reported for the Pohoiki and Opihikao area. Many villages were totally destroyed. At Kawaihae reefs were exposed and as many as 13 waves were observed. At Honolulu a runup of about 2 feet was reported. In 1975 the tsunami was reported to be 1 foot in Kahului, less than 4 inches in Honolulu, and about 4 inches in Nawiliwili. The tsunami struck in a remote area early in the morning around 5 AM. As a result fatalities were far less than they could have been at other locations later in the day.

For the 1868 (1 October) and 1869 tsunamis, there were **no fatalities**, no felt earthquakes, and no distant earthquake that could be found to be responsible for these tsunamis. In the 1868 tsunami, a 20 foot runup was reported for the Opihikao area. In 1869 runups of up to 27 feet were reported along the Puna Coast and waves travelled 1000 feet inland south of Cape Kumukahi. In 1952 a small earthquake generated a 10 foot tsunami that travelled 600 feet inland at Kalapana. Residents did not report that they felt the earthquake and there were **no fatalities**.

**WEST COAST OF THE BIG ISLAND.** Tsunamis reported for the coastal area of the Big Island from South Point to Kawaihae occurred in 1813 or 1814, between 1887 and 1909, in 1901, 1919, and 1951. Of these the most deadly was a tsunami that struck Milolii on a certain date (2 February) but indefinite year (1887 – 1909). The story of this tsunami is preserved in song and oral history. There were an unknown **number of fatalities**. Only a local tsunami could produce such a highly localized wave. There were no reports of a felt earthquake.

For the other tsunamis, runups ranged from 4 to 14 feet at various locations from Hookena to Kailua-Kona. For the 1813 – 1814 tsunami, an earthquake was found on the exact date (21 December) but in 1812. Since the quake was in California, it seems unlikely that the only effects would be at Hookena on the west coast of the Big Island. No felt earthquake was reported and **one fatality** may be partially attributed to the tsunami. There were **no fatalities** or felt earthquakes reported for the 1901, 1919, and 1951 tsunamis. For the 1919 tsunami, lava had flowed into the ocean shortly before the tsunami and Mauna Loa remained active at that time. As many as 10 waves were observed. The 1901 tsunami was thought to have been generated by a large earthquake near Tonga, but no observations were reported in Fiji to the west of Tonga and in Samoa to the north of Tonga. An unfelt underwater landslide off the west coast of the Big Island is more likely.

**EAST COAST OF THE BIG ISLAND.** An earthquake on the Big Island in 1908 generated a 4 foot tsunami in Hilo, and **no fatalities** or other observations were reported.

**MAUI.** In 1860 a tsunami was observed along the north coast of Maui from Kahului to Maliko with 8 to 12 foot runups. Dwellings were removed from their foundations and a building on a wharf was carried inland. The tsunami was also reported as “observed” on Molokai. There were **no reported fatalities** and no reports of a felt earthquake. Suggestions that the tsunami was generated by a distant earthquake would have to explain the absence of any waves elsewhere (e.g., Oahu’s north shore and Hilo). An unfelt underwater landslide is more likely.

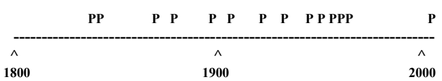
**MOLOKAI.** An ancient chant describes a possible tsunami on the west coast of Molokai just east of Oahu [Lander and Lockridge, 1989, p.23]. “The sun shines brightly at Kalaeloa which sank into the sea. A huge wave came and killed its inhabitants, scattering them and leaving only Papala’au; their cries are all about.” Papala’au can have several meanings: a type of fern, a platter on which to pound poi, a board, floating trees, or floating ferns. There were probably **many fatalities**. A felt earthquake is uncertain.

**OAHU.** Around midnight on 20 January 1878, the ocean unexpectedly washed about 500 feet inland on Oahu’s north shore at a height of about 10 feet relative to normal sea level. A sleeping family in Waialua awoke in a flood of ocean water that soaked them and destroyed part of their house. At around the same time people in Honolulu noticed a sudden increase in the sound of the surf and fisherman noticed an unusually higher than normal tide. On the northern shore of Maui, where the runup was about 12 feet, canoes and houses were destroyed, and taro patches were flooded. There were **no reported fatalities** and no earthquake was felt. If the flooding was the result of a tsunami generated by a distant earthquake, the size of the waves on Oahu and Maui would suggest similar or larger values in Hilo based on historical data. There were no reports of a tsunami in Hilo. A locally generated tsunami from an underwater landslide seems likely.

