SHORELINE MODELING SEGMENTS IN THE HAWAIIAN ISLANDS CRITICAL FOR REGIONAL TSUNAMI EVACUATION DETERMINATIONS

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SUMMARY

Historical data is used to determine those sections of shorelines in the Hawaiian Islands most likely to have the largest runup values for Pacific-wide tsunamis. Accurate modeling of these sections of shorelines are essential for regional evacuation determinations for small tsunamis. Potentially important areas are identified for each of the major Hawaiian Islands. For tsunamis originating in the North Pacific (i.e., the Kamchatka, Aleutian, and Alaska portion of the circum-Pacific arc), the most critical areas appear to be the shorelines around Haena, Kaena Point, Haleiwa, Waimea, Kahakuloa, Kahului, Pololu, Waipio, and Hilo. Other coastal areas having large runups are identified. For tsunamis originating elsewhere along the circum-Pacific arc, more data is needed for a comprehensive determination of critical shoreline areas. However, for tsunamis originating in South America, available runups indicate that Haleiwa, Kahului, and Hilo may have some of the largest values on their respective islands and that some of the largest values on Kauai may be found along its northern and southern shores. For tsunamis originating in the Western Pacific, some of the largest values may be found in the Kailua-Kona area of the Big Island.

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INTRODUCTION

In an earlier paper (Walker, 2004), historical runup data indicated that regional warnings, rather than statewide warnings, would be appropriate for small tsunamis from the Kamchatka, Aleutian, and Alaska portion of the circum-Pacific arc. The historical data indicated that runups on northern shores were generally at least twice as large as runups in many other coastal areas. Thus, if modeling of maximum runups for those northern shores predicted runups of less than 2 meters, runups in many other coastal areas should be less than 1 meter - 1 meter being the generally accepted threshold for a dangerous tsunami. Possible evacuation zones and non-evacuation zones for small tsunamis from the North Pacific were identified for each island. In this report historical data is further examined to determine specifically those sections of shorelines most likely to have maximum runups for tsunamis from the Kamchatka, Aleutian, and Alaska portion of the Pacific Rim, thereby substantially reducing the extent of coastal areas that would have to be modeled for regional warning determinations. Maps showing the historical runup data, on which this report is based, may be found in Walker (2004). In addition, consideration is given to potentially important shoreline areas for tsunamis generated in other portions of the circum-Pacific arc.

ANALYSIS OF HISTORICAL RUNUP DATA

KAUAI

For 1946 the largest values were found in the Haena area (one of 45 feet and three others at or in excess of 30 feet), Kilauea Point (around 45 feet), Moloaa Bay (45 feet), and south of Hanamaulu Bay (40 feet). For 1952 there are no specific reported runup values, but damage was reported along the north shore (Lander and Lockridge, 1989). For 1957 the largest values were in the Haena area (six in excess of 20 feet) with the largest value of 53 feet near Lumahai Beach. For 1964 the largest values are again in the Haena area (one at 6 feet and another reported at less than 10 feet). Based on these data the shoreline section most likely to have the largest runups from the Kamchatka, Aleutian, and Alaska regions is the north shore of Kauai from Kee Beach west of Haena to the western edge of Hanalei Bay. Values for this shoreline section are at least twice the values for the non-evacuation zones identified earlier (Walker, 2004). Also of interest is Moloaa Bay at the northeast corner of the island. This small bay had runups comparable to some of the largest values reported in the Haena area for the '46, '57, and '64 tsunamis. Other areas of possible interest are Kilauea Point and south of Hanamaula Bay.

OAHU

For 1946 the largest values (five in excess of 30 feet) are at or near Kaena Point (four of the five; the largest being 35 feet) and at Makapuu (37 feet; possibly due in part to splash effects on the steep cliffs). For 1952 the largest values are in the Haleiwa area (four of 15 feet or more; the largest being 20 feet). For 1957 the largest values are in the Kaena Point area (three of 22 feet or more; the largest being 30 feet). For 1964 the largest values are in the Haleiwa area (three of 10 feet and one of 15 feet) and at Waimea Bay (16 feet). Based on these data the shoreline sections most likely to have the largest runups from

the Kamchatka, Aleutian, and Alaska regions are the Kaena Point, Haleiwa, and possibly, Waimea Bay areas on Oahu. Values for the Kaena Point and Haleiwa areas are at least twice the values for the non-evacuation zones identified earlier (Walker, 2004). Other areas with large values are Sunset Beach and Kahuku.

MOLOKAI, LANAI, NIIHAU, AND KAHOOLAWE

Although '46 data is available for Molokai (many values), Lanai (two values) and Niihau (one value), specific shoreline sections can not be properly identified because of the absence of sufficient data for the '52, '57, and '64 tsunamis [Walker (2004) and Lander and Lockridge (1989)]. For Molokai, Lanai, Niihau, and Kahoolawe, values for '52 and '64 were not reported; and the only values reported for these islands for '57 are single data points for Molokai and Niihau.

MAUI

For 1946 the largest values are in the Napili Bay to Maliko Bay area (17 values of 20 feet or more; the largest being 33 feet at Kahakuloa). For 1952 there are no specific reported runup values, but damage was reported in the Kahului area. For 1957 the largest values were in the Waihee through Kahului to Maliko Bay areas (15, 16, 16, and 17 feet). For 1964 the largest values were all in the Kahului area (11, 12, and 12 feet). Based on these data the shoreline sections most likely to have the largest runups from the Kamchatka, Aleutian, and Alaska regions are from Napili Bay to Maliko Bay. Modeling only the Kahului area from Waihee to Spreckelsville may be adequate for determining regional warning criteria. With one exception, values for the Kahului area are at least twice the values for the non-evacuation zones identified earlier (Walker, 2004). The exception is for 1957 when values of 9 and 17 feet were found for the Kealia Pond and Waihee areas, respectively. The 17 feet at Waihee is the largest value on Maui for this tsunami and is in the "greater" Kahului area.

