 4 feet probably refers to the horizontal distance along the beach; the wave height would have been much less. Cassidy also noted falls of earth in the banks between La Playa and Point Loma. If one of these were large enough it might have caused a single wave in San Diego Bay similar to, but much smaller than, that caused by a rockslide in Lituya Bay, Alaska, in 1958 (Miller, 1960). In light of this possibility it would be premature to use this observation to conclude that tsunamigenic earthquakes can occur near San Diego. Such a conclusion, and any estimates of risk from local tsunamis, would have to come from a combined study of earthquake recurrence rates and types of faulting in the offshore area, together with model studies of tsunami generation, propagation, and runup. All the historical evidence shows is that damaging local tsunamis have not occurred at San Diego in the last two centuries.

The following list, which is based on that of Joy (1968), is limited to those tsunamis for which there is some evidence of a record at San Diego. For each date, the list gives the location and magnitude of the causative earthquake, followed by the size of the tsunami at tide gauges near San Diego. Where possible, earthquake magnitudes have been given according to the  $M_w$  scale introduced by Kanamori (1977). Three terms have been used to specify tsunami size. "Range" is the maximum value from peak to trough, also called "maximum rise or fall". "Height" (taken from Iida et al., 1967) is the maximum positive departure from normal sea level. "Amplitude" is used when the definition of size in the original source is unclear. Though it is tempting to estimate a period for a tsunami record, it may not be too meaningful. Detailed analysis of the 1960 tsunami as recorded at La Jolla showed a broad spectrum (Miller et al., 1962). Tsunami records from San Diego harbor give the general impression that the predominate periods are in the range of one-half to one hour.

Unless otherwise specified, the sources of information for this list are as follows. Earthquake locations before 1900 are from Iida et

al (1967); from 1900 to 1954 locations are from Gutenberg and Richter (1954), and  $M_s$  magnitudes are from Geller and Kanamori (1977) and Geller et al (1978); after 1954 locations and  $M_s$  magnitudes are from epicenter lists published by the U. S. Coast and Geodetic Survey and its successor agencies.  $M_w$  magnitudes are either from Kanamori (1977) or have been computed from moment estimates. Tsunami information is from Iida et al (1967). Other references are given in the individual listings.

## TSUNAMIS AT SAN DIEGO

1854-1975

- 1854 July 24. No source is known, but the tidal observer at San Diego noted that on this date, "Water rose & fell nearly a foot in 10 minutes - currents set up also, harbor calm." (Andrew Cassidy, "Miscellaneous Notes on the Tide Gauge & Tidal Observations at San Diego - Cal: 1853-1854". Cassidy Papers, Serra Museum Library, San Diego).
- 1854 December 23. Japan,  $34^\circ$  N,  $138^\circ$  E. Range 0.1 m at San Diego (Bache 1855).
- 1856 August 23. Japan,  $42^\circ$  N,  $141^\circ$  E. Recorded on the coast of California (Joy, 1968).
- 1862 May 27. Earthquake at San Diego caused a small tsunami in San Diego Bay. See text for details.
- 1868 April 2. Hawaii,  $19.3^\circ$  N,  $155.3^\circ$  W (Wood, 1914). Height 0.1 m at San Diego.
- 1868 August 13. Chile,  $18.5^\circ$  S,  $71^\circ$  W. Amplitude 0.8 m at San Diego (Hilgard, 1869).
- 1872 August 23. Davidson (1872) said that on this date a tsunami was recorded at San Diego, San Francisco, and Astoria. He used relative arrival times to infer a source in the northwest Pacific.
- 1906 January 31. Off the coast of Ecuador,  $1^\circ$  N,  $81.5^\circ$  W.  $M_w = 8.8$ . Recorded at San Diego.
- 1917 May 2. Kermadec Islands,  $29^\circ$  S,  $177^\circ$  W.  $M_s = 7.9$ . Recorded on the west coast of the U. S. (Heck, 1947).
- 1917 June 25. Tonga,  $15.5^\circ$  S,  $173^\circ$  W.  $M_s = 8.4$ . Recorded on the west coast of the U. S. (Heck, 1947).
- 1919 April 30. Tonga,  $19^\circ$  S,  $172.5^\circ$  W.  $M_s = 8.2$ . Recorded in California (Heck, 1947).
- 1922 November 10. Central Chile,  $28.5^\circ$  S,  $70^\circ$  W.  $M_w = 8.5$ . Height 0.2 m at San Diego.
- 1923 February 4. East coast of Kamchatka,  $54^\circ$  N,  $161^\circ$  E.  $M_w = 8.3$ . Height 0.2 m at San Diego.
- 1923 April 14. East coast of Kamchatka,  $56.5^\circ$  N,  $162.5^\circ$  E.  $M = 7.2$  (Gutenberg and Richter, 1954). Height 0.1 m at San Diego.

- 1927 November 4. Off Point Arguello, California,  $34.5^{\circ}$  N,  $121^{\circ}$  W.  $M_w = 7.3$  (Hanks *et al.*, 1975). Range 0.006 m at La Jolla (Byerly, 1930<sup>w</sup>).
- 1933 March 2. East of Honshu,  $39.2^{\circ}$  N,  $144.5^{\circ}$  E.  $M_w = 8.4$ . Height less than 0.1 m at La Jolla.
- 1944 December 7. Near Honshu,  $33.7^{\circ}$  N,  $136^{\circ}$  E.  $M_w = 8.1$ . Height 0.1 m at San Diego.
- 1946 April 1. Southern Alaska,  $52.75^{\circ}$  N,  $163.5^{\circ}$  W.  $M_w = 8.4$  (Kanamori, 1972). Range 0.43 m at La Jolla, 0.37 m at San Diego (Green, 1946; Symons and Zetler, 1960).
- 1952 March 4. Hokkaido, Japan,  $42.5^{\circ}$  N,  $143^{\circ}$  E.  $M_w = 8.1$ . Range 0.02 m at La Jolla (Munk, 1953).
- 1952 November 5. Off east coast of Kamchatka,  $52.7^{\circ}$  N,  $159.5^{\circ}$  E.  $M_w = 9.0$ . Range 0.24 m at La Jolla, 0.7 m at San Diego (Zerbe, 1953<sup>w</sup>).
- 1957 March 9. Rat Islands,  $51.3^{\circ}$  N,  $175.8^{\circ}$  W.  $M_w = 9.1$ . Range 0.6 m at La Jolla, 0.45 m at San Diego (Salsman, 1959<sup>w</sup>).
- 1960 May 22. Coast of central Chile,  $39.5^{\circ}$  S,  $74.5^{\circ}$  W.  $M_w = 9.5$ . Range 1 m at La Jolla, 1.5 m at San Diego (Symons and Zetler, 1960; Miller *et al.*, 1962). Some damage to piers and moorings in San Diego Bay.
- 1964 March 27. Southern Alaska,  $61^{\circ}$  N,  $147.8^{\circ}$  W.  $M_w = 9.2$ . Range 0.7 m at La Jolla, 1.1 m at San Diego (Spaeth and Berkman, 1964).
- 1968 May 15. East of Honshu,  $29.9^{\circ}$  N,  $129.4^{\circ}$  E.  $M_w = 8.2$ . Amplitude 0.1 m at La Jolla (Joy, 1968).
- 1975 November 29. Hawaii,  $19.3^{\circ}$  N,  $155^{\circ}$  W.  $M_s = 7.1$ . Amplitude 0.3 m at La Jolla, 0.12 m at San Diego, 0.37 m at Imperial Beach (Spaeth, 1976).

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