

**VOLCANIC ACTIVITY, TIDAL WAVES, AND  
OTHER MARINE DISTURBANCES IN HAWAII,  
SEPTEMBER - DECEMBER 1903**

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## ABSTRACT

Local contemporary documents indicate that a number of unusual and even peculiar geophysical events occurred in Hawaii during the last four months of 1903, some of which seem not to have been noted in recent geophysical literature.

The reported evidences of the unusual phenomena and conclusions as to their nature may be summarized as follows:

Date	Evidence	Conclusions
Sep 1	Flow over Mauna Loa seen from Haleakala.	Probable brief summit eruption of Mauna Loa.
Sep 3	Flashes of light from Mauna Loa direction seen from Kaieiewaho Channel.	Possible continuance or brief resumption of Mauna Loa activity.
Sep 28	Waterspout at Punaluu, Kau, Hawaii.	Possible waterspout.
Oct 5	Unusually high tide and waves at Punaluu, Kau, Hawaii.	Probably no unusual phenomena.
Oct 5	Waterspout at Punaluu, Kau, Hawaii.	Event of Sep 28 misdated.
Oct 5 to 6	Rotary currents (and unusual waves) off-shore west or southwest of Hawaii.	Unusually strong eddies in the wake of Hawaii.
Oct 6 to Dec 11	Glow over Mauna Loa seen from distance; and fire fountains and lava flows and lakes in Mokuaweoweo seen from rim.	Mauna Loa eruption, continuing 63½ days. Major vents and flows probably confined to Mokuaweoweo although an outbreak possibly occurred high on south rift.
Oct 8 to 9	Evidence at Punaluu, Kau, and at Hilo, Hawaii, identical to those there reported on Oct 10 to 11.	Punaluu event of Oct 10 to 11 misdated.
Oct 10 to 11	Rotary currents (and unusual waves) south-east of Kahoolawe.	Possible unusually strong eddies.
Oct 10 to 11	Unusually low sea level at Punaluu, Kau, Hawaii followed in a "rush" by an unusually high tide.	Probably no very unusual phenomena.
Oct 10 to 11	Effects at Hilo similar to those at Punaluu.	Probably no unusual phenomena.
Nov 17	Unusual waves at Punaluu, Kau, Hawaii, with sudden onset and brief duration, sufficient to capsize boat.	Disturbance possibly related to exceptional swell from northwest observed in Kaieiewaho Channel; not a storm surge or tsunami.
Nov 24	Evidences at Punaluu identical to those reported on Nov 17.	Punaluu event of Nov 17 misdated.
Nov 25 to Jan 10 (1904)	Five fountains, lava flows and lava lake, Halemaumau.	Summit eruption of Kilauea, probably continuing 47 days, its vent and flows being confined to Halemaumau.
Nov 27 to 30	Unusual swells, without wind, on northwest, north, and northeast coasts of Hawaii, Maui, Oahu, and Kauai.	Unusual swells from a storm in the north or northwest Pacific.
Nov 29	Tidal wave at Honokohau, Maui, and at Halawa, Pelekunu, and Kalaupapa, Molokai.	Probably exceptional swells of the series continuing Nov 27 to 30, but possibly a tsunami, most likely one of distant origin.
Dec 14 to 19	Unusual waves on southeast, south and southwest coasts of Hawaii and Maui, destroying a wharf at Keawakapu, Maui on Dec 19; capsizing a boat at Makena, Maui, on Dec 18; and destroying a wharf at Keawakapu, Maui, and causing damage at Hookena, Hawaii on Dec 19.	Unusual storm waves, not a tsunami or storm surge.

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## INTRODUCTION

A number of geophysical events were reported as occurring in Hawaii during the last four months of 1903, including some that, from available accounts, seem to represent occurrences of unusual and even peculiar phenomena.

A summit eruption of Mauna Loa volcano, Hawaii, lasting from early October to early November 1903, is recorded in the geological literature (e.g. Stearns and Macdonald, 1946; Macdonald and Abbott, 1970). Reports in Honolulu newspapers suggest that there may also have been a brief Mauna Loa summit eruption in early September, and that there was an eruption of Kilauea in Halemaumau beginning in December and continuing into January 1904. During October and November a number of unusual marine disturbances were reported along various Hawaiian coasts, including a tidal wave that was reported to have inundated the north coasts of Maui and Molokai, the northeast coast of Hawaii, and some coast of Oahu on 29 November, and a disturbance that was identified as a small tidal wave that affected places on the west coast of Hawaii and the south coast of Maui on 19 December.

The reports of several of the marine disturbances were reviewed in some detail by Cox and Morgan (1977). Recently, however, copies of Honolulu marigrams, for 1903 have become available, including one that shows the disturbance recorded at the time of the November "tidal wave." The further review whose results are presented in this report was initiated to combine the marigraphic evidence with that previously available concerning the occurrence and nature of the reported tidal wave. Evident confusions among the reports, which had been noted by Cox and Morgan, led to an extension of the review, initially intended simply to assure that any changes in the interpretation of the reported tidal wave resulting from the marigraphic evidence did not affect earlier conclusions as to the relationships among the events more generally. However, additional evidence concerning the other events covered in the Cox and Morgan report came to light as the review proceeded, and, more or less accidentally, evidence suggesting the occurrences of the brief Mauna Loa eruption a month before that recorded in the geophysical literature and of the December "tidal wave". The details of the evidence of the various reported geophysical events, and even details of conclusions as to their nature, will probably not be of widespread interest. However, because of the evident confusions among the reports and the speculative nature of any conclusions drawn from them, it has seemed best to make the evidence and the analysis based on it a matter of record for future reference.

Although some of the original sources of information on the marine disturbances of the period were quoted by Cox and Morgan, their quotations are repeated and in some cases extended in this report, and several additional sources of information are quoted, so that readers will have conveniently available all of the now known evidences of the marine disturbances as they were originally reported. Quotations are also supplied from the sources of information on the possible Mauna Loa summit eruption of September 1903, and references are given to the original sources of information on the eruption of October to December that is already recorded in the geophysical literature.

In this report the term tidal wave will be used in its commonly used sense as including storm surges and tsunamis — waves or trains of wave that, like the astronomic tides may rise gradually against a coast or may convert to bores. It will be used also, in quotes, for phenomena reported as tidal waves.



## ORIGINAL ACCOUNTS

### Introduction

The original published accounts of the Hawaiian geophysical events of the last third of 1903 consist in all cases, so far as I know, of those in articles in Hilo and Honolulu newspapers. The newspapers and places and schedules of their publication are listed in Appendix A. For convenience, the newspaper titles and of months of publication will be abbreviated in citing issues of the newspapers in this report; and, for issues in 1903, the year will be omitted. In general, errors in grammar and spelling in the newspaper accounts will be copied without special notice in the quotations included in the report.

Some reports of the volcanic activity of the period have been preserved in the Volcano House register which has been transferred for safekeeping to the Kilauea Volcano Visitor Center of Hawaii Volcanoes National Park. Most of these relate to details of the activity of Kilauea, but some were reports of parties that had returned from the summit of Mauna Loa while it was active, and two of these were accompanied by sketches. Reference will be made to the latter in connection with the newspaper accounts of the observations of the parties.

### Possible Mauna Loa summit eruption, September

In early August 1903, there were rumors of a Mauna Loa eruption based on reports from Keaau that steam had been seen rising from the volcano (Herald, 6 August). The rumors were soon discounted. However, evidences of activity reported in early September are less easily discounted.

The first published notices suggesting a Mauna Loa summit eruption in early September were ones in the Star (4 Sep) and Bulletin (4 Sep) that were based on observations from the inter-island steamer "Iwalani", which was in the Kaieiewaho Channel between Kauai and Oahu late at night on 3 September. The Star reported:

According to the statements of Captain Mosher, the Iwalani was coming from Kauai last night to Honolulu. When about 45 or 50 miles this side of Nawiliwili, he saw at ten minutes past 10 o'clock, a sudden flash in the skies directly ahead. The flash mounted high in the heavens and the light lasted about five to eight minutes. Ten minutes later a second flash of light was seen from the same spot, and ten minute after a third flash was seen. The durations of all the flashes was from five to eight minutes.

According to both newspapers, Mosher and the other ship officers thought the first flash was from a cane fire on Oahu, but on checking after the occurrence of the second they found the flashes came from the direction of Mauna Loa rather than any point on Oahu. When they arrived at Honolulu, they were surprised that there was no news of a Mauna Loa eruption. The Star indicated that the lack of news of an eruption was not surprising because the purser of the steamer "Mauna Loa", which had been at Punaluu on the southeast coast of Hawaii the previous week, had reported smoke so heavy in that vicinity that the mountain could not be seen. However, the Advertiser (5 Sep) reported that residents at Pearl Harbor had seen similar flashes looking westward and considered them reflections from trash fires at Waianae.

In its next two issues, the Star carried brief articles indicating unawareness of any eruption on the island of Hawaii, based respectively on interviews with the purser of the "Kinau", which had been at Hilo on 3 September (Star, 5 Sep), and with someone from the "Helene", which had been at Kawaihae, probably on 6 September (Star, 7 Sep). However, a further report of evidences of an eruption was carried in the second issue of the Star, that of the Advertiser on the same day (7 Sep), and that of the Gazette on 8 September. These evidences, which had been observed from Maui two days earlier than those reported from the Kaieiewaho Channel, were called to the attention of the newspapers by the observer, C.J. Austin, when he arrived in Honolulu. Austin was quoted as follows:

"On Tuesday evening, September 1, I was at the top of Haleakala with a young fellow named Hansted. We had climbed to the summit from the cave below, about seven in the evening, when Hansted noticed a bright light in the direction of Mokuaweoweo. He called my attention to it and asked what it was. I saw that the volcano undoubtedly was in action. The light became brighter and



dimmer at times. I had seen Mokuaweoweo in action in 1887 and the outbreak of 4 years ago, but last Tuesday was the grandest sight of all. There was not a flow of lava or anything of that kind, but a reflection from the flames in the crater, which was carried upon the smoke arising from it. We could see over the clouds and the top of Mauna Kea and also the dome of Mauna Loa.

"When we first saw the light it was very dim but got brighter as we watched it. We got to the top of Haleakala about seven o'clock in the evening and remained there watching the eruption until nine o'clock. Then it became so cold that we had to quit and we went down again to our cave on the other side of the mountain.

"It certainly was a beautiful sight, a solid wall of light extending two hundred feet or more into the air, and about one hundred feet wide. It was not a flame, but the reflection upon the clouds of smoke that we saw. Columns of smoke were visible. The light would get brighter and brighter, and at times would foam up into flashes, like a flaming fountain. The light was plainly not from Kilauea. The smaller crater was visible just below Mauna Loa. We stayed watching the sight as long as we could stand it, then it got so cold that we went to the cave two hundred yards down the opposite side of the mountain.

"The next morning we climbed to the summit again, hoping to get another glimpse of the volcano. It was too foggy and cloudy to see anything though. We stayed there until daylight, but could not see through the fog and clouds.

"I should have thought that the smoke and flames could have been seen from the Volcano House, though possibly it may have been foggy. There is not the least doubt in my mind, but what Mokuaweoweo was in eruption at least on Tuesday night."

The Star considered that Austin's observation "would seem to be confirmatory of the report of an outbreak of Mokuaweoweo", the Mauna Loa summit caldera. Telegraphic inquiries resulted in no reports that the volcanic activity had been seen on the island of Hawaii, but it was recognized that: "Mr. Austin is not given to fanciful reports. He was 10,000 feet up, and his view to Mauna Loa, 13,000 feet high, was unobstructed."

No further evidences of the possible eruption were reported. Officers of the "Mauna Loa", which apparently made trips to Lahaina and Maalaea on Maui and to ports on the Kona and Kau coasts of Hawaii at intervals of about 10 days, reported that, after a trip when the ship was at Punaluu on 4 September there was no evidence of the eruption there and no news of it in Kau and Kona (Star, 8 Sep), and, after the next trip, that the weather had been very clear with no signs of smoke from the volcano (Star, 18 Sep).

#### Mauna Loa activity and marine disturbances, early October

The Mauna Loa summit eruption of October to December 1903 commenced early in the afternoon on Tuesday, 6 October. According to the Herald (8 Oct):

Shortly after noon on Tuesday Manager Bidgood of the Kilauea Volcano House telephoned the HERALD office that an immense volume of smoke was issuing from the big crater at the top of Mauna Loa.

The day was perfectly clear at Kilauea and the smoke and steam was plainly visible from the verandas at Kilauea. Attaches of the hotel who have been in that vicinity for years say they never before saw so much smoke coming from the upper crater.

...The present outbreak is apparently in the old crater of Mokuaweoweo...

During Tuesday night the glow over the crater was tremendous in area indicating one of the most extensive eruptions the crater of Mokuaweoweo has experienced in many years.

From Punaluu the sight is one of the magnificent grandeur. Robert Forrest who is in charge of the Inter-Island landing there, reports the fire as large and says the glow extends for some distance toward Kona and he is under the impression that there is a lava flow, probably a-a, from the crater, or from a point near it, going slowly towards Kona. This will be determined when the first prospecting party reaches the summit.

Manager Bidgood telephoned again Wednesday morning that fire is plainly seen from his hotel and that on Tuesday night there seemed to be four places where the fire was strongest and with the reflection on the smoke and steam high in the heavens they gave the appearance of four enormous columns of fire. Kilauea shows no unusual activity.

Perhaps because the Herald had already reported on the eruption the previous day and no further news on it was available, the Tribune issue of 9 October did not mention it.

According to a report from the Hilo representative of the Wilder Steamship Co., the Mauna Loa eruptions had begun at 12:45 (Star, 8 Oct; Advertiser, 9 Oct). The report was sent to Honolulu via the "Helene", which had been on the Hamakua (northeast) coast of Hawaii and was on its way to Kawaihae on the west coast at the time. Those on the "Helene" saw the glow of the eruption when the ship reached Kawaihae at 18:00. No evidences of Mauna Loa activity had been seen from the "Iwalani", which had been on the Kau coast on the 3rd and 4th of October and returned to Honolulu, presumably by the way of Kona, on the 6th. However, evidences were seen from the bark "Ormsery", which was sailing along the Kona coast on its way to Honolulu on the 6th. (The spelling is that used in most reports; the Star and Herald used "Ormsary"; Wood (1904) used "Omesery").

The "Ormsery" carried to Honolulu, not only the first news of the eruption, but also news of most peculiar marine disturbance observed offshore that was published in all three Honolulu newspapers in slightly different versions. The Bulletin (7 Oct) quoted the ship's captain, Coath:

"At 8 o'clock Monday evening as my vessel was off the coast of Hawaii we had a most unique experience. The sea gradually became very much disturbed and whirling currents set in. They twirled around first to one side and then to another, and raced in all quarters of the compass like mad storms. Sometimes such a whirlpool would suddenly reverse and start racing back in just the opposite direction to that in which it had previously been running.

"The waves at times broke over the vessel which was rendered absolutely unmanageable. She would not answer her wheel and could not make any headway whatever in the tumultuous currents. She remained almost stationary and acted exactly as if she were anchored.

"Once previously I had a somewhat similar experience south of the Equator. That time the disturbance was due to volcanic action. When I saw the volcanic outbreak on Hawaii the next day, no doubt was left in my mind that the strange action of the sea was due to some submarine volcanic disturbance which acted as a forerunner.

"The outbreak of the volcano we saw the next day between 12 m. and 1 p.m. The first thing visible was a great column of smoke which shot up suddenly from a point, which I judged must have been near the crater of Kilauea.

"The smoke arose from a point in the side of the hill below the summit. The dense smoke shot up with great rapidity as if impelled by some most tremendous force. It then spread out to the sides and as new smoke continually kept shooting up a dense cloud kept gathering.

"During the day we could not see flame, but towards dusk a large sheet of flame, spreading about a mile could be plainly seen. The fire did not die down, but after we had been watching it for about two hours and a half we lost sight of it, as the atmosphere became very clouded by a mixture of smoke and clouds. We did not see any ashes and anything of that kind would be carried aft of us."

Captain Coath in his log book has the following accurate details of the event:

"Monday, Oct. 5 - A.M. strong trades and cloudy. Squally weather, sea decreasing. Full sail set. P.M. cloudy weather, brisk breeze, wind east by north. Sea getting more smooth. At 8 hours, calm with whirling current setting in every direction like whirlpools and races. At times a fine breeze from southwest, but the ship was entirely ungovernable and remained so all the night through.