## TIME LINES

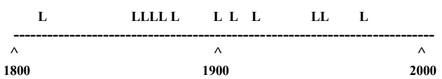
### PACIFIC-WIDE TSUNAMIS

A “**P**” appears for every year in which a Pacific-wide tsunami with wave heights of 10 or more feet was observed in the Hawaiian Islands. Included are all Pacific-wide tsunamis that caused fatalities in the Hawaiian Islands – the last occurring in 1960. The 2011 Japan tsunami has been the only large tsunami since 1964. Large Pacific-wide tsunamis may be “overdue”.




### LOCAL TSUNAMIS

An “**L**” appears for every year in which a locally generated tsunami was observed in the Hawaiian Islands. The last reported local tsunami was in 1975. Local tsunamis may also be “overdue”. Neither the 1500 – 1600 nor the 1887 – 1909 tsunamis are shown.




**SOURCES.** Data for the 1 October 1868 tsunami were taken from Cox and Morgan (1977). Data for the 2011 tsunami can be found on NOAA’s International Tsunami Information Center website – “Hawaii Runup Observations”. All other data were taken from Lander and Lockridge (1989).

Cox, D.C. and J. Morgan, 1977, “Local Tsunamis and Possible Local Tsunamis in Hawaii”, Hawaii Institute of Geophysics, HIG 77-14, 118 pp.

Lander, J.F. and P.A. Lockridge, 1989, “United States Tsunamis 1690 – 1988”, National Geophysical Data Center, Publication 41-2, 265 pp.



**‘Iliki ke kai i ka**
**‘ope‘ope lā, lilo;**
**i lilo no he hawawā.**

**Literal Translation**

**The sea snatches the bundle, it is gone; it goes when one is not watchful.**

**Interpretation**

**A person who fails to watch out often loses. Never turn your back on the sea.**

# TSUNAMI ESSENTIALS

KNOWLEDGE NEEDED TO SAVE YOUR LIFE AND THE LIVES OF OTHERS

**If you are in a low-lying coastal area and you hear a warning siren, ask yourself if it's a test. If it's not, or you don't know, you should try to get information on what is happening. At the same time, begin to move to higher ground or further inland. A tsunami could be headed your way. The amount of time you have could be hours or minutes, depending on where you are and where the tsunami originated. If you feel the ground shake and are in a low-lying coastal area, do not wait for an official warning to evacuate. Regardless of what island you are on, a local tsunami may have been generated nearby. You may not receive a warning in time to save your life. Also know that there may not be any sirens in some remote areas, some sirens might not work, and heavy rain and winds could cancel out siren sounds. The following are additional facts based on historical data. Knowledge of any one of these facts could save your life or the lives of others.**

- **Tsunamis are a series of waves that can wrap around islands, last for many hours, and the first wave may not be the largest.**
- **Reefs and ocean floor can be exposed.**
- **Predicting the wave heights of a tsunami in all shoreline areas is not yet possible. A tsunami could be large in one area and small only a short distance away.**
- **On land tsunamis can travel faster than a person can run.**
- **You might be able to hear a tsunami as it hits reefs or neighboring coastlines with more energy than normal surf.**
- **Debris laden, tsunami generated currents can be more powerful than the currents associated with the largest surfing waves.**
- **Although most local earthquakes and underwater landslides are on or around the Big Island, they can occur closer to other islands.**
- **Local earthquakes and underwater landslides can be responsible for deadly, highly localized or island-wide tsunamis.**
- **For areas closest to the source of a local tsunami, warnings may not be issued in time.**
- **In a local tsunami generated by a small earthquake or underwater landslide, you may not feel shaking.**
- **Pay attention to the ocean and know the signs of a tsunami.**
- **Short memories and wishful unrealistic thinking can end lives. "Let's stay, nothing happened last time."**

## HISTORICAL OBSERVATIONS OF PACIFIC-WIDE TSUNAMIS

Observations for the fourteen Pacific-wide tsunamis with wave heights of 10 feet or more on land in the Hawaiian Islands are given here. All of these large tsunamis were generated in four regions of the Pacific: Chile, Japan, Kamchatka, and the Aleutian/Alaska area. Included in these are all five of the known Pacific-wide tsunamis that caused fatalities in the Hawaiian Islands. Tsunamis from other regions could cause fatalities should sufficiently large earthquakes occur in those areas. Also, it should be noted that tsunami waves of only 3 feet could be extremely dangerous.