HAWAII

For 1946 many of the largest values are in the Hilo Bay area from Honolii Cove to Leleiwi Point (7 values of 28 feet or more). The largest values on the island are at Waipio (40 feet) and Pololu (55 feet). Other large values (30 to 38 feet) can be found along the Hamakua Coast. For 1952 the largest values (11, 11, and 12 feet) are in the Hilo area. For 1957 many large values (3 at 13 feet and 2 at 14 feet) are again in the Hilo area. The largest values on the island are at Waipio (26 feet) and Pololu (32 feet). For 1964 the largest reading (10 feet) was in Hilo Bay. Based on these data the shoreline sections most likely to have the largest runups from the Kamchatka, Aleutian, and Alaska regions are the Hilo Bay, Waipio Valley, and Pololu Valley areas. Modeling only the Hilo Bay area may be adequate for determining regional warning criteria. Values for this shoreline section are at least twice the values for the non-evacuation zones identified earlier (Walker, 2004).

OTHER TSUNAMIS

The 1960 Chilean earthquake produced the only other tsunami with a large number of runup values for the major Hawaiian Islands. [There are no values for 1960 for Molokai, Lanai, Niihau, or Kahoolawe.] Largest values on Kauai are in the Haena to Hanalei area (as large as 13.5 feet) and the Pakala Point to Wahiawa Bay area (as large as 14 feet). Largest values on Oahu are south of Kaena Point (12 feet), Waialua Bay (12 feet), Waimea Bay (11 feet), and north of Makaha (11 feet). Largest values on Maui are 17, 15, 14, 13, and 13 feet in the Waihee to Spreckelsville area. The largest value on the Big Island was 35 feet in the Hilo area. Most of the values for the 1896 and 1933 Sanriku Japan tsunamis are reported on the Big Island with the largest values in the Napoopoo to Keahou areas of the Kona coast (18 feet in 1896 and 10 feet in 1933).

CONCLUSIONS

Shoreline regions with expected highest runups for tsunamis originating in the Kamchatka, Aleutian, and Alaska areas are summarized in Table 1. For Kauai the shoreline area from Kee Beach west of Haena to the western edge of Hanalei Bay may be adequate for determining regional warning criteria for that island. The largest values for this shoreline area have been at least twice the values for the non-evacuation zones identified earlier from Kawelikoa Point through Kekaha Beach Park (Walker, 2004). For Oahu the largest values for the Kaena Point, Haleiwa, and Waimea areas are at least twice the values along the Windward Coast from Chinaman's Hat to Waimanalo, excluding the shorelines of the Marine Corps Air Station, and along the south shore from Hawaii Kai extending just to the west of Ewa Beach (through Oneula Beach), excluding the shoreline around Diamond Head. For Maui the largest values for the Waihee to Spreckelsville areas are, with one slight exception, at least twice the values for the shorelines north of La Perouse Bay (i.e., Makena, Wailea, and Kihei) west through Maalaea and Olowalu, and on to the north of Lahaina (Puunoa Point). The exception is for 1957 when values of 9 and 17 feet were found for the Kealia Pond and Waihee areas, respectively. The largest value for '46 is at Kahakuloa. For the Big Island the largest values for the Hilo Bay area are at least twice the values for areas west of Kaimu along the Puna and Kau coastlines, with the exception of South Point, and up through the Kona and Kohala coasts just past Kawaihae. The largest values for '46 and '57 are at Pololu and Waipio. In the absence of data on Molokai and Lanai for '52, '57, and '64, the '46 data suggests that if regional evacuations were indicated as possible for Kauai, Oahu, and the Big Island in some future tsunami, Molokai shorelines from Waialua through Kaunakakai and Coconut Grove, as well as Lanai shorelines at Kaumalapau Harbor and Manele Bay, could be excluded from evacuations (see Walker, 2004). To examine the resolution of modeling efforts and to compare predicted tsunami wave heights in the ocean to actual adjacent shoreline runup values for tsunamis from the North Pacific, the following additional shoreline areas may be of interest Kilauea Point, Moloaa Bay, and south of Hanamaulu Bay (Kauai); Sunset Beach and Kahuku (Oahu); Napili, Honokohau, and Maliko (Maui); and other sites along the Hamakua Coast (Hawaii). For tsunamis originating elsewhere in the Pacific, shoreline areas of interest in addition to those already cited might be Pakala Point to Wahiawa Bay on Kauai and the Napoopoo to Keahou area of the Big Island.

TABLE 1

Shoreline Regions with the Highest Runups for Tsunamis from the Kamchatka, Aleutian, and Alaska Regions of the Circum-Pacific Arc.

Island*	Largest Runups	Very Large Runups
Kauai	Kee to Hanalei	Kilauea, Moloaa, Hanamaulu
Oahu	Kaena, Haleiwa, Waimea	Sunset Beach, Kahuku
Maui	Kahakuloa, Waihee to Spreckelsville	Napili, Honokohau, Maliko
Hawaii	Pololu, Waipio, Hilo	Hamakua Coast

* Data is insufficient for identifying shorelines on Molokai, Lanai, Niihau, and Kahoolawe

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