"Tuesday, Oct. 6 A.M., same calm weather and whirling currents. Island of Hawaii east by north. Current running in whirlpools, swinging the ship around and making her ungovernable, setting eastward direction. Noon, Lat. 19.34° N. Long. 156.42° W. - P.M. fresh gale, increasing rapidly. Shortened sail at 4 hours. Much smoke ascended from a volcano on Hawaii which at sunset showed a volume of flame spreading fully one mile in breadth. Bearing east-southeast (true) about seventy or eighty miles showed a fine spectacle."

J. Brydson, one of the sailors, who was at the wheel at the time the outbreak was first observed stated as follows: "I was steering between 12 m. and 1 p.m. yesterday when suddenly I saw a dense volume of smoke shoot high up in the air. The smoke came from a point away inland very near the summit of the mountain, it seemed. The smoke shot up with a tremendous force. Then it spread mushroom shape and kept rolling towards the side as fresh smoke kept on coming from the middle.

"During the daytime we could see some fire but in the evening when the darkness made the fire more easy to distinguish, we could see a great sheet of flame, which was a grand sight."

Brydson's statement was corroborated by several other sailors who stood near him while he told his story to a reporter.

According to the Star (7 Oct).

A large eruption of one of the summit craters of Mauna Loa is described by Captain Coath. First Mate Carter and others of the British ship Ormsary, which arrived this morning from Newcastle and passed Hawaii on the west side yesterday and last night. All descriptions agree that there was an eruption of great brilliance last night and the mate says it was preceded by some unusual ocean disturbances.

According to the mate's story the eruption must have begun at about noon yesterday. "The mountain was perfectly clear," he said, "when we went in to dinner at about 12:30. An hour later there were columns of smoke on the summit. We could see them quite plainly. There was no fire at that time, but there were discolorations of the smoke as if from fire below. We were probably fifty or sixty miles away."

On the evening previous the ship encountered some unusual disturbances which indicate a subterranean upheaval. There was a dead calm and the vessel was suddenly found to be drifting hard astern. She was quite helpless for a time. The vessel appeared to be in a sort of maelstrom. The sea was boiling and swelling and all hands noticed unusual heat.

When evening came yesterday the smoke on Mauna Loa became brighter. The smoke column is estimated by Carter to have been about three-quarters of a mile wide and two miles high. As the mountain was clear, the officers and crew of the vessel are all quite positive that it was an eruption.

"We saw it suddenly come out white hot, on the lower slope," said the mate. "We didn't lose sight of it at all. We could see white hot lava running down and fire shooting up into the dense column of smoke. The lava and fire was visible when we were eighty or ninety miles away."

The Advertiser (8 Oct) version of the account was as follows:

As the British ship ORMSERY approached the west side of the island of Hawaii Monday night she found the sea agitated as if by great springs boiling up from below. Unusual heat prevailed. For a little time the ship was forced astern as if by the impact of a tidal wave starting from the coast. Before long the sea became quiet again and nothing more of an extraordinary nature happened until the early afternoon of Tuesday when high land being in sight, one of the ships officers, taking the sun, noticed a column of smoke rising from the summit of Mauna Loa, about 14,000 feet above the sea. The column was an imposing one. First mate Carter thought it to be two miles high and three quarters of a mile wide.

After awhile a white hot spot appeared below the summit and lava began running down the mountainside. By this time the smoke had begun to show streaks of fire. This spectacle was on view while the ship was at a great distance from shore.

Additional reports of evidences of the eruption, all seen from a distance, were brought to Honolulu on October by the "Mauna Loa" (Star, 9 Oct; Bulletin, 9 Oct; Advertiser, 10 Oct), and the Star reported that:

Like the officers on the ship Ormsary, the officers of the Mauna Loa observed a peculiar action of the sea preceding the eruption. On Monday morning [5 Oct] the steamer reached Punaluu on the Kau coast of Hawaii, within plain view of the top of Mauna Loa. A very very high tide was running at the time and with a rough and heavy sea. The tide was unusually high and the sea was running in a peculiar way. There were great big rollers chopped up and irregular in form, rushing in from the eastward. This condition of the water was very remarkable at Punaluu and Captain Simerson and his officers remarked about it. Ordinarily the sea runs from the northeast.

The Tribune (9 Oct) also reported an unusual event at Punaluu:

W.P. Fennell of Punaluu has been seeing things. The latest thing he claims to have seen was a waterspout. He said that the waterspout was rushing along the sea off Punaluu on last Monday. The waterspout was a very big one. Some of the officers of the steamer Mauna Loa, which brought the news here today, were unkind enough to insinuate that Fennell was a bigger one . . .

The Monday before the publication of that issue of the Tribune would have been 5 October. However, the Tribune must have held the story a week without altering it. Fennell's report of the waterspout had been carried by the "Mauna Loa" to Honolulu where it was published in the Bulletin on 29 September. Hence the date of the waterspout, if there was one, was probably 28 September.

As usual, the newspapers carried accounts of not only of geophysical phenomena occurring at the time of the volcanic eruption but of what were thought to be precursors of the eruption.

Schools of the red fish alalauwa (young aweoweo: Pukui and Elbert, 1957) had appeared in Honolulu Harbor about a week before the possible September eruption (Star, 5 Sep). The appearance of these fish was traditionally supposed to foretell a death in the royal family of Hawaii or a significant change in the government. It was said that the fish left the harbor on the day of or the day preceding the outbreak, leading to the supposition that volcanic activity also could be foretold from the behavior of the alauwa (Star, 9 Oct 1903). Red fish of a different species were later said to have been forced from underwater caverns by the eruption making them easier to catch along the Kau and Kona coasts of Hawaii (Star, 19 Oct).

One actual prediction of the eruption was reported (ex post facto). There had been an eclipse of the moon early on the morning of the 5th. As seen from the "Mauna Loa", which was en route to Punaluu, that was accompanied by a lunar rainbow, a circle around the moon, and a brilliant meteorite; and one of the boatboys "at once declared that there would be an outbreak of the volcano" (Star, 9 Oct).

No significant earthquakes seem to have occurred at the time the eruption began. A "short but heavy shock" occurring two days later was felt in Kau, but not in Kona (Herald, 15 Oct).

Still more observations of the eruption, all from the lower parts of Hawaii or offshore, were reported in the newspapers during the week after the outbreak. Several observations of lava flows were reported, including an observation supposedly made by two persons sent from Kailua-Kona to the top of the mountain for the purpose of investigating the outbreak (Herald, 8 Oct). In most cases the flows were thought to be advancing down the mountain in some direction other than toward the observers. A few reports, however, related to flows thought to be advancing toward the observers, for example one in an extract from a letter from E.D. Baldwin, a surveyor, to F.S. Dodge, published in the Star (10 Oct):

"Mauna Loa is in eruption again and a flow is in progress from a point near the top amongst the small cones on the Kahuku side. We saw the glow, and lava flow clearly last night from our house (at Puneo) for the first time."

The Star (10 Oct) added to the report that the cowboys of Kahuku Ranch on the south side of the mountain rode down the mountain to escape a flow they thought was advancing on them. On Tuesday, 13 October, a "heavy earthquake shock" was reported at Honuapo (Advertiser, 16 Oct).

It was a week before a party actually reached the Mauna Loa summit area. This party, climbing from Kapapala Ranch, reached the rim of Mokuaweoweo early Tuesday afternoon, 13 October, spent the night there, and left the next morning. A brief account of the observations of the party was telephoned to Hilo when they reached Kapapala on 14 October (Herald, 15 Oct, which misprinted the account date as 12 October).

The lava, on the floor of the crater, is about a half mile long, but they were unable to estimate the width. Twenty-five fountains were playing continually, the highest extending from the floor to several feet above the bank which is four hundred feet high. The lowest cannot be less than two hundred feet in height.

The most extensive description of the scene was published by the Bulletin (17 Oct) on the basis of an interview with an unidentified member of the party:

We tethered our horses to stones near the yawning depths of Mokuaweoweo. We looked down upon a waste of burnt rock. Forbidding and deserted would have been the scene but for the display of Madame Pele at our feet. We sat on the rim of a giant crater. In its bottom, one thousand feet below, was a smaller crater two thousand feet across. Molten lava, white with heat and flowing as the tide, welled up and illuminated the caverns of Mokuaweoweo. From the lake of fire twenty or thirty great fiery arms reached upward a distance of three hundred to eight hundred feet. These great geysers of illuminating fluid cast their glare of light on walls of lava on clouds and upon the bleak black plateau which is the summit of Mauna Loa . . .

...In the bed of this great amphitheater is a smaller crater of living liquid fire, Mokuaweoweo covering an area of something like 300 acres. From its surface the giant geysers of fire shoot upwards from 200 to 600 feet. The play of these fountains is unintermittent.

The Volcano House register contains a sketch view of Mokuaweoweo signed by T.C. Ridgway (Figure 1), and a sketch map of the caldera initialled by him (Figure 2). Both seem to have been transferred to the record book from original pencil sketches made by him at the summit, the shading of the view suggesting it was sketched on the morning of 14 October. Engravings apparently made from the same original sketch were published in the Herald on 22 October, together with the results of an interview with Ridgway and the description in the Bulletin that, Ridgway commented, was the best he had read.

In another report of the party's observations, derived second-hand through Captain Mosher of the "Iwalani" (Star, 16 Oct), there were only three places of major fire fountaining although lava was spouting or bubbling up from 12 or 13 smaller holes. From the central and most active fountain a flow 200 to 400 feet wide was spreading toward the most easterly fountain a couple of miles away. Although in the account relayed by Mosher, the lava had not covered the floor of the caldera, the party estimated that it "had filled up to within 500 feet of the top".

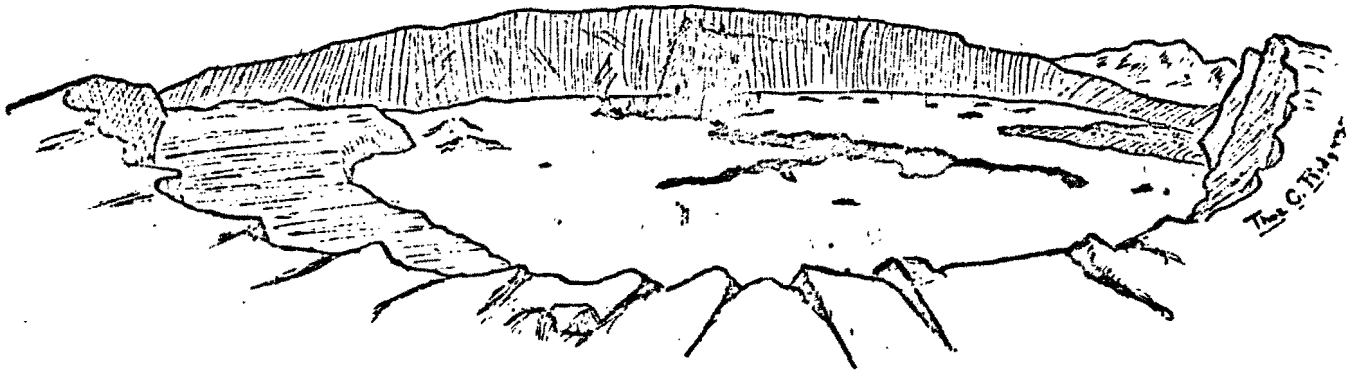


Figure 1. Mokuaweoweo on 13 or 14 October 1903.  
 Sketch from southeast rim by T. C. Ridgway,  
 probably on the morning of the 14th.  
 From Volcano House register.

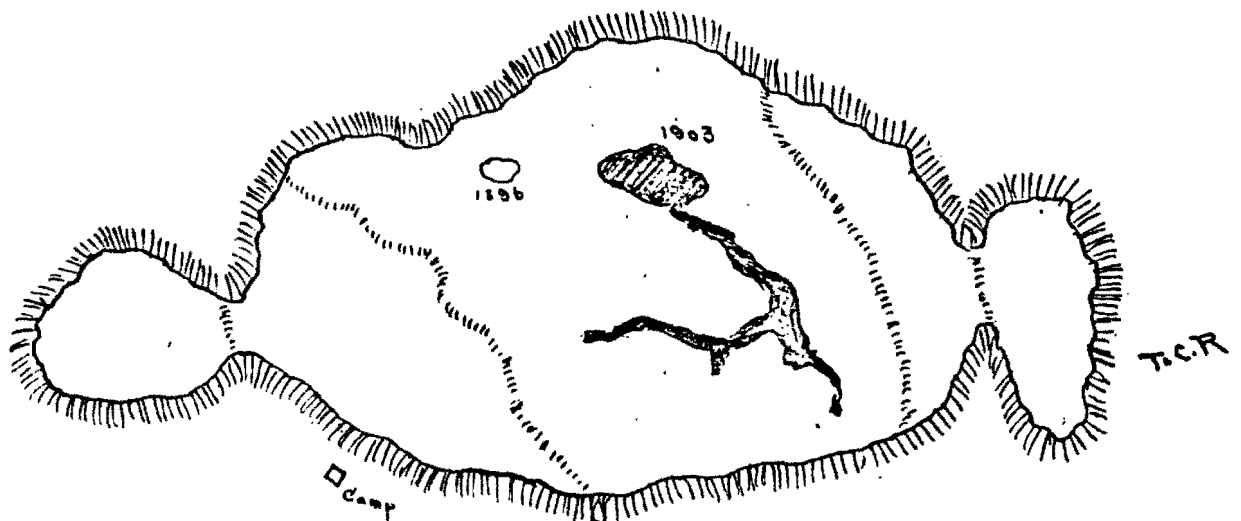


Figure 2. Mokuaweoweo on 13 or 14 October 1903.  
 Sketch map by T. C. Ridgway.  
 From Volcano House register.

"While the information of the exact location of the outbreak corroborates what was first reported, it is not surprising that there have been so many mistaken ideas as regards the exact location. The summit of Mauna Loa is very extensive and is flat. The activity is in the center. The result is that the people viewing it from the Hilo side think that the outbreak must be over toward the Kau side, while people viewing from the outbreak from the Kau side naturally think that the eruption is further over the Hilo side. The flat top deceives people from all sides and gives the impression that the eruption must be further down the mountain on the opposite sides, whereas, it is on the summit."

Two more brief second-hand reports of the observations were published by the Advertiser (19 Oct; 18 Oct), the second one accompanied by a map of the Mauna Loa-Kilauea area compiled from a 1886 survey and the reports to date of the 1903 eruption. The map showed what appear to be the inward-facing scarps across the northeastern and southwestern parts of Mokuaweoweo that were shown in Ridgway's sketch. The accompanying article spoke of "a score of fiery geysers rising from two to six hundred feet. . .to fall back into a surrounding lake of liquid fire"; and a small inner center, perhaps a quarter mile in diameter that contains the troubled lake of fire".

In carrying to Honolulu the report of the party that made the trip to Mokuaweoweo, the "Iwalani" also brought news of a peculiar action of the sea at Punaluu, Kau; a similar phenomenon at Hilo; and what was considered to be a continuation of the peculiar disturbance off the west coast of Hawaii. As reported in the Star (16 Oct):

The Iwalani arrived at Honuapo and Punaluu on Sunday [10 Oct]. Ordinarily there is about two feet of water over the rocks inside of the reef at Punaluu, but to the astonishment of Captain Mosher and other officers who had visited Punaluu before, the water was not over the rocks. The natives had observed the peculiar action of the water and they told Captain Mosher that "water too much go no can float raft". Ordinarily cargo is loaded from the steamers onto scows and floated through a channel between some rocks into the reef. This operation could not be done however owing to the shallowness of the water of the reef. The natives were able to wade outside by the outer edge of the reef and catch opihi, a thing that none of them ever remember having been able to do before with such a small quantity of water over the reef. There was practically no water on the reef.

It was at first thought that there had been an unusually high ebb tide and that more than the accustomed amount of water had gone out during Saturday night. Instead of the flood tide bringing the high water back, nothing of the sort occurred. The water remained low during the entire Sunday morning and afternoon, and not until the evening did the water begin to run back again and cover the rocks. It came with a rush and caused a small sized flood over the landing.

None of the natives were able to explain the cause of the strange action of the water. They did not recall a similar condition before. Neither had Mosher nor his men. Naturally they attributed the action to some unknown influence of the volcano. Subsequently Captain Mosher ascertained that a similar condition had prevailed at Hilo. On Sunday the water had run out of the Harbor, leaving the Waiakea river practically dry.