**CHILE.** Of the known large tsunamis from Chile (1837, 1868, 1877, 1906, and 1960), the 1960 tsunami had the highest reported runups in the Hawaiian Islands. **["Runup" is the term used for the vertical limit, or wave height, that the water from a tsunami reached on land relative to sea level.]** Runups as high as 35 feet were reported in the Hilo area, 11 feet on Maui in the Kahului area, 13 feet on Oahu's north shore, 3 feet in Honolulu, and 14 feet on Kauai's south shore. On the Big Island, runups of 17 feet were reported at Honuapo and 16 feet at Napoopoo. Some areas of Hilo experienced total devastation. Boulders weighing as much as 22 tons were moved up to 600 feet inland. In Hilo the 3rd wave was the largest. On Lanai the tsunami was reported as "observed". All of the **61 fatalities** in the Hawaiian Islands were in the Hilo area. Some of the fatalities occurred when people went to the shoreline to watch the tsunami's arrival and were unable to outrun the larger, later arriving waves.

Aside from more or less similar observations in 1837, 1868, 1877, and 1906 compared to 1960, additional important observations follow. In the 1837 tsunami, people went looking for fish on the newly drained harbor floor in Kahului. When the wave returned, survivors were carried more than 700 feet inland. In the 1868 tsunami, waves continued to be observed throughout the islands for 3 days. In the 1877 tsunami, runups of 12 feet were observed in Lahaina, and in Hilo Bay the time intervals between waves grew from about 8 to 20 minutes. In the 1906 tsunami, runups of 12 feet were reported at Maalaea on Maui. All of the above additional observations may have been available to a greater or lesser extent for all of the large Chilean tsunamis. Some are available, but measurements do not exist for all locations for all of the large tsunamis from Chile. For the 1837 tsunami, **14 fatalities** were reported for Hilo and **2 fatalities** for Kahului. For the 1877 tsunami, **5 fatalities** were reported for Hilo. In the Hawaiian Islands there were **no fatalities** reported for the 1868 and 1906 tsunamis. Travel times from Chile to the main Hawaiian Islands ranged from about 14 to 15 hours.

**JAPAN.** Of the known large tsunamis from Japan (1896, 1933, and 2011), the 2011 tsunami had the highest reported runups. Measurements as high as 17 feet were reported on the north shores of Kauai and Oahu, 7 feet on Maui near Kahului, 17 feet on the Big Island at Kealakekua, and 7 feet in Hilo. There was damage to several harbors due to powerful currents.

Aside from more or less similar observations in 1896 and 1933 compared to 2011, additional important observations follow. In 1896 there were exposures of the seafloor on Kauai at Kapaa and Nawiliwili. In Honolulu where runups of about 2 feet were observed, many fish were stranded in Nuuanu Stream. On Maui runups of about 4 feet were observed at Kaanapali, and runups of about 12 feet were reported at Punaluu and Honuapo on the Big Island. In 1933 runups of 11 feet were reported near South Point on the Big Island. Values between 1 and 2 feet were reported for Honolulu and Lahaina. At Kailua-Kona the tenth wave was the largest, and the seafloor was exposed. All of the above additional observations may have been available to a greater or lesser extent for all of the large Japan tsunamis. Some are available, but measurements do not exist for all locations for all of the large Japan tsunamis. There were **no fatalities** reported in the Hawaiian Islands for any of the Japan tsunamis. Travel times from Japan to the main Hawaiian Islands were about 8 hours.

**KAMCHATKA.** Of the known large tsunamis from Kamchatka (1841, 1923, and 1952), the 1923 tsunami had the highest reported runups in the Hawaiian Islands. Runups as high as 3 feet were reported in Honolulu, 12 feet in Haleiwa, 11 feet in Kahului, and 20 feet in Hilo. In Honolulu reefs were exposed and waves continued arriving for several hours. The time between the waves was from 15 to 20 minutes. In Kahului the ocean floor was exposed. In Hilo **one fatality** was reported.

Aside from more or less similar observations in 1841 and 1952 compared to 1923, additional important observations follow. In 1841 parts of Honolulu Harbor were drained dry. In Lahaina the tsunami could be heard as it rolled across the reef. In 1952 damage was reported at Midway Island. On Oahu runups of 17 feet were reported for Waialua and 30 feet on the north shore at Kaena Point. All of the above additional observations may have been available to a greater or lesser extent for all of the large Kamchatka tsunamis. Some are available, but measurements do not exist for all locations for all of the large Kamchatka tsunamis. There were **no fatalities** reported in the Hawaiian Islands for the 1841 and 1952 tsunamis. Travel times from Kamchatka to the main Hawaiian Islands were about 6 to 7 hours.

