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Professor Harry Yeh
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Dear Harry:

One of the subjects for the NSF Tsunami Workshop in Hilo, Hawaii, 26-28 December 2006 is tsunami scour. It would be useful to find out if anyone has data on the scour on a fringing reef during a tsunami drawdown. Or, a combination of drawdown and runup. This is a difficult subject, owing to the need for before and after data in an area normally under water. I haven't been able to find any data on how much scour has occurred, let alone the rate of scour.

Several years ago I did a study of Waikiki Beach, Oahu, Hawaii, which included information on tsunami drawdown at this fringing reef (Wiegel, 2002). The reef is several thousand feet wide, and gently sloping. Before giving information on tsunami drawdown, it should be noted that the sand cover on the fringing reef at Waikiki is not continuous, and is not deep. Sand occurs in patches on the reef flat, and the beach is narrow (e.g., Chave et al., 1973; Wiegel, 2002, pp 74-76). Much of the sand on the beach at present has been brought to the beach from other sources in Hawaii (Wiegel, 2002). This reef, like many others has much algae (Chave, et al., 1973; for information on other reefs with algae, see Vroom, et al., 2006)

On three occasions, during one or more drawdowns of a tsunami, much of the reef, and on one occassion the entire fringing reef at Waikiki was observed to became bare. The tsunamis for which direct observations were made were: 14 August 1868 (?; Harriet N. Deming recalled it in the "late 1860's"), 1 April 1946 (several observers), and 23 May 1960 (at night, several observers, and a flash photo at the Hawaiian Village Hotel catamaran dock). A drawdown likely occurred on another occasion, 7 November 1837 (based on tide observation in Honolulu Harbor). The currents on the reef would have been strong, and much sediment scoured from the reef flat, carried seaward over the reef edge, and lost to the littoral. It is my opinion that this is an important factor in the relatively small amount of sand at Waikiki; but I have no data.

7 November 1837 (source, Chile). Pararas- Carayannis and Calegbaugh, 1977, p. 9) say:

"At 05:00 the water began receding to 2.4 m below normal tide leaving Honolulu Harbor partly dry, then slowly returned. Wave action lasted until the following day."

One must be cautious in extrapolating to the open coast tsunami observations in a harbor, as harbors often have a "signature" owing to their response characteristics. However, it is likely that there was a substantial drawdown on the fringing reef at Waikiki.

14 August 1868 (?) (source, Chile). Deming, as quoted in Kanahele (1995, pp 142-143) says:

"There came a morning when on first looking out to sea we beheld a strange phenomenon. The tide was so low that the bed of the ocean was uncovered all the way out to the reef, with rocks and seaweed glistening in th sunlight, a most untoward sight ...[the] sea came flooding in, rising higher and higher, not stopping at the edge of the beach, but rushing on up the long slope until the waves were lapping at our veranda foundations.....In a few minutes the waters again receded, seemingly sucked up by some force beyond the reef, leaving the ocean bed bare. Three times was this movement repeated, each time a shorter interval occurring between the slipping out of the tide and its return, After the third influx there was no further withdrawal. The water remained knee deep in our yard, and where the beach had been, ominous waves were dashing and hurling themselves higher and higher."

1 April 1946 (source, Aleutian Islands). Shepard, MacDonald and Cox (1950, p. 423) say:

"At Diamond Head the water rose as high as 12 feet but came in very gently. The largest wave there was said to be the fourth...At the eastern end of Waikiki Beach, 1.5 miles northwest of Diamond Head, the water flooded over the seawall and attained a height of about 9 feet. All along the south side of Oahu the reefs were laid bare between waves."

23 May 1960 (source, Chile). A flash photo taken of the bared reef bottom at the catamaran loading pier at the Hawaiian Village Hotel at 2:26 a.m., is in the *Honolulu Star-Bulletin* (23 May 1960), photo by Jack Titchen. USC&GS Chart 4132 (10th Ed., June 3/63) shows a pier and dock, a small basin in the reef at the end of the pier, with a note "being dredged to 5 ft." [Was this the depth at the dock/pier on the date of the tsunami? Chave et al. (1973, their Fig. 11) shows the bathymetry, with a basin up to 10 feet deep, about 7 feet deep at the end of the pier.] In the same issue of the *Honolulu Star-Bulletin* (Anon., 1960, p. 1-E), it was reported that at Kuhio Beach (a part of Waikiki Beach): "Between waves foolhardy persons were able to run out on the reef and pick up fish."

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Sincerely yours

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