This remarkable action by the water would seem to prove the claim of some scientists that the sea is the cause of volcanic activity. According to a fairly well established theory the bottom of the sea caves in, causing the sea to rush into the bowels of the earth. This sudden volume of water striking the intense heat underneath the earth's surface generates gasses and steam and causes those forces to seek outlets through the top of the earth. Some unexplained force was responsible for the strange action of the water off Punaluu last Sunday.

Captain Mosher encountered on both the up and down trips of his vessel a peculiar ocean whirlpool or current. The extent of the thing was not of course determined, but from his observation Captain Mosher says that it must be at least ten miles long and five miles across. The peculiar section of the waters is

located southwest from Kahoolawe, about ten miles off shore. It was in this same place that the officers of the British ship Ormsary encountered a peculiar current that set them out of their course and swept the vessel along for some distance.

Captain Mosher says that going to Punaluu he encountered the same thing. He passed through it coming home yesterday. The water acts as almost like a whirlpool. The sea was choppy and the man at the wheel was unable to keep the vessel on her course. First a wave would strike against the bow and drive the vessel over to port, then a wave from the other side would strike her and drove the vessel over to starboard. This peculiar action continued with the vessel for a distance of fully ten miles. The action of the water was such, at times, as to all but swing the vessel half way round. Accompanying this rotary movement the current was sweeping in a general southerly direction.

There was no wind at the time only the peculiar sea running. The seas would rush up on the vessel and several times flooded Captain Mosher's cabin, an occurrence that had never before been experienced.

The peculiar sea has been in action in that particular spot ever since the volcano became active. The two courses that the Iwalani took on her round trip were about five miles apart, showing that the width of the whirlpool is at least five miles. Mosher thinks that it is even greater. The steamer Kaiulani is also reported to have experienced the same condition of the water while passing Kahoolawe.

The Advertiser (16 Oct) published the results of an interview with the Mauna Loa's purser, J.L. Logan, in which there was no mention of either the disturbance at Punaluu or that offshore, the purser mentioning only "we had exceptionally fine weather on the trip up" (toward Hawaii), and that: "Yesterday morning, just before daybreak, the Iwalani ran into a terrific thunder and rain storm and the view of Hawaii was shut out." The context suggests that the thunderstorm occurred on Wednesday the 14th rather than the next day. The Bulletin (16 Oct) carried an article based on an interview with the purser of the "Helene", which had returned from the Hamakua coast, in which the weather was described as cloudy but there was no mention of rough seas or strong wind. However, in the same issue the Bulletin (16 Oct) carried reports of "heavy northerly swell" on the north and east coasts of Kauai on 14 October forcing the "Ke Au Hou" to land at Hanalei freight that was destined for Kalihiwai, holding the "Waialeale" weatherbound at Hanamaulu, and making the landing at Anahola too rough to work.

#### Continuing Mauna Loa activity and marine disturbances, late October and early November

Although the first party to reach the Mauna Loa summit had reported activity only in the caldera, there were continuing reports of lava flows or eruptive action on the flanks, including a report from Kaupo, Maui, dated 13 October, that, since the beginning of the summit eruption, there had been evidences of eruptions on the north slope of the volcano (Star, 16 Nov). However, the reports of later parties reaching the caldera rim cast increasing doubt on the actual occurrence of extra-caldera flows.

The newspaper accounts of the visits of the subsequent parties are confusing. In any one account there might be only partial listing of the members of the party, a partial itinerary, and inaccurate statements of the number of members, or an ordinal number indicating incomplete knowledge of the number of parties previously visiting the summit area. By comparison of the various accounts, a log of visits to the summit area has been prepared (Appendix B) which has been used in dating the visits and arranging the descriptions of the activity described in the following discussion.

The second party reached the summit area only four days after the first, having ascended from Kona. According to an account by E.A. Berndt, a member of the party, dated at Napoopoo on 18 October (Star, 20 Oct), they viewed the eruption for about 2½ hours on Saturday, 17 October, taking many photographs. As published, the viewpoint of the party was reported to have been on the southeast rim of Mokuaweoweo, but the narrative suggests strongly that it was on the southwest rim. According to Berndt:



The sight is simply indescribable. Columns of fire from 40 to 100 feet are playing, now here, now there. We counted about 30 fountains. One fully formed cone nearly 75 feet high in about the center of the crater and one forming a little to the southwest of it. There is smoke and steam every where in the crater, but the principal eruption is in a line running through the center of the crater of Mokuaweoweo from the southeast to northwest. The entire crater is bubbling and the molten lava covering the entire floor has risen from the thousand foot mark to the seven hundred, thus filling in 300 feet. The crater is about two and a half miles wide and three miles long.

The greatest sight was after the fully formed cone which only spit fire from the center caved in. Now here, now there, the volume of fire would be greatest in turn, lessening that of the other fountains. Finally the fully built cone showed more activity and before appreciation of the grand display could be voiced, it crashed the northwest portion causing an awful rumbling and trembling. The spectacle seemed to be arranged especially for us. Many cave-ins must have occurred there lately as there are still evidences of land slides. Cracks two to three feet wide run from 20 to 30 feet away from the top and will soon have to cave in as the foundation below is disturbed.

The entire bottom of Mokuaweoweo which apparently is two miles across and three and a half miles long is in a line running from southeast to northwest. Cones are constantly forming and keeling over, and in this process filling the crater. The bottom has risen to about the 700 foot level. During Dr. Goppe's visit in 1899 it was fully 100 feet deep. . .

The whole bottom is one molten mass, for when preparing to take snap-shots we had the particular pleasure of seeing the cone at the south-east end which must have been forming for days cave in at the north-west side and the rushing lava seek its level with the rest. Once here, once there, the fiery mass would be entered and shoot with giant effort hundreds of feet into the air. Of the 30 fountains playing at different times, all would lend help in this united effort and recede for the time being, then all would flare together, as it were. Many and loud were the explosions that were caused by the fierce snow fall. As it fell into the molten lava, was melted and burst into superheated steam. These explosions could be heard for miles.

Many land slides must have occurred. During our stay one was looked for, as there was about a 50-foot belt along the edge of the crater, separated from the crest by a crack about five to ten feet wide. The least disturbance below would have caused a cave-in. . .

The greater the activity above, the sooner a flow is likely to follow. Already has the bottom risen to the height of the bank made during the 1899 disturbance. Then a flow found its way towards Mauna Kea below the eleven thousand foot level.

A third party reached the summit area at 15:00 on the 17th and spent the night there. According to some member of the party interviewed by F.B. McStocker (Advertiser, 27 Oct), there were 35 to 40 fountains, never less than 15 playing at once, ranging up to 250 feet in height, surrounded by a lava lake from which there extended a eastward flow short three quarters of a mile long and ranging up to 500 feet in width. A sketch by a George Stratmeyer accompanied the article in the Advertiser (27 Oct). However, Stratmeyer was not listed by a member of the party.

A fourth party, reaching the northeast caldera rim on Monday morning, 19 October, by way of the northeast rift of Mauna Loa, reported seeing fountains from 50 to 250 feet high (Herald, 29 Oct). During the day they followed the rim to the campsite of the first party. During the following night, they reported, there was a cluster of fountains on the western side of the caldera, an increase in activity after midnight, with a flow about 100 feet wide extending a mile to the northeast, and the peaking of the activity at about 3 am. with fountains appearing to be two-thirds the height of the opposite caldera rim. In Hitchcock's (1909) book, Hawaii and Its Volcanoes, there is a plate labeled "Mokuaweoweo in 1903" (Figure 3 in this report). From its appearance the plate might have represented a photograph of the Crater taken by some member of the third or fourth party to visit the Mauna Loa



Figure 3. Mokuaweoweo in 1903 (from Hitchcock, 1909).  
Probably a painting by D.H. Hitchcock from southeast rim.

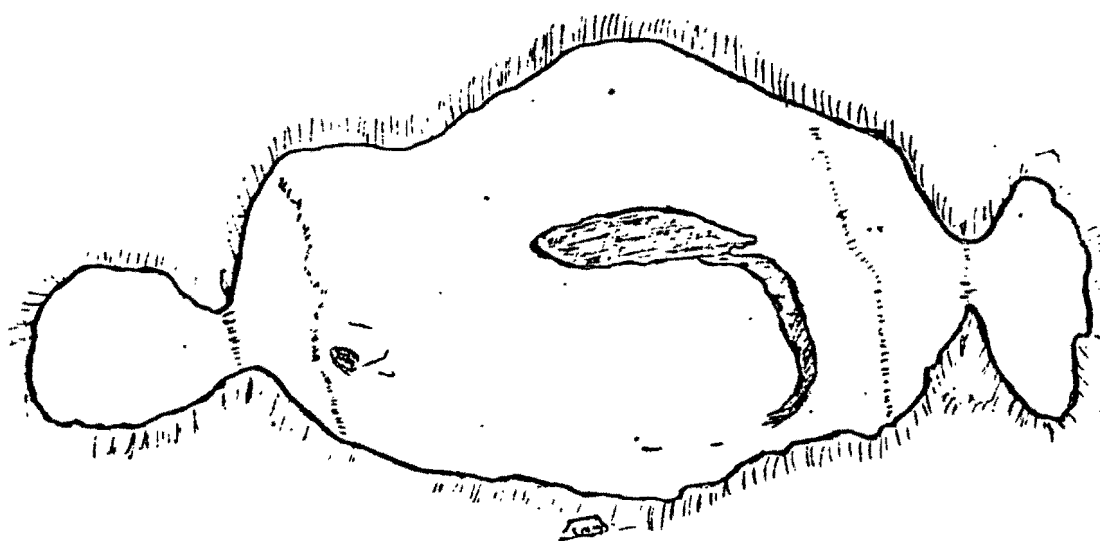


Figure 4. Mokuaweoweo on 21 October 1903.  
Sketch map from Volcano House register.

summit area. However, the plate is further identified in the list of plates as: "From D. Howard Hitchcock" and hence it is more probably a photograph of one of the many paintings of volcanic scenes by Howard Hitchcock. Hitchcock is not listed as a member of any of the parties visiting the summit area at the time of the eruption, and it seems most probable that the painting was based on the appearance of the caldera at some other time modified on the basis of descriptions and sketches of the eruption by others.

A fifth party, following the Kapapala route, reached the summit at 12:35 on 20 October, and spent the day and the following night on the southeast caldera rim. In the account of L.W. Haworth, editor of the Tribune (23 Oct), a member of that party:

The general picture was as has been described in this paper and others. The main action was in the center where the heaviest fountains were hurling to great heights their burden of hot boulders and molten lava. In this center was an enormous cone behind which, the fiery forces played as gunners behind impregnable barricades. At the left, near the edge of the lake of fire was a small volcanic cone in process of formation. To the extreme right was a still smaller cone, whose peculiarity was that it belched fire of an entirely different color from the others. This fire was like molten silver while the spray of the fountains was like red blood under a light.

During the night, a tremendous explosion occurred, completely demolishing the large central cone which was so conspicuous the evening before. The effect of this explosion was far more grand than that of spouting lava. The sides of the immense cone were shattered; they crumbled and melted away in the liquid waves of fire that had built them up. . .

The morning of Wednesday saw the central cone replaced by a dozen lively geysers, which patiently set about to erect another. That morning the transformation in the cone at the left end of the lake was also remarkable. It had grown into a symmetrical pyramid of respectable proportions, and was belching out fire from the apex. . .

Some unidentified member of the party sketched a map of Mokuaweoweo as of 21 October in the Volcano House register (Figure 4).

A sixth party reached the west rim of the caldera on 21 October at 13:45. According to a letter from T.C. White, a member of the party, published in the Advertiser (27 Oct), hearing an explosion at 06:45 the next morning they "saw the top of a new cone blown off, which was a grand sight".

A seventh party of only two persons, D.T. Fleming of Maui and a Dr. Douglas from Kona, ascending from the Kona side, reached the summit, presumably on the west rim of Mokuaweoweo, on Monday afternoon, 26 October. According to a report from Fleming, quoted in the Bulletin (30 Oct):

"We got a very close view of the crater and it was very active indeed. The lake was something like 1,200 by 1,000 feet. There were a number of spouting cones, but the largest and most active was on the Kau side and was at least two hundred feet high. It would spout fire into the air, collapse and then send volumes of dense, thick smoke into the air. All this was accompanied by rumblings that shook the earth under our feet.

"There have been a good many conflicting reports regarding the flow of lava, but I wish to state that there has been a flow. It went down the Kahuku side, just as the boys from Greenwell's ranch reported. It was between three and four thousand feet in width and flowed about a half mile down the mountain side."

Reports at the end of the month suggested a slackening of the activity (eg. Star, 30, 31 Oct). However, a party ascending to the west rim of Mokuaweoweo from Kona on 5 November at 11:00 and spending the following night there found it still vigorous. Accounts quoting G.P. Thielen, a member of the party, were published in the Bulletin (10 Nov), the Star (10 Nov), the Advertiser (10 Nov), and the Gazette (13 Nov). Thielen was quoted in the Advertiser as follows:

"On arriving at the crater we found that the central cone was very active, ejecting lava every few seconds with an explosion very much like the blowing off

of steam by a locomotive. The jets rose to a height of about 200 feet. There were other signs of fire in the immediate neighborhood of the cone.

"The cone stood on the rim of a circular space in which activity was shown all over, fire being also visible in the daytime. Eruptions were intermittent, occurring every few seconds, and throwing up ejects to a height of from a few feet to possibly a hundred feet.

"Other evidences of fire appeared all over the floor of the crater, steam from apertures and fire occasionally visible during the day. Over in the corner, on the Kau side, there were also evidence of considerable activity. Great quantities of steam were being emitted.

"To the left of the main lake, during the night, there were two small lakes almost in a straight line about midway between the wall of the crater and the main lake. A third lake was situated at the foot of the cliff on which we were standing. Neither of these smaller lakes seemed to have any walls. The one at the foot of the cliff, beneath our feet, had a little cone which broke out and boiled over like water from an artesian well.

"Almost the entire floor of the crater is gridironed with orifices through which fire gleams at night. The entire lower plateau as it is called, has been filled up by the present eruption so as to be flush with the formerly higher level.

"I can state definitely that there has been no flow out of the main crater. Dr. Douglas, who accompanied Mr. Fleming on the trip from which it was reported there had been a flow on Kau side, states that the story was unfounded and that Mr. Fleming must have been misquoted."

Thielen's statement that no extra-caldera flow had been seen by Dr. Douglas (of the two-man party visiting the summit area on 26 October), and that Fleming must have been misquoted on the matter, brought rebuttals from Fleming in the form of a letter published in the Bulletin (16 Nov) and a longer one in the Advertiser (21 Nov) from which the following is taken:

True enough, at that time there had been no flow from the main crater, as far as I could see; nor did it seem at all possible that there had been. But there was flow emanating from an immense crack about 100 yards or less from the brink of the crater, at the Kau end of the active part of the crater. This point is about twelve miles from the place where we reached the crater. The flow itself is about 200 yards or less wide and only half a mile in length — not any more — and appeared to be connected in no way with the main crater. The channel through which the lava had risen to the surface had evidently been blocked very thoroughly, as little heat was rising from the crack from which the flow came; but all around for a radius of fifty yards or so were numerous cracks from which were pouring steam and smoke, and all were more or less hot; one within twenty yards of the head of the flow being hot as a furnace.

The flow was pahoehoe and had been extremely liquid — a very rapid-running flow, judging from appearances, although it was quite cool, it could not have been over a week or ten days old, for even the heat of the sun was cracking it.

Further, on the night of Saturday, October 17th a party of eight from Makawao went up to the summit of Haleakala to see if Mokuaweoweo was visible at this distance. We could distinguish very plainly a spot of fire at the summit, and above that the reflection of the fire below upon the clouds of smoke from the main crater. That this fire was anything other than this flow is impossible, as Haleakala is 400 feet lower than Mauna Loa, and the fires in the crater could never have risen for six or eight hundred feet from the pit, so that we could see them from this distance.

At no time was Dr. Douglas within a couple of miles of the flow, over which such a difference of opinion seems to have arisen, as he was too mountain-sick to leave camp at any time.

Storm conditions or rough water were reported at various times during late October and early November including:

1. A violent thunderstorm at the north coast of Maui between Wailuku and Maliko beginning on the 14th of October and continuing until the 15th. (News, 17 Oct; Star, 20 Oct);
2. A thunderstorm at Lahaina, Maui and on Lanai on 15 October, especially violent on Lanai (Star, 19 Oct, 20 Oct);
3. Heavy rain on Kauai with a flood at Kealia on 16 October (Star, 17 Oct);
4. Heavy rain on the Hamakua and Kona coasts of Hawaii and rough seas on the Kau and Kona coasts in the period from 25 to 29 October, with waves washing over the wharf at Napoopoo on 29 October (Star, 30 Oct);
5. Such rough conditions in Hilo Bay on 5 November beginning shortly after midnight, that the "Aloha" had to be moved away from the wharf and the "Kinau" could not land passengers at the wharf; during the afternoon the near capsizing of a boat at the Waiakea River; and waves covering the waterfront railway with sand (Advertiser, 9 Nov; Star 9 Nov; Gazette, 10 Nov; Bulletin, 10 Nov);
6. High seas at Honolulu on Wednesday night, 11 November — the schooner "Aloha" being damaged by being forced repeatedly against the new dock against which she was moored (Advertiser, 16 Nov);
7. Such rough seas on the Hamakua coast on Thursday, 12 November, that at Honokaa that afternoon a boat from the "Iwalani" was capsized and wrecked, injuring two seamen (Advertiser, 16 Nov; Star, 16 Nov; Gazette, 17 Nov). The Advertiser and Gazette described the seas as "the usual rough weather. . . at Honokaa", and reported further: "The following Saturday there was a heavy rainfall on the Hamakua coast, but the seas were moderate as the "Iwalani" returned to Honolulu" (Advertiser, 16 Nov);
8. An exceptionally heavy rainstorm and a flood of Nuuanu Stream in Honolulu on 15 November (Advertiser, 16 Nov; Gazette, 17 Nov).

Kilauea activity, continuing Mauna Loa activity,  
and marine disturbances, late November

The storm conditions continued into the latter part of November. On the night of the 16th, the "Ke Au Hou" on a trip from Honolulu to Kauai ran into tremendous swells from the northwest. The wind from the northeast, although not exceptionally strong, resulted in a confused sea that rolled the vessel to such an extent that the pulleys hanging from her davits touched the water. The waves boarded the vessel, flooded cabins, washed lines overboard, and nearly swept overboard a woman and a child who were deck passengers. In rescuing them the chief engineer was injured. For an hour the ship had to be headed into the wind to avoid a possible capsizing (Bulletin, Nov 21).

Although the mid-November storm conditions in Honolulu were considered by the territorial meteorologist to represent a "clearing off storm" (Star, 16 Nov), another marine disturbance on the Kau coast on 17 November was reported in the Star on 20 November, as well as yet another observation of supposed extra-caldera activity of Mauna Loa:

There is evidently some increased forces at work in the volcano of Mauna Loa. In addition to increasing signs of activity on the summit the eruption has broken out lower down the side of the mountain. News of the progress of the eruption was brought today by the steamer Mauna Loa. The action of the water at Punaluu last Tuesday was remarkable and shows that some submarine force was at work.

Purser Conkling reports that the eruption has broken out at Pohakuhanalei which is a small crater on the Kona side of Mauna Loa. The smoke can be seen every day coming out of this eruption and at night the reflection of fire is very distinct. There are no signs of the eruption of the summit crater diminishing and

the reflection now at night is more brilliant than it was the last trip of the steamer Mauna Loa to Hawaii.

The peculiar action of the sea occurred in the afternoon of Tuesday. At that time the vessel was lying off Punaluu with her head toward the prevailing wind. Suddenly the sea about the vessel became churned up. The water acted similarly to the way the water does when a propeller strikes it. The sea was disturbed to such an extent that it capsized a ship's boat that was near the steamer and threw the small boat's occupants into the water. So sharp and choppy and quick was the action of the waves that the men had the greatest difficulty in swimming until they could be picked up. The Mauna Loa was swung around from her former position. The disturbance continued for perhaps ten minutes. Later in the day a huge black cloud was seen to belch out of Mokuaweoweo, the summit crater, and then followed the usual column of white smoke and steam.

The officers of the vessel think that the disturbance of the water was due to some gases from the bowels of the mountain forcing their way through the bottom of the sea.

The Bulletin (20 Nov) and Advertiser (21 Nov) also noted the event on the basis of what may have been a joint interview with the captain of the ship. According to the Advertiser:

"... On last Tuesday morning increased activity was apparent as a big column of smoke suddenly rose from Mokuaweoweo. During the forenoon, while the Mauna Loa was lying off Punaluu, the water began to boil and churn, and the marine phenomenon was witnessed by the entire crew. Captain Simersen states that the peculiar disturbance was something he had never before seen. A gale was blowing at the time, when cross seas unexpectedly appeared. So sudden was the disturbance that a boat lying in the water at the steamer's side was capsized, and the boat's crew was thrown into the water. The sailors were pulled aboard the steamer by ropes thrown out to them. Fifteen minutes later the sea calmed down and resumed its former functions.

All on board attributed the strange marine freak to volcanic activity, connecting it with the sudden discharge of smoke from the craters.

High seas on 21 November forced the "Niihau" to cut short its landing of freight at Honokaa, on the Hamakua coast of Hawaii, although later in the week the ship experienced good weather on the Kau coast and on her return trip to Honolulu (Bulletin, 27 Nov).

The "Niihau" experience was also reported in the Bulletin (27 Nov).

An eruption in Halemaumau, the pit within the Kilauea caldera, began a week later, very early Wednesday morning, 25 November (Herald, 26 Nov). According to the Star the evidences were seen first at 02:30 from the Volcano House; according to the Herald (26 Nov) at 05:00.

According to a report telephoned on the 26th from the Volcano House (Tribune, 27 Nov):

A lake has formed on the bottom of the crater, and the intruding flood of lava can be heard quite a distance from the edge of the crater. . . The whole northern section of the bed of Kilauea shows a rising temperature. . . the lava is breaking into Halemaumau from beneath a ledge in the southern corner. . .

By 27 November, it was reported, "the lake of boiling lava 125 feet by 30 feet has risen 200 feet" (Bulletin, 28 Nov), and by the 28th or 29th that the lake measured 150 by 300 feet. On the night of the 27th, the evidences of the Mauna Loa eruption were reported to be especially spectacular (Bulletin, 9 Dec).

The "Kinau", which brought the news of the conditions at Kilauea on the 27th to Honolulu, reported no unusual weather condition on the coasts of Hawaii. However, on the day that the Kilauea eruption began, the tanker "Rosecrans", on its way from San Francisco to Honolulu, where it arrived on 3 December, had experienced a violent cross sea resulting from the combination of a westerly swell and

a moderate gale from the southeast. The next day the wind had shifted to the southwest and strengthened to a full gale, and the waves caused some damage to the ship and nearly swept the first and third mates overboard from the fore-deck (Star, 4 Dec). During the next week, high waves were reported on various Hawaiian coasts, including a tidal wave. The reports are cited in the order of their publication.

On 30 November the Advertiser reported that the "Iwalani", apparently just returned from Hawaii, had experienced good weather but heavy swells, and that it had managed to land only a sack of mail and no freight at Kukuihaele where "at intervals seas broke over landing". The "Ke Au Hou" had twice been unable to load sugar at Kilauea, Kauai, because of heavy northern swells, the second time on 27 November.

On the same date the Star (30 Nov) reported that on Oahu, after a week of "prevailing southerly and westerly weather", heavy waves washed out the railroad track between "Koolauloa and Waianae Point".

The same issue of the Star (30 Nov) noted: "R.C. Lydecker, Territorial Meteorologist, reports that the local tide gage shows disturbances of unusual character. . .", commenting: "Mr. Lydecker thinks they indicate submarine volcanic disturbance of some kind near enough to the island for it to affect the tide gage".

The Bulletin on 1 December and the Advertiser on 2 December reported on an interview with the purser of the "Mauna Loa", which had arrived early on the morning of the 1st from Hawaii and Maui:

"On the outward trip we had smooth sea all the way to Kau where during our stay the water was almost as smooth as glass. Getting to Kona on our return we found very rough weather. At Hoopuloa a landing was made with great difficulty and work done. At Hookena it was impossible to get into the landing as great waves were breaking over the wharf. At Napoopoo work was done under great difficulty as the wharf there was being continually swept by huge breakers. During the lull between the breakers the boats were loaded and gotten out. Keauhou and Kailua being differently situated work was carried on regularly as at these landings the sea was comparatively smooth."

The Star (1 Dec) carried a similar article which, however, did not mention the experience of the "Mauna Loa" at Keauhou.

On 2 December, the Star carried a report on a "tidal wave" that had affected the north coast of Molokai on the 29th:

Pelekunu was visited by a tidal wave Sunday afternoon. News of the occurrence was brought today by the steamer Lehua. John Wilson, who resides at that place, experienced the rush of waters.

The sudden rush of waters occurred about 2 o'clock in the afternoon. The sea rushed in suddenly in a series of big rollers each succeeding one larger than the others. The water ran fully 250 feet further inshore than the highest tide mark. A number of houses that were located about 130 feet from the tide water mark were inundated. Had it not been that a stone fence served as a break to the rushing waves the houses would have been swept from their foundations. The stone fence was about four feet in height and checked the force of the inrushing waters. The rise of water lasted fully two hours. Nobody was drowned. The water has been very rough along that part of Molokai. All of the freight could not be landed from the steamer Lehua at Kalaupapa.

The same event was reported by the Advertiser (3 Dec) and the Gazette (4 Dec):

John H. Wilson, engineer, returned in the Lehua yesterday from doing surveying for the Kalaupapa wharf construction. He reports what he believes to have been the action of a tidal wave last Sunday on the windward side of Molokai.

A big sea washed away two houses at Kalaupapa. At Pelekunu the incoming waves rushed clear through the houses on the beach, causing general

consternation. Taro patches were flooded. The sea reached a point 250 feet inshore of the highest former tide mark.

The flooding prevailed all along the coast from Kalaupapa to Halawa for about two hours. A strange feature, one that favors the tidal wave theory, was that of smooth water in the ocean a quarter of a mile from shore.

On 3 December the Star reported:

Rough weather about Hawaii delayed the Gas. schr. Eclipse on her return trip to Honolulu. The vessel nearly lost a boat and a crew at Honoipu last Friday [27 Nov]. The sea was very rough at Honoipu that day and the boats had been worked under difficulties. A shore line from the buoy to the beach was used by the boats in getting in and out with the loads. Captain Gahan had been on the deck of the schooner all of the day watching the big rollers come booming in. Whenever he would see any very large ones that looked as if they might endanger the boats, he would shout to the crew in the small boats to come out to sea beyond the line of the breakers.

Toward the evening while the last boat was inside the line of breakers, Gahan saw three monster swells go rushing in. He shouted to the crew to come out. It was well that the men did not try to buck against the immense waves. Had they done so the four men would have been lost and the boat probably dashed to pieces on the rocks. The boat was capsized by the second breaker and all of the men dumped out. One of the men was thrown fully 15 feet into the air. He alighted the water about 25 feet away from the boat. The undertow was very strong but the men succeeded in getting their boat ashore and bailing her out.

At Kawaihae the weather was the roughest that Captain Gahan has ever known in that place. The Eclipse arrived there Sunday night [29 Nov] for a load of cattle. The sea increased in volume until it became so bad on Monday that the anchorage of the vessel had to be shifted. The sea began breaking in eight fathoms of water. The Eclipse was weatherbound two days at Kawaihae before she could load the cattle for Honolulu. She arrived here yesterday afternoon.

On the same day, the Herald (3 Dec) reported:

Last Saturday [28 Nov] the surf on the Maui coast was unusually high and on Sunday it increased. At 11 a.m. a wave twenty-five feet high came in at Honokohau. Two hours later it was followed by another. At 1 o'clock there was one thirty feet high dashed up the valley, carrying away stone fences and two native dwellings. The height was ascertained by measuring the mark left by the sea on the side of the pali. The damage amounts to several hundred dollars. No lives were lost.

The Advertiser on 4 December carried an account of the experience of the "Eclipse" at Honoipu.

The Maui News seems not to have taken notice of the occurrence of the unusual wave of 29 November on the north coast of Molokai nor even that at Honokohau, Maui. However, the Star on 5 December carried an article on the wave at Honokohau based on a description by B. Kuhns:

We had a tidal wave that did considerable damage. There was no wind and not a cloud in the sky. I was at church when the first wave came, about 10 o'clock a.m. There were two others. The third one was over thirty feet in. . . [line obliterated] foundations. A number of us were on the beach and the rush of water almost caught us.

On 7 December the Bulletin published a letter from Judge T.K. Nathaniel of Kalaupapa describing the wave effects of 29 November there:

"Last Sunday early in the morning there was a steady southern wind wafting over the settlement. At about 8 a.m. the sea became rough. It was so rough that the landing you built recently was completely under water all day. You remember, I



believe the fumigating house standing under the shade near where the boys were mixing pana. That was shifted off by the waves about 5 or 6 feet from where it stood. The wall makai was completely taken away. The oil house would have been washed away if it was not tied up to the posts of the shade. Seas went over the burying ground at Papailoa [Papaloa] did lots of damage to stone walls and houses at eliopil [?]. Oh! it was a grand sight to look at the big waves sailing in 40 or 50 feet high and beat the sea wall of the land unmercifully. The pile of rockets [rocks] makai of the landing were all washed away both ashore and into the sea where the boat comes in. The derick is all right except that the guy wire rope was broken. I believe it must have been struck by a big rock. I have been at the settlement over ten years but have never seen such a sea like the one we saw last Sunday.

On 8 December the Star reported on wave effects on the Hamakua coast at Kohalalele Landing (misspelled in the newspaper article):

The roughest weather that has been known in 16 years is reported from Kohalalele landing. The schooner Ka Moi arrived this morning with news of the rough weather. There was not much wind prevailing but the sea was so high as to reach a point inshore never before attained. The same tidal wave that visited Oahu, Molokai and Maui on November 29 was evidently the one that swept into Kohalalele.

The waves must have been enormous. They came as a northerly swell. The sea at Kohalalele seemed, if anything, to be larger than the tidal wave reported from other places about the islands. The sea swept clean over the top of the crane. This implement stand 40 feet in height at the landing, but the big rollers covered it completely from sight when they came dashing in. Enormous boulders were picked up and carried inland some distance. Several houses were washed away. Nobody was drowned. The high seas continued for some hours.

Continuing Kilauea activity, cessation of Mauna Loa activity, and another marine disturbance, December

Reporting on the continuing activity of Mauna Loa and Kilauea, the Tribune (4 Dec) and Star (5 Dec) stated:

Manager Bidgood has just made new measurements of the circumference of Halemaumau. He finds that it now measures 4391 feet, whereas a year ago it was only a little more than 3000. This increase in size is caused by a falling in of the walls. The debris in the bottom, with the present outpouring of lava, has filled up a space of about 200 feet.

The Herald (3 Dec) and Star (5 Dec) noted that on Tuesday morning, 1 December, "there were two fountains playing in the lake that was about 200 feet in diameter", and that the pit Halemaumau "has been gradually filling since last August until now its depth is not much above 600 feet".

The two newspapers also reported on the trip of another party to the Mauna Loa summit, this one for the first time ascending from the Humuula saddle between Mauna Kea and Mauna Loa and hence probably seeing the eruption from the northern rim of Mauna Loa. Henry Beckley, one of the party, reported that the activity was about the same as that reported by the first party that made the ascent via Kapapala in October. Probably about 30 November, another party had visited the summit area, but its route and viewpoint were not reported (Herald, 3 Dec).

With respect to the Kilauea eruption, the Tribune (4 Dec) reported:

The lava lake in the bottom of Halemaumau is now 300 by 123 feet in size and is not more than 650 feet from the surface. The lake is kept in commotion by one fountain which works steadily. At times another fountain plays.

On 6 December according to the Herald (10 Dec):

The lava in the pit was flowing toward the center from two sources on the Kau side. These flows joined and formed a lake nearly two hundred feet in diameter. There was great activity at the time and several fountains were playing.

As seen from Kilauea, Mauna Loa was unusually active on Tuesday, 8 December, according to the Herald (10 Dec), but in the evening:

Suddenly at nine o'clock, the reflection disappeared and evidently the fire sunk out of sight for nothing could be seen from that point or from Hilo. On Wednesday morning, though the mountain was perfectly clear, the smoke and steam that has been visible every clear day since October 7 was not to be seen and the supposition is that activity on the summit crater has ceased.

As reported by Conkling, the purser, of the Mauna Loa, which was somewhere on the Kau or Kona coast, the cessation of the activity was two hours later, at 23:00 (Star, 11 Dec). According to Captain Simersen, the volcano was still in full activity at 22:15, when he retired, but had ceased by 23:00 when, unable to sleep, he returned to the deck (Bulletin, 11 Dec).

The last parties to have seen the Mauna Loa activity before it ended had apparently been at the summit the night of 7-8 December, one probably on the southeast rim (Tribune, 11 Dec; Advertiser, 14 Dec), the other on the west rim (17 Dec letter from C.W. Baldwin, Advertiser, 20 Dec). Both parties described the activity as unabated but restricted mostly to one cone, Baldwin reporting from the west rim:

The appearance in the region of activity was very similar to that of the "Dewey Crater" during the height of its activity, or rather during the latter part of that eruption. There was a cone quite similar in shape, size and height containing a lake of lava which was tossing about in a fearful manner and constantly leaping into the air — at times twice the height of the cone; through an opening in one side of the cone a stream of lava was issuing, flowing towards Kau and then circling to a point almost directly beneath us. The first mile and a half of the flow was pahoehoe, which changed to a-a for the last mile. In this case the pahoehoe appeared to turn to a-a but it is probable that the first flow had been a-a which now was being pushed along by the later flow of pahoehoe. We estimated that the active cone was a mile from our point of observation above Kealahou, Kona, which would make it two miles from the opposite or Hilo side. The display at night was very grand. At eight o'clock the following night (two hours before the disappearance of the fire) the reflection from Kainaliu was as brilliant as it ever has been during the whole eruption. There was an unusually large column of smoke ascending from the crater at this time.

The cone which I have referred to above undoubtedly now stands unique in the crater of Mokuaweoweo — a monument to the eruption of 1903.

Two photographs of the eruption, one taken during the day, the other at night, were published by Brigham (1909) with attribution to C. Baldwin. From the description of Baldwin's viewpoint in the above quotation, and the shadows in the day-time photograph (Figure 5), that one was probably taken looking north-northeast from a promontory on the southwest rim of the caldera or a point on the rim nearby during the afternoon of 7 December. The night-time photograph (Figure 6) was probably taken from the same viewpoint during the following night.

The Kilauea eruption continued through December although, to judge from a description of the activity published in the 23 December issue of the Star, it was not so vigorous as earlier.

The occurrence of another "tidal wave" was reported on 19 December. The Bulletin (22 Dec), the Advertiser (23 Dec), and the Gazette (25 Dec) quoted the purser of the "Mauna Loa" on the event, and on the conditions of the seas more generally, as follows:

"A small tidal wave at Hookena did minor damage early Saturday morning . . .

"Coming home fair weather with moderate seas and N.E. trades prevailed . . ."

The same event was reported, even more briefly, in the Star (23 Dec).



Figure 5. Mokuaweoweo on night of 7-8 December 1903  
probably from promontory on west rim  
(from Brigham, 1909)



Figure 6. Mokuaweoweo on 7 December 1903  
probably from promontory on west rim  
(from Brigham, 1909)

The Gazette (22 Dec) and the Maui News (26 Dec) reported the occurrence of an unusual wave on the south coast of Maui the evening before the occurrence of the "tidal wave" at Hookena. According to the News:

On last Friday night at Makena a very serious accident happened to one of the Kinau's shipboats, although fortunately no lives were lost. The first boat, containing several kiddies and children put off from shore and safely reached the steamer. The next boat, containing the mail and considerable freight including some six dozen live turkeys, pigs, chickens, and other freight met a comber which washed the freight clerk overboard. He shouted to the oarsmen to pull ahead as he was in no danger, but they hesitated a moment, instead of pulling forward a few strokes to safety.

The result was that an immense comber caught the boat, upsetting it and dumping the mail and freight into the water. Only one mail sack was recovered, and all the freight was lost. Some three hours was spent looking for the lost articles, after which the Kinau left Makena, reaching Maalaea Bay some three hours late.

More news on the event was reported in the Star on 30 December:

The tidal wave that visited Maui December 19, did more damage than was first reported. The fine new landing at Keawakapu was washed away entirely by the heavy seas. News of the affair was brought today by Purser Birmingham of the steamer Lehua.

The tidal wave struck the wharf about 4 o'clock in the morning. There was nobody on the wharf at the time so the size of the wave could not be learned. In any event the force of the sea must have been terrific for the entire wharf including the cement piling was torn loose and swept many yards inland onto the rocks at the gulch. About 120 feet of the landing was ripped up by the wave. The wharf was a total loss. Considerable material was recovered however.

Keawakapu is a landing between Makena and Kihei. The wharf was built only recently by the government. It cost in the neighborhood of \$2,000.

It was the same heavy sea that wrecked the wharf that caused trouble for the steamer Kinau at Makena. One of the boat crews was swept inland and one of the boats dashed on the rocks.

The incident was also reported by the Bulletin (30 Dec).

#### Cessation of Kilauea activity and another marine disturbance, January 1904

The diminution of the Kilauea activity at Halemaumau seems to have been so gradual that no newspaper seems to have mentioned its end, which was been reported by Hitchcock (1909) to have been on 10 January 1904.

The Star (2 Feb 1904) reported that the "sea acted in a strange manner at Hookena on Sunday, 31 January, and similarly at Kailua the next day", comparing the action with that of 1903 but not identifying it as that of a tidal wave.



## SUBSEQUENT REVIEWS AND INTERPRETATIONS AND FURTHER INFORMATION

A number of reviews of the geophysical events of the latter part of 1903 were published during that year or in the next few years. These and recent listings of the events are cited in this chapter. The discussion in the chapter calls attention to discrepancies between the reviews and the original accounts, and to interpretations in the reviews of ambiguities and discrepancies in the original accounts -- in particular, interpretations as to the identification of the marine disturbances.

Included in the changes, in addition, is some further information on the marine disturbances of 27-30 November in the form of marigraphic evidence and an anecdote of the event of 29 November.

### Monthly weather summaries

Of considerable interest are the Monthly Weather Summaries that were issued by R.C. Lydecker, the Territorial Meteorologist and were published in the newspapers, which refer to many of the geophysical phenomena reported earlier by the newspapers, and from which the following abstracts and quotations are taken:

#### September

Max. 24-hr. barometric change 0.06; lows 12th, 13th, 16th. Incidence of southerly winds June-September even lower than normal. Av. force: Beaufort 2.3. Exceptionally heavy rainfall (2 in. in 3 hrs. at Weather Bureau at Punahou) on 23rd, although confined to Honolulu, preceded and followed by clear weather. Rainy period last 3 days of month. Thunderstorms, evenings of 28th and 29th. Pepeekeo, Hawaii: thunderstorm 27; heavy surf 7th-9th, 14th, 15th, 27th, 28th. Waimea, Hawaii: Snow on Mauna Kea and Mauna Loa, 28th; fresh and strong trade with gale 10th and 11th. Hilo: Earthquake 19:16 on 1st; thunderstorm 28th.

#### October

Max. 24-hr. barometric change 0.13 in., 12th to 13th; lows 13th-16th and 20th. Tradewind days: NNE 1, normal 22; force: Beaufort 2.2 Heaviest 24-hr. rainfalls: Hilo, 4.0 in. 5th; Naiku (Maui) 5.8 in., 25th; Waiakea (Hawaii), 5.8 in., 5th.

The principal features of the month were the eruption of Mauna Loa, the heavy electric storm on Maui and Lanai and the low average temperature. Smoke was first observed issuing from the crater of Mauna Loa (Mokuaweoweo) at 12:45 p.m. on the 6th, and activity has continued up to the present time. At the close of the month the lava lake was reported to have risen to within 700 feet of the crater's rim, but as this is an eye estimate due allowance must be made: the best authority gives an estimated rise of the lava as from 25 to 30 feet above the floor of the crater, which when the volcano was not in an active state, was 300 feet below the crater's summit. This crater is oblong in shape being 3.7 miles long and 1.74 miles in width. The mountain has thus far withstood the pressure from within, and no outbreak from its sides has occurred hence no flow of lava. In connection with this eruption the reports of Captain Coath of the British ship Ormsary is of more than passing interest. Captain Coath reports having experienced a remarkable disturbance of the sea lasting from the afternoon of the 5th to the morning of the 6th, currents and high cross seas in every direction, the vessel making no headway and unmanageable, Mauna Loa bearing E. S. E. distant about 80 miles on the afternoon of the 6th the activity of the volcano was noticed from the ship. There are no reports of earthquakes previous to the outbreak which occurred without warning, and an interesting question arises as to whether this disturbed condition of the sea was the result of a cause, or an effect of volcanic activity.

Severe thunderstorm Maui and Lanai 14th afternoon to 15 morning.

Hilo: earthquake 06:05 on 2nd.; thunderstorm to NW, evening 14th., heavy thunder shower, 16th. Kohala (Hawaii): Kona wind 14th-16th. Pepeekeo (Hawaii): winds NNE, av. force 1.3; heavy surf 4th-7th, 28th, 29th; distant lightning, 15th; thunderstorm 16th. Waimea (Hawaii): fresh, strong trades, first and last parts of month; gale 8th and 9th; calms and light winds 10th-21st. Naalehu (Hawaii): tradewinds 26 days; moderate earthquake 14:45 on 7th.

#### November

Max. 24-hr. barometric change, 0.09, 15th-16th and 20th-21st. Lows: 11th-14th and 26th-28th. Heaviest 24-hr. rainfalls: Kaumana, 9.0 in., 15th; Puuohua, 8.6 in., 15th; Honokaa, 8.2 in. (22nd). Unusual absence of southerly winds.

The month closed with continued volcanic activity, that of Mauna Loa's summit crater, Mokuaweoweo, was reported at the end of the month as being about the same as when first visited in October. The crater of Halemaumau in Kilauea was discovered in eruption at 2:30 a.m. of the 25th and activity has since continued. The lava lake at the end of the month was reported as being 300 by 125 feet in size and not more than 650 feet from the crater's summit. This crater is 1.95 miles wide and 2.93 miles long, containing an area of 4.14 square miles or 2650 acres. Mokuaweoweo's dimensions were given in the October summary.

There have been no earthquakes reported to this office, but a newspaper report gives one in the Kona and Kau districts on the 12th, followed by increased activity of Mokuaweoweo, and the steamer Mauna Loa reports a disturbance of the sea while the vessel was at anchor off Punaluu, Hawaii, on the 17th. The sea suddenly became churned up and disturbed to such an extent as to capsize one of the ship's boats lying along side, throwing its occupants into the water, where, though they were natives, they maintained themselves with difficulty, and the ship itself was swung around from its former position. This disturbance is reported as lasting ten minutes. Later in the day a huge black cloud was seen to belch from the summit crater, followed by the usual column of white smoke and steam. High seas in the channels and heavy surf along the windward coasts have been the rule. Tidal waves were reported from Pelekunu, Molokai; Kahului and Honokohau, Maui, on the 29th. At the latter place one wave rose to a height of 30 feet as measured by the mark left by the sea on the pali, doing considerable damage. From Koholalele, Hawaii, comes a report of heavy seas lasting some hours which swept clean over the top of a forty foot crane at the landing and carried enormous boulders some distance inland. On this same date a portion of the railroad track along the northern part of Oahu was washed away by high seas, and the tide gauge in the harbor of Honolulu recorded evidence of an unusual agitation. Whether the cause of these latter disturbances was local volcanic activity, or the result of seismic disturbances at, or around the Aleutian Islands, a theory advanced by one authority, (the above mentioned places, with the exception of Honolulu harbor, all having northern exposure and the latter fact would, to a certain extent, tend to eliminate the local theory), or unusually heavy weather in the North Pacific, is problematical, with the weight of evidence in favor of seismic origin.

Thunderstorm, Honolulu, afternoon 15th. Pepeekeo: wind N to E., av. force Beaufort 1.3; Heavy surf except for a few days. Kohala: trade winds 1st-6th, variable balance. Waimea: fresh, strong trades, 1st-18th, light thereafter. Snow on Mauna Kea 15th. Hilo: extremely high surf 4th-8th.

#### December

Exceptionally light rainfall. Max. 24-hr. barometric change 0.08 in., lows 8th to 10th.

Volcanic activity abated somewhat, that of Mauna Loa's summit crater, Mokuaweoweo, ceasing on the night of the 8th. The disappearance of activity in this crater was as sudden as its beginning, earlier in the evening the reflection was the same as had been common during the eruption, but at about eleven p.m. this suddenly ceased, to be seen no more. Activity of the crater Halemaumau, in

Kilauea, was reported at the end of the month to be about the same as at the beginning, a lava lake about 200 feet in diameter having formed in the pit.

A small tidal wave did minor damage at Hookena, Hawaii, during the early morning of the 19th; and the landing at Keawakapu, Maui, was destroyed by high seas at the same time.

Pepeekeo: Snow on mountains, distant thunder 21st; heavy surf 4th-8th, 16th-21st, 30th-31st. Kohala: trades 25 days, SW remainder. Waimea: fresh strong NE winds alternating with calms; northerly gale 15th-16th. Hilo: slight earthquake, 07:15 on 8th.

#### Other early reviews

Thrum (1903) wrote a review of the Mauna Loa eruption at some time after the first four or five parties reached the Mauna Loa summit in October 1903. The review was based principally on the reports of the first and second parties and, indeed, included extensive quotations from them not identified as such. Thrum mentioned the circumstances of the first observations of the eruption from a distance, including those from the "Ormsery", and of the marine disturbance off the west coast of Hawaii, also from the "Ormsery", implying that the date of the disturbance was that of the observation of the eruption, 6 October. Thrum also reported:

Tidal phenomena was [sic] also experienced after the outbreak along the Kau coast, and at Hilo. At Punaluu, the night of the 8th, the tide ran out and did not return until the night following when it came back with a rush, flooding the wharf but fortunately without effecting any damage.

S.E. Bishop, a Honolulu minister interested in geophysical phenomena, in a letter dated 3 December and published in the Star the next day, commented on the source of the marine disturbances of 29 November. At the time he wrote he was aware of only the disturbance on the Honolulu tide gage, the washout of the railroad track around the west end of Oahu (which he considered occurred on the same date), and the "tidal wave" inundation at Pelekunu. His only comment was:

I venture that on or soon before the 29th, a violent earthquake and probably a volcanic eruption took place in the well known volcanic region of the Aleutian Islands, which is remote from telegraphic communication.

Wood (1904) published a review of the Mauna Loa eruption of October-December 1903. Like Thrum, he referred to the observations from the "Ormesery" ("Ormsery"), but unlike Thrum he considered the observation of the marine disturbance off the west coast of Hawaii to have been on 5 October.

Wood stated that: "Surveyors Baldwin and Dodge reported what seemed to be a flow among the small cones on the southwest side of the mountain, going towards Kahuku along the general line of the flows of 1868 and 1887. This flow was probably lost among the many cones and chasms of that slope as it was soon lost sight of". He also referred to a report that the lava had overflowed the caldera at the lowest point on its rim and was flowing down toward south Kona in the general line of the flow of 1859, but commented: "This report, although verified by two different parties, is probably not correct." Wood reported that the eruption had ended at 22:00 on 7 December.

Rudolf (1905) listed the tidal wave of 29 November in his catalog of 1903 earthquakes, stating that it caused inundations on Maui, Molokai, and Oahu, and was recorded on the Honolulu tide gage.

C.H. Hitchcock (1909) included in his history of the eruptions of Mauna Loa a section on that of October-December 1903 based principally on Wood (1904) but referring to Ridgway's sketches of Mokuaweoweo, which he found in the record book of the Volcano House under the date of October 13th. He also included what seems to be the photographic reproduction of the painting of Mokuaweoweo by D. Howard Hitchcock showing the eruption (Figure 3).

Hitchcock also reported:

Upon November 24th the sea was disturbed at Punaluu, unaccountable waves rising suddenly where it had been smooth before and lasting for ten minutes. At the same moment a black column of unusual size arose from Mokuaweoweo.



In his history of the eruptions of Kilauea, Hitchcock included a paragraph on the eruptions of November 1903 to January 1904, stating that the eruptions began at 04:15 on 25 November and ended on 10 January.

Brigham (1909) included in his discussion of Mauna Loa and Kilauea volcanoes a discussion of the Mauna Loa eruption of October to December 1903 and notes on Kilauea eruption of November 1903 to January 1903. The discussion of the Mauna Loa eruption was based principally on the accounts of first and second parties reaching the summit and was accompanied by a copy of Ridgeway's sketch map and by Baldwin's December photographs of Mokuaweoweo.

#### Recent reviews of volcanic activity

The only 1903 Mauna Loa volcanic activity listed in recent standard geophysical references (e.g. Stearns and Macdonald, 1946; Macdonald and Abbott, 1970) is the summit eruption commencing on 6 October that was reported to have lasted 60 days. Neither vent cones nor lava flows of that eruption are shown on the geologic map of the Mauna Loa quadrangle (Macdonald, 1971).

The standard references indicate that there was sporadic Kilauea volcanic activity in the period between 1894 and 1907 but list no specific activity in 1903.

#### Recent reviews of marine disturbances

Iida *et al.* (1967), in their preliminary catalog of Pacific tsunamis, included the reported disturbance of 8 October 1903 on the coast at Punaluu as a questionable tsunami and the reported disturbance of 6 October off the west coast of Hawaii as a non-tsunami or mistakenly dated event, citing Thrum (1903) and Wood (1904). They considered the accounts of both events fanciful.

Pararas-Carayannis (1969), in his first catalog of Hawaiian tsunamis, citing the same works, added 5 October as another non-tsunami or erroneous event date and the added "tidal phenomena" reported at Hilo to the event effects.

Solov'ev and Go (1975), in their catalog of eastern Pacific tsunamis, added to the list the reported marine disturbance of 24 November at Punaluu, citing Hitchcock (1909), and the "tidal wave" of 29 November at Maui, Molokai, and Oahu, citing Rudolf (1905). They considered these events, as well as that of early October, questionable occurrences of waves of tsunami type but of meteorological or unknown origin.

Pararas-Carayannis and Calebaugh (1977), in the second edition of the Hawaiian tsunami catalog, citing Solov'ev and Go (1975) as well as the works cited in the first edition, classified the reported event dates as follows:

5 October:	erroneous or non-tsunami date;
6 October:	erroneous or non-tsunami date;
8 October:	date of questionable tsunami at Punaluu;
24 November:	date of questionable tsunami at Punaluu (mistakenly identified with north coast of Hawaii);
29 November:	date of questionable tsunami inundating coasts of Oahu and Molokai and recorded at Honolulu.

Cox and Morgan (1977), in reviewing the reported marine disturbances as possible locally generated tsunamis, consulted several of the newspapers accounts of the events. They concluded that the disturbance off the west coast of Hawaii (which they assigned to the period 5-8 October), whatever it might have been, could not have been a tsunami. They concluded that the unusual behavior of the sea at Punaluu in October occurred on 10-11 October, considering Thrum's (1903) date of 8 October erroneous. However, they considered it unlikely that the behavior was that of a tsunami pointing out that, in any case, a tsunami could not have caused a rise in sea level lasting the better part of a day.

Finding no evidence to confirm Hitchcock's (1909) report of an unusual wave occurrence at Punaluu on 24 November, they concluded that the report probably confused the 10-11 October event at Punaluu with the reported "tidal wave" of 29 November.

From the accounts in the Star (12 Dec), the Herald (3 Dec), and the Gazette (4 Dec) of the "tidal wave" of 29 November and its effects, Cox and Morgan concluded that the descriptions were consistent with the identification of the wave as those of a tsunami. They considered local generation through slumping on the steep submarine slope north of Molokai more likely than a distant source. From the observations reported they estimated the runup height of the probable tsunami to be  $30 \pm 2$  feet at Honokohau, Maui, and  $13 \pm 6$  feet at Pelekunu, Molokai.

Cox (1979) estimated the profiles of the runups of the possible tsunamis of 10-11 October and 29 November along the coasts in the vicinity of the places of their reported observations.

#### Further information on marine disturbances of November 27-30

##### Marigraphic evidences

Because the marine disturbance of 29 November, which was identified as a tidal wave in the newspaper accounts of its effects on Maui and Molokai, was reported to have been recorded on the Honolulu tide gage, the NOAA Environmental Data and Information Service was asked to supply copies of the Honolulu marigrams for the periods in November and December during which marine disturbances were reported and copies of the San Francisco marigram for the period from several days before to several days after 29 November. The records were found in the archives of the U.S. Coast and Geodetic Survey, and copies were provided as requested.

The Honolulu marigrams were charts recorded on a drum with a rate of rotation of two revolutions per day. The charts were changed daily at about 08:00 or 09:00. The traces on the charts are very sharp, with no discernible broadening by high-frequency oscillation such as is almost always present in Honolulu Harbor now and must have had somewhat greater amplitudes in 1903 when the channel was less restricted. The ratio of orifice size to stilling-well size must have been much smaller than used with the later standard Coast and Geodetic Survey tide gage, and even oscillations with periods from 10 to 100 minutes must have been considerably damped. The record for the period from noon on 27 November until the morning of 1 December has been compiled in Figure 9.

A standard Coast and Geodetic Survey tide gage recording on a strip chart was used at San Francisco. The record for the period of interest, generally clear, shows a characteristic continuing oscillation generally with a period of less than 5 min. and a range of less than 0.01 ft. The more distinctive oscillations recorded during the period are noted in Table 6.

##### Anecdote of the "tidal wave" at Pelekunu

It will be recalled that John Wilson whose reports of the disturbance of November 29 at Kalaupana and Pelekunu, on the north coast of Molokai, was identified in one Honolulu newspaper as an engineer returning from a project at Kalaupana and in another as a resident of Pelekuna. A friend, Morris Fox, to whom I mentioned quite casually that I was reviewing the events of the period, turned out to have been an assistant to Wilson, and although this was at a time 40 years ago and nearly 40 years after the 1903 event, to remember vividly Wilson's anecdotal account of the event.

According to Fox (personal communication, July 9, 1982):

Johnny and Jennie Wilson were living at the mouth of Pelekunu Valley in the early 1900's. One day, Johnny noticed sea conditions which he believed meant there was going to be a tidal wave. He told Jennie to grab some belongings and head mauka. He opened the front and rear doors of the house and ran.

The wave(s) swept past and through the house, going in the front door and out the back. The house survived. A rock wall which enclosed the front yard where they had hibiscus bushes was destroyed. They found the stones scattered over much of the garden area.

Fox could associate the anecdote only with a date early in the 1900's but, after providing me with the above anecdotal information, learned that John and Jennie Wilson were not married until after 1903. Because of the significance of the information in the identification of the waves of this event, information bearing on the provenance of the anecdote is pertinent.

John H. Wilson (1877-1956) was a part-Hawaiian whose mother was a member of an alii (chiefly) family. He himself was a protege of Queen Liliuokalani. Early plans of Wilson and Jennie Kapahu to marry were opposed by his parents because she was a makaainana (commoner). He went off to Stanford University in 1981 for training as an engineer, was forced to leave the University because the Hawaiian revolution cut off his support, and became the manager of the Royal Hawaiian band, still royalist, on a tour of the United States. He apparently was not in Hawaii again until 1896, and he "returned with a hauole wife". He worked as a engineer for Oahu Railway for a year and then became a partner in the contracting firm that constructed the road over the Nuuanu Pali that served until the present highway was constructed in the 1950's. The partnership was dissolved in 1900, but Wilson continued to work as an engineer and contractor on Maui, Molokai, and Oahu and also grew taro on Molokai, apparently employed almost simultaneously in more than one of these activities on more than one island.

When Wilson's first marriage ended in divorce is not clear. He and Jennie Kapahu, who had become a professional hula dancer, seem to have kept in touch, and it was after her return from a mainland tour that they were married in 1908. Their home then was at Pelehunu where his taro farm was and where she served as postmistress. They moved to Honolulu in 1919 when he became chief engineer for the City and County. He served as Mayor from 1920 to 1926, 1928 to 1930, and 1946 to 1954, and as Director of the State Department of Public Welfare from 1939 to 1946. It was while Morris Fox was his assistant in that Department that he related the tidal wave anecdote to Fox.

It is quite unlikely that Wilson experienced two events of the kind to which the anecdote relates; the newspaper accounts clearly date it in November 1903, and the anecdote clearly places Wilson at Pelehunu at the time. The woman with whom he was living might possibly have been his first, "hauole wife", but with at least equal probability it was Jennie Kapahu.

Evidently, between the time Wilson realized that his house was likely to be inundated and the time of its actual inundation, there was a lapse sufficient for him to open the doors so that the water could run through the house, for the woman to pick up a few belongings, and for both of them to escape inland--several minutes at least.

Fox does not remember what evidence it was that led Wilson to expect the inundation, but Wilson's reference to the phenomena as a tidal wave in both the anecdote and published account (Star, Dec 2; Advertiser, Dec 3) suggests that the evidence was a recession preceding the highest wave of a tsunami. The anecdote is, however, open to the alternative interpretation that Wilson anticipated the inundation on the basis of observations of the effects of the wave setup of a swell and of the approach of higher swells.

The second interpretation is suggested by Wilson's description of the waves in the Star (Dec 2) account as "a series of big rollers each succeeding one larger than the others", and with Nathaniel's report (Bulletin, Dec 7) that at "the sea became rough" at Kalaupana at 08:00, six hours earlier than the time of the inundation at Pelehuna reported in the Star. The second interpretation is, however, inconsistent with the report identified with Wilson in the Advertiser (Dec 3) the water was smooth a quarter of a mile offshore.

## VOLCANIC ACTIVITY IN 1903-1904

Mauna Loa

The last activity of Mauna Loa prior to 1903 had been a 4-day eruption on the northeast rift in July 1899 (Stearns and Macdonald, 1946; Macdonald and Abbott, 1970). The last summit eruption had been a 16-day one in April-May 1896.

The evidence of the Mauna Loa eruption in early August 1903 (Herald, 6 Oct) seems appropriately to have been discounted. However, the evidences of an eruption in early September, can certainly not be discounted completely. As pointed out at the time, night-time observation of a Mauna Loa summit eruption is quite possible from the top of Haleakala without observation on Hawaii (Star, 7 Oct; Advertiser, 7, 8 Oct), and the observer, Austin, seems to have had a substantial basis for interpreting what he saw on the night of 1 September. The only evidence of unreliability in Austin's report is his statement that he could see Kilauea in front of Mauna Loa. He was probably referring to Hualalai or Kohala. The glow from an eruption in Kilauea Crater would have been seen from Haleakala just to the left of the Mauna Loa summit. However an eruption there would surely have been noted at the Volcano House, and an eruption on the southwest rift of Kilauea would surely have been reported by observers in the Kau district. Even an eruption on the east rift of Kilauea, if large enough to have its glow seen from Mauna Loa, would probably have been reported by observers on Hawaii. Hence it seems quite probable that there was activity at the summit of Mauna Loa on the night of 1 September.

The evidence of the eruption reported from the Kaieiewaho channel on the night of 3 September is less convincing, but it is not improbable that the eruption of 1 September continued for two days or was renewed two days later. In any case the September eruption or eruptions must have been brief.

There is no question as to the occurrence of the summit eruption of October to December 1903. All of the evidence indicates that it began not long after noon on 6 October, probably at about 12:45 as indicated in the October monthly weather summary. The contemporary accounts indicate that it ended, fairly abruptly, at night on 8 December -- at about 21:00 as reported from Kilauea (Herald, 10 Dec) or about 23:00 as reported from the Kau or Kona coast (Star, 11 Dec). Wood's (1904) report (and Hitchcock's 1909 report derived from Wood's) that the eruption ended the previous night seems mistaken. The duration of the eruption was, therefore, not quite 63½ days, rather than 60 days as later reported.

Spacial relationships between the eruptive fissure and early flows in Mokuaweoweo and the pre-existing features of the caldera suggested by the contemporary descriptions of the eruption, Ridgway's sketch and sketch map of 13 or 14 October (Figures 1 and 2), the probable Howard Hitchcock painting reproduced by Hitchcock (1909) (Figure 3), the sketch map of 21 October (Figure 4), and Baldwin's photographs of 7-8 December (Figures 5 and 6) are shown in Figure 7. The outlines of the caldera shown in the figure have been taken from the modern U.S. Geological Survey Mauna Loa quadrangle. The scarp across the southwesterly part of Mokuaweoweo shown in the sketch, the sketch maps, and the photograph, is assumed in Figure 7 to follow a concealed fault in the same area mapped by Macdonald (1971). The smaller scarp across the northeastern part of the caldera shown in the sketch map is similarly located in the figure. A description of Mokuaweoweo in 1885, written by J.M. Alexander, who with J.S. Emerson had surveyed the caldera then (Advertiser, 22 Oct), indicates that both scarps predated the 1896 eruption.

It is doubtful that the bank referred to by Berndt (Star, 20 Oct) was created during the 1899 eruption, as he supposed, but it may well have been the southwesterly scarp. Berndt's statement that the lava fill had nearly reached the top of the bank on 17 October and that "the entire bottom of Mokuaweoweo . . . is one mass of molten, streaming lava", and Thielen's statement (Star, 10 Nov) that on the whole floor of the crater was covered by fresh lava, suggest that most if not all of the part of the caldera between the two scarps was eventually covered and filled nearly to the level of the southwestern scarp. The contemporary estimates of the depth of the fill depended critically on both the estimated depth of the caldera in 1899 and on estimates of the height of its rim above the 1903 flows, and are not necessarily reliable.

The position of the 1903 rift and its north-northeast trend in Figure 7 are based primarily on Ridgway's sketches. As pointed out by Jack Lockridge of the Hawaiian Volcano Observatory, the southeast-northeast orientation of the rift reported by Berndt (Star, 20 Oct) would not fit the trend of other historic Mauna Loa rift zones or dikes, and Berndt also misidentified the major axis of the caldera as southeast-northwest.

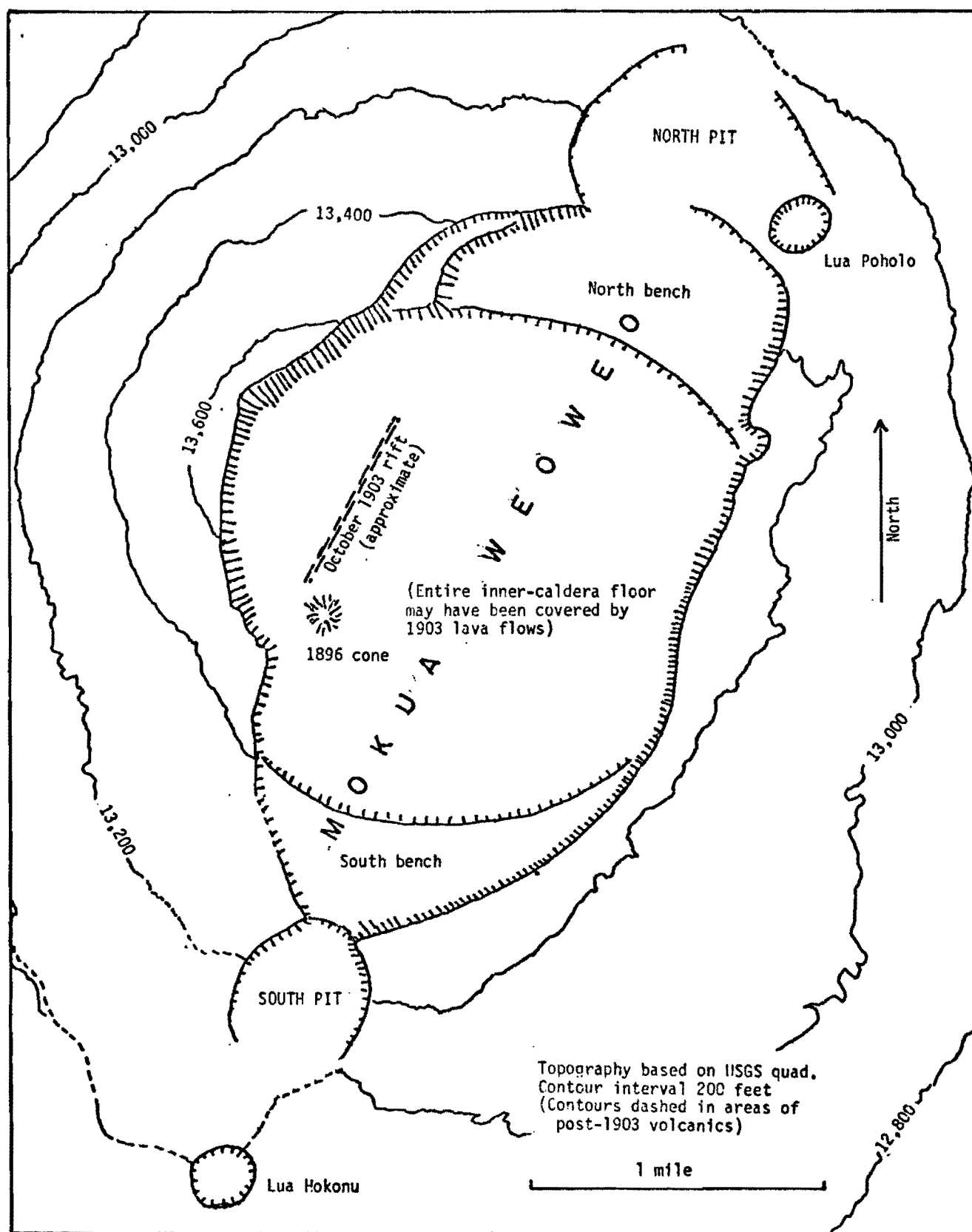


Figure 7. Map of summit of Mauna Loa showing approximate location of October 1903 rift.

Ridgeway's sketches and sketch map of 13 or 14 October (Figures 1 and 2) and the unidentified sketch of 21 October (Figure 4) show the major flow on those dates extending east-northeast from the rift and Baldwin's description and photographs of 7-8 December indicate that on December the major flow had the same trend, although Baldwin indicated that, after passing in the Kau direction, the flow circled around to the south and returned toward the southwest margin of the caldera. The most active parts of the rift and the position of the major flow seem to have changed from time to time, and most of the inner caldera may have been covered by the flows formed at various times during the eruption. Hence attempt has been made to delineate in Figure 7 the extent of the various individual cones, flows, and lava lakes.

Although extra-caldera flows were reported from time to time, it is not certain that there were any. Certainly there was no overflow from the caldera. The reports that are least easily discredited are that of E.D. Baldwin (Star, 10 Oct. Attributed by Wood (1904) to Dodge and Baldwin) of a flow originating at a vent high on the Mauna Loa south rift, and that of Fleming (Bulletin, 30 Oct, 10 Nov), which might have related to the same flow and vent after they were no longer active. No party ascended Mauna Loa along the south rift, and Baldwin saw what he thought were evidences of the flow only from a distance. However, in Fleming's rebuttal to the claim that neither he nor Douglas had seen an extra-caldera flow (Advertiser, 21 Nov), he provided what seems to be a detailed description of the flow and its vent. They were inactive when he saw them, but he reported a crack "within twenty yards of the head of the flow that was hot as a furnace", leading him to believe that the flow was "not over a week or ten days old".

It is very unlikely that there were vents on the north flank of Mauna Loa as suggested by the observation of 13 October reported from Kaupo, Maui, in the Star (16 Nov) and that of 17 October from Haleakala, reported by Fleming (Advertiser, 21 Nov). The party ascending from Humuula on about 30 November would have had to pass within a few miles of the reported vents, and should have seen some signs of recent activity if the vents had been active a few weeks earlier.

That none of the products of the 1903 eruption are shown on Macdonald's (1971) geologic map of the Mauna Loa quadrangle is not surprising. The post-1903 floor of Mokuaweoweo and even the 1903 vent cones have undoubtedly been covered by the products of subsequent eruptions.

### Kilauea

There can be no doubt as to the occurrence of the 1903-04 eruption of Kilauea. The eruption began early in the morning of 25 November, 1903, evidences being seen at 02:30 according to the Star (25 Nov) or 05:00 according to the Herald (26 Nov). Hitchcock's statement that the eruption ended on 10 January 1904 may be correct. The fire fountains and flows were confined entirely to Halemaumau.



## OFFSHORE DISTURBANCES, OCTOBER 1903

Although the observation of marine disturbances reported from the "Ormsery" on 5 or 6 October and from the "Iwalani" and "Kaiulani" several days later (Table 2) were considered by the newspapers to relate to the same disturbance, not only the dates of observation but, as will be shown, the sites of observations were quite distinct.

Table 1. Reported offshore marine disturbances, 5-15 October.

Place	Mon, 5 Oct	Tues, 6 Oct
Off Hawaii	Whirlpool-like disturbance; waves breaking over vessel; vessel unmanageable: "Ormsery" ( <u>Bulletin</u> , 5 Oct); <u>Herald</u> (15 Oct)). "A sort of maelstrom"; boiling and swelling; ship forced astern: "Ormsary" ( <u>Star</u> , 7 Oct; <u>Herald</u> , 15 Oct). Agitation as if by great springs; unusual heat; vessel forced astern as if by tidal wave from coast: "Ormsery" ( <u>Advertiser</u> , 8 Oct). Currents and high cross seas: (Mo. Weath. Sum.) Boiling as if from great springs; increase in temp, shock to vessel as if from tidal wave: "Ormsery" (Wood, 1904).	"Peculiar commotion... as if a submarine explosion" "Ormsery" (Thrum, 1903)
	Sat, 10 Oct and Thur, 15 Oct (Date approximate)	
Off Kahoolawe	Action like whirlpool: "Iwalani" and "Kaiulani" ( <u>Star</u> , 16 Oct).	

Off Hawaii, 5 or 6 October

All accounts of the marine disturbance south or west of Hawaii on the 5th or 6th of October stem from the reports of witnesses aboard the "Ormsery" (or "Ormsary" or "Ormesery") a British ship, identified as a bark by the Herald (15 Oct), bound for Honolulu from Newcastle. The vessel was probably one of several sailing ships employed to carry coal from Newcastle. Another, the schooner "Kailua", arrived in Honolulu on 19 December after what was considered an unusually slow trip of 74 days (Star, 19 Dec). The Newcastle from which the coal was imported was clearly not the Newcastle-on-Tyne in England, which had been a coal town for centuries, but the Newcastle in New South Wales in Australia, near which large coal fields had been opened up.

The most reliable of the descriptions of the disturbance seem to be those quoted from the ship's log and interview with Coath in the Bulletin (7 Oct) — rotary currents sufficiently strong and of sufficiently small dimensions to cause the ship to swing unmanageably under calm conditions and even when there was a breeze from the southwest. Coath also reported waves breaking over the vessel, presumably meaning onto its deck, although the effect was not mentioned in the log. The log mentioned a net eastward set to the currents, although how such a set could be determined is not clear considering the lack of determined positions of the ship on the 5th or before noon on the 6th.

The other descriptions published in the newspapers, based on interviews with Coath, or with the first mate, Carter, are similar except that they suggest a somewhat simpler rotary motion of the water like a single whirlpool (Star, 7 Oct) or maelstrom (Advertiser, 8 Oct) rather than erratic and reversing rotary motions; forcing of the vessel astern (Star, as if by the impact of a tidal wave starting from the coast", Advertiser) rather than merely its inability to make headway; "boiling and swelling" indicating "a subterranean upheaval" or agitation "as if from great springs boiling up from below" (Advertiser; Wood, 1904) and unusual heat (Star; Advertiser; Wood).

The disturbance was first observed on Monday evening, 5 October according to all of the newspapers accounts — at 20:00 according to both Captain Coath and the ship's log (Bulletin, 7 Oct).



Thrum's (1903) report that the disturbance was observed on the same day as the first evidences of the Mauna Loa summit eruption, Tuesday, 6 October, was not wholly wrong, however, because the log indicates that the ship remained ungovernable all Monday night and until at least 06:00 Tuesday morning.

Just where the disturbance was encountered is not immediately apparent from the accounts. The Star (16 Oct) later considered that the site of the disturbance was the same as that of the disturbance encountered by the "Iwalani" about 5 and 10 days later. However, the later disturbance was reported not far southwest of Kahoolawe, and the "Ormsery", travelling northward toward Honolulu and off the west coast of Hawaii at noon on Tuesday, 6 September, could have been that anywhere near Kahoolawe the previous evening. Wood (1904) implied that the ship was still out of sight of land. However, Captain Coath described the vessel as already "off the coast of Hawaii" (Bulletin, 7 Oct).

The location of the area in which the disturbance was observed may at least be approximated by reference to the ship's position at noon on the 6th of October and notes in the log on the relation of its position at other times to the island of Hawaii. It must first be determined, however, whether the Bulletin correctly quoted the log as to the ship's noon position or whether, in the original, the geodetic coordinates were expressed in degrees and minutes, as usual in marine navigation, and the numerical values in minutes were erroneously indicated in the quotation as decimals of degrees.

The question may be resolved by comparing the alternative possibilities for the ship's position at noon on the 6th with the note in the log as to the bearing and estimated distance of Mauna Loa from the ship at sunset on the same day. If the error had been made, the ship would have been directly over the Indianapolis Seamount at noon (Figure 8). The direction from this position to that at sunset suggested by the bearing and distance to Mauna Loa would have been far to the north of the direct course to Honolulu, especially if the distance were given in statute miles, and the ship's progress during the afternoon would have been much smaller than expected considering the fresh gale that sprung up, strengthening so that sail was shortened at 16:00. In contrast, the direction and distance travelled during the afternoon are consistent with the weather conditions and the ship's destination if it is assumed that her noon position was that indicated in the Bulletin and her estimated distance from Mauna Loa was given in nautical miles. Hence it is the noon position indicated in the Bulletin that is plotted in Figure 8.

Unless the ship were considerably farther east than seems probable, the south point of the island, Ka Lae, would not have been visible from the ship on the morning of October 6th, and the bearing to the island given in the ship's log probably referred to some point on the slope of Mauna Loa if not the summit of the mountain. The bearing is, in fact, almost exactly that of the summit from the plotted noon position of the ship, suggesting that, as expectable from the weather conditions, the ship made very little progress during the morning.

No fix of the ship's position is given in the log for 5 October. However, the fact that during that afternoon the sea became smooth in spite of a "brisk breeze" from east by north suggests that the ship passed into the lea of Hawaii, probably well offshore because no landfall was reported. It thus appears that the ship made no more than about 30 n. mi. to the north between some time in the afternoon of the 5th of October and noon of the 6th. Most of that progress was probably made during the afternoon and early evening of the 5th, before the breeze failed.

The area in which the marine disturbance that affected the "Ormsery" has, therefore been plotted in Figure 8 as extending from the ship's noon position on the 6th no more than about 10 n. mi. to the south.

Parts of the descriptions of the disturbance are consistent with its origin in a submarine volcanic eruption as Captain Coath surmised (Bulletin, 7 Oct). One of the seamounts southeast of Hawaii, Loihi (Figure 6), is now known to be an active volcano, but the "Ormsery" could not have been in this vicinity of Loihi on the evening of the 5th or morning of the 6th of October, and there are no seamounts in the vicinity of the estimated position of the disturbance.

The Advertiser (8 Oct) reported that, during the disturbance, "the ship was forced astern as if by the impact of a tidal wave starting from the coast", and an abnormally high tide and very large "rollers" were reported at Punaluu on the southeast coast of Hawaii (Star, 9 Oct) (See later discussion of coastal disturbance). However, even a tsunami with a very high runup on the Kona coast could not have been observed in the deep water offshore.

By the process of elimination, therefore, it seems most probable that the disturbance was a series of eddies generated in the wake of the island of Hawaii by the prevailing easterly current with the possible reinforcements of tidal currents. However, both the intensity of the eddies encountered by and the small dimensions suggested by their effects on the ship's heading seem quite unusual.

#### Off Kahoolawe, about 10 and 11 October

As indicated earlier, although the disturbance encountered by the "Iwalani" on its mid-October run to Hawaii, and also apparently by the "Kaiulani" at about the same time (Star, 16 Oct), was reported to have been at the same location as that encountered earlier by the "Ormsery", the sites were not the same. The area of the later disturbance is plotted in Figure 6 and with dimensions and at the location reported in the Star, about 5 by 10 miles and centered about 10 miles southwest of Kahoolawe.

The "Iwalani" left Honolulu on Friday afternoon, 9 October and arrived at Kailua the next night (Advertiser, 17 Oct). She left Punaluu on her return voyage at 18:00 on Wednesday, 14 October, and arrived at Honolulu the next night. (Star, 16 Oct. The interview with her purser published in the Advertiser 17 October must have occurred on 16 October and the purser's reference to arrival "yesterday" at Honolulu must have referred to 15 October.) Hence the ship was presumably southwest of Kahoolawe early Saturday morning, 10 October, and again late Thursday morning or early Thursday afternoon, 15 October.

The effects on the vessel reported by Captain Mosher (Star, 16 Oct) seem clearly to have been those of large waves, sufficiently steep for Mosher to describe the sea as "choppy" although there was no wind.

The description of the mid-October disturbance as "almost like a whirlpool" may well have been influenced by the reports of the earlier disturbance encountered by the "Ormsery". A south-setting current, such as reported by Mosher, could not have been detected directly but might have been determined by comparing the ship's actual course as determined by navigation with that estimated by dead reckoning.

The disturbance seems most likely to have been simply that of an unusual swell from some storm center not very distant, although the description does not suggest from what direction the swell came.

Nothing in the description of the disturbance suggests a connection with the disturbances reported at Punaluu and possibly at Hilo on 10-11 October (see next chapter).

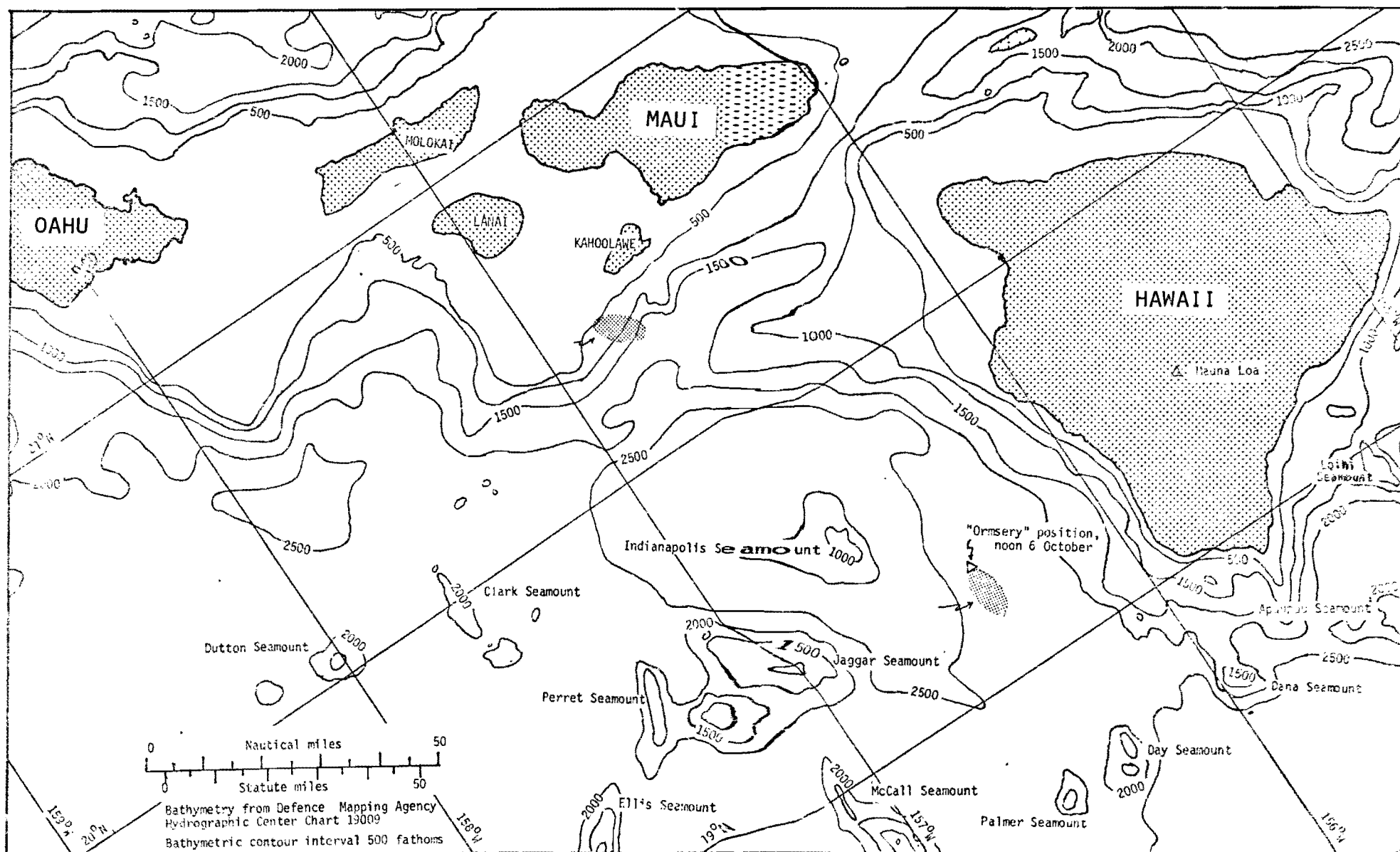


Figure 8. Bathymetric map of southeastern Hawaiian Islands showing location of reported offshore marine disturbances of October 1903.

## COASTAL DISTURBANCES, OCTOBER - DECEMBER 1903

### Introduction

Of the numerous marine disturbances reported at various places along the Hawaiian coasts in the last quarter of 1903, four were originally described as "tidal waves" or have been considered possible tsunamis, those of:

- i) 8 October on the Kau coast of Hawaii;
- ii) 10-11 October on the same coast;
- iii) 29 November on the north coasts of Maui, Molokai, and on Oahu; and
- iv) 19 December on the Kona coast of Hawaii and the south coast of Maui.

The locations of places of reported effects of these and other reported coastal disturbances are shown in Figures 9 and 10.

Other than the first three of the above events, the only Pacific tsunami events reported for the last four months of 1903 are a very doubtful Taiwan tsunami occurring on 7 September, a questionable Chile tsunami on 26 September, and a probable Chile tsunami on 7 December (Solov'ev and Go, 1974, 1975). No hurricanes or other tropical disturbances have been identified by Shaw in his history of tropical cyclones in the central north Pacific and the Hawaiian Islands for the period from January 1903 to November 1904. The only Pacific earthquake listed for the period by Ganse and Nelson (1981) was one that occurred at 7.0 W, 127.0 E, in southeastern Mindanao, Philippines, on 28 December. Although it had a magnitude of 7.8 and caused moderate damage, there is no evidence it was accompanied by a tsunami.

Two tables of information that may be useful in the analysis of the reports of coastal disturbances such as those reported in October-December 1903 are appended to this report:

Appendix C: Criteria that may be useful in distinguishing among tsunamis, storm surges, and other waves that may be confused with them from the descriptions of the waves as they impinge on a coast and from their reported accompaniments.

Appendix D: A tide table for Honolulu, compiled from tide forecasts published regularly in the Star. The times of the tides on the Kau coast of Hawaii should have preceded those at Honolulu by about 25 minutes and those for other coasts of islands east of Oahu by lesser amounts. The published forecasts included heights only for the higher high tides alone.

### Disturbances of 5 October to 24 November

For convenience of reference, descriptions of the disturbances reported as occurring in the period between 5 October and 24 November are summarized in Table 2.

#### Punaluu, 5 October

The only report of the marine disturbances at Punaluu on Monday, 5 October, is that of Captain Simersen of the "Mauna Loa" (Star, 9 Oct).

The "Mauna Loa" arrived at Punaluu on the morning of the 5th but almost certainly not before the higher high tide of the day and in any case the effects of that tide could not have been observed from the ship at night. Although Simersen reported a "very, very high tide" there on that day (Star, 9 Oct), it would seem strange if he considered the lesser high, occurring early in the afternoon, as unusually high. The big irregular rollers described by Simersen could, of course, have represented, of course, a distant swell. However, Simersen seems to have reported nothing out of the ordinary on the 6th of October, while the "Mauna Loa" was still at Punaluu, nor at Hoopuloa, Kealakekua Bay, or Kailua, on the Kona coast, which were visited by the "Mauna Loa" on the 7th and 8th.

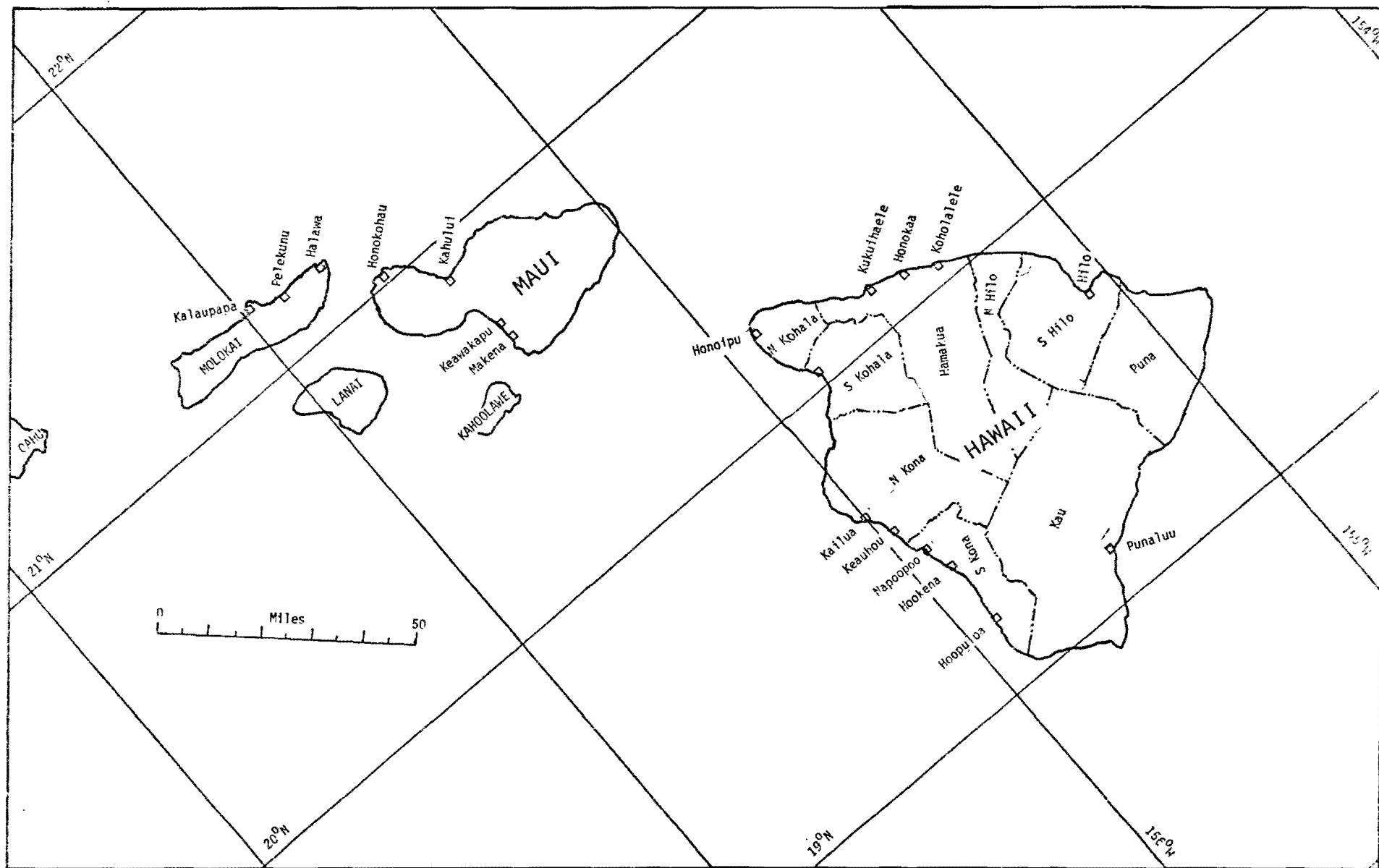


Figure 9. Map of southeastern Hawaiian Islands showing places mentioned in connection with unusual waves of October-December 1903.

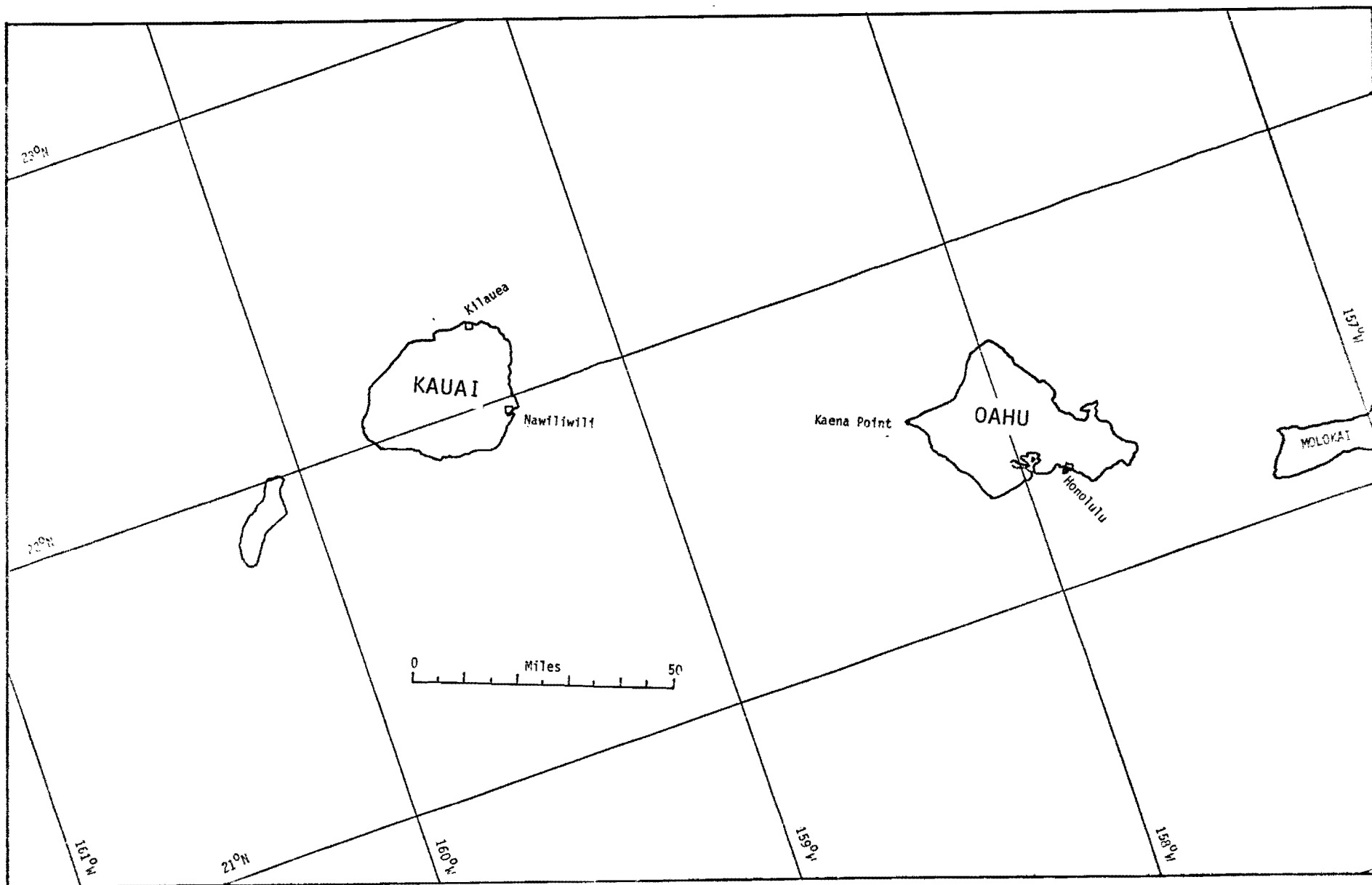


Figure 10. Map of northwestern Hawaiian Islands showing places mentioned in connection with unusual waves of October-December 1903.

Table 2. Reported marine disturbances, 5 October - 24 November.

Place	Mon, 5 Oct	Thurs & Fri, 8-9 Oct	Sat & Sun, 10-11 Oct	Sun - Thurs, 25-29 Oct
<u>Hawaii</u>				
Kona				Rough seas: ( <u>Star</u> , 30 Oct)
Napoopoo				Waves over wharf, 29th: "Mauna Loa" ( <u>Star</u> , 30 Oct)
Kau Punaluu	Unusually high tide & big, irregular rollers: "Mauna Loa" ( <u>Star</u> , 9 Oct). Waterspout: Fennell, (Tribune, 9 Oct)	Tide ran out night of 8th; did not return until night of 9th, when rush flooded wharf Thrum (1903)	Extraordinary low tide, night of 10th, continuing until eve- ning of 11th when rush covered wharf: "Iwalani" ( <u>Star</u> , 16 Oct)	Rough seas ( <u>Star</u> , 30 Oct)
Hilo Hilo		Behavior similar to that at Punaluu (Thrum, 1903)	Behavior similar to that at Punaluu ( <u>Star</u> , 16 Oct)	
Place	Thurs, 5 Nov	Wed-Thurs, 11-12 Nov	Tues, 17 Nov	Tues, 24 Nov
<u>Hawaii</u>				
Kau Punaluu			Choppy sea & churning water swinging ship about & capsizing boat: "Mauna Loa" ( <u>Star</u> , 20 Nov; <u>Bulletin</u> , 20 Nov; <u>Advertiser</u> , 28 Nov; Mo. Weath. Sum.)	"Unaccountable waves last- ing 10 minutes": (Hitchcock, 1909)
Hilo Hilo	High seas almost capsizing boat & throwing two men overboard: ( <u>Advertiser</u> , 9 Nov; <u>Star</u> , 9 Nov; <u>Gazette</u> , 10 Nov; <u>Bulletin</u> , 10 Nov)			
Hamakua Honokaa		Rough water, 12th; boat capsized and wrecked, two seamen injured: "Iwalani" ( <u>Advertiser</u> , 16 Nov; <u>Star</u> , 16 Nov; <u>Gazette</u> , 17 Nov)		
<u>Oahu</u>				
Honolulu		High sea; night of 11th surges causing damage to vessel at new dock: ( <u>Advertiser</u> , 16 Nov)		

There were reports suggesting storm conditions in Hawaii at the time, and it is notable that Simersen's report of the unusual disturbance at Punaluu was not carried in any other newspaper. It appears that the Star, especially, was actively seeking news of any geophysical phenomenon that might in some way be connected with the volcanic activity of the time. Hence exaggerations are quite possible in the reports of interviews with these officers, whether the exaggerations were those of the officers or the Star reporters.

Whether or not there were any unusual marine disturbances at Punaluu on 5 October, there is nothing in Simersen's description that suggests the occurrence of a tsunami or storm surge.

Although in noting the report by W.P. Fenell, the wharf superintendent at Punaluu, that a waterspout occurred off the coast at Punaluu, the Tribune (9 Oct) implied that the occurrence was on 5 October, the actual occurrence must have been about 28 September, as indicated by the Bulletin (29 Sep).

#### Punaluu and Hilo, 8-11 October

There are no newspaper accounts of an unusual disturbance at Punaluu on Thursday, 8 October or the next day. The unusually low level of the sea of extraordinary duration at Punaluu and the similar behavior off Hilo reported by Thrum (1903) as if occurring on those days seem obviously to have been based on the report in the Star (16 Oct) of disturbances at those places. The actual dates of the disturbances or at least that of the disturbance at Punaluu were presumably those reported in the Star on the basis of the account of Captain Mosher of the "Iwalani", Saturday and Sunday, 10 and 11 October.

Having left Honolulu on Friday, 9 October, the "Iwalani" reached Kailua the next night (Advertiser, 16 Oct) and went on to Honuapo and Punaluu, probably visiting those ports in that order on Sunday, 11 October. The recession Saturday night reported by Mosher could not, therefore, have been observed by him but must have been reported to him.

There was a lower low tide that night. The forecast record for Honolulu (Appendix C) suggests that it should have been lowest on the Kau coast at about 23:30 although the Honolulu marigram suggests it occurred about 20 minutes earlier. However this was succeeded by the higher high tide of the day, probably at about 07:40 to judge from the Honolulu marigram, when, according to the report, the water remained low. The later high water described by Mosher might have been at about 18:15 when there should have been another high tide (but not the higher of the day), and the rise from the low to the high should not have resulted in the "rush" causing a "small sized flood over the landing" as reported by Mosher. The Honolulu marigram shows no unusual tide behavior or oscillation at the time of the reported disturbance.

It is notable that the purser of the Mauna Loa made no mention of the disturbance at Punaluu when interviewed by the Advertiser (16 Oct), mentioning only a thunder and rain storm on 14 October. The only other report suggesting storm conditions at about the time of the disturbance was that in the Bulletin (16 Oct) concerning a heavy swell from the north on the north and east coasts of Kauai, also on 14 October.

A tsunami could not possibly have had a period as long as that suggested by the description of the disturbance of 10-11 October. Cox and Morgan (1977) pointed out that the effects described for the event could conceivably have resulted from a temporary elevation of the coast followed by a subsidence accompanied by a small tsunami. They estimated that, if one did occur, the tsunami would have had to have a height of  $5 + 2$  feet to flood the wharf at