**ALEUTIANS/ALASKA.** Of the known large tsunamis from this region (1946, 1957, and 1964), the tsunami of 1946 is the most devastating of any known tsunami to ever strike the Hawaiian Islands. Runups as high as 9 feet were reported for Waikiki, 11 feet for Haleiwa, 14 feet for Waianae, and 27 feet for Kahuku. Runups were as high as 7 feet at Lahaina, 28 feet at Kahului, and 30 feet at Hana Bay. In Hilo the 3rd wave was the largest at 27 feet and there were extensive exposures of the sea floor. Largest runups were 45 feet at Haena on Kauai, 36 feet at Makapuu on Oahu, 54 feet at Waikolu Valley on Molokai, 33 feet at Kahakuloa on Maui, and about 40 feet in the valleys of Pololu and Waipio on the Big Island. On Kauai's north shore, waves washed nearly 1600 feet inland and corals as large as 12 feet in diameter washed about 500 feet inland. A 20 foot runup was reported on Niihau. In Hilo parts of a steel railroad bridge were washed about 900 feet upstream at the Wailuku River. Additional descriptions of damage in the Hilo area are given by Lander and Lockridge (1989, p. 42). "Houses were overturned, railroads ripped from their roadbeds, coastal highways buried, and beaches washed away. The waters off the island were dotted with floating houses, debris, and people." This destruction was repeated throughout the islands. A total of **159 fatalities** were reported in the Hawaiian Islands. Most were on the Big Island but deaths also occurred on Maui, Oahu, and Kauai.

Aside from generally similar but smaller observations in 1957 and 1964 compared to 1946, additional important observations follow. In the 1957 tsunami, runups of 5 feet were reported at Waikiki, 23 feet at Kahuku, and 17 feet at Haleiwa. Nawiliwili Harbor on Kauai was alternately drained and filled. In the 1964 tsunami, the largest reported runup was 16 feet on Oahu at Waimea Bay. All of the above additional observations may have been available to a greater or lesser extent for all of the large Aleutian/Alaska tsunamis. Some are available but do not exist for all locations for all of the large Aleutian/Alaska tsunamis. There were **no fatalities** reported in the Hawaiian Islands for the 1957 and 1964 tsunamis. Travel times for the Aleutian and Alaska tsunamis to the main Hawaiian Islands were about 5 to 6 hours.

## HISTORICAL OBSERVATIONS OF LOCALLY GENERATED TSUNAMIS

A total of fourteen confirmed or suspected local tsunamis have been reported in the Hawaiian Islands. Using a variety of pre-1813 sources, as well as local newspapers dating back to 1839 that commonly reported felt earthquakes, Cox and Morgan (1977) found that only four local tsunamis could be associated with felt earthquakes. Fatalities occurred in five of the fourteen tsunamis. Most of the fourteen were observed along the coastal areas of the Big Island. However, suspected local tsunamis were also found on Maui, Molokai, and Oahu. Probable causes of local tsunamis may be small unfelt earthquakes or underwater landslides of loose volcanic debris. **Locally generated tsunamis may pose a greater danger in terms of injuries and deaths than Pacific-wide tsunamis**. Reasons are the short time interval between the issuance of a warning and a local tsunami striking nearby coastal areas, and the fact that warnings may not even be issued in time for coastal areas nearest to the source location of the local tsunami. **As with any future tsunami, destructive potential will be greater than in the past because of growth and development, especially with increasing use of the ocean and shoreline areas.**

**SOUTHEAST COAST OF THE BIG ISLAND.** Tsunamis reported for the coastal area from Cape Kumukahi to South Point occurred in 1868 (two), 1869, 1952, and 1975. Of these the largest were in 1868 (3 April) and 1975. These tsunamis were triggered by the largest earthquakes ever reported for the Hawaiian Islands. There were **47 tsunami fatalities** in 1868 and **2 fatalities** in 1975. Both had similar runup patterns and values. Runups as high as 46 feet were reported near Halape with double digit runups extending from Cape Kumukahi to Kailua-Kona. Runups of 9 feet were reported in Hilo and the tsunami was reported as "observed" in Lahaina. In 1868 runups of 17 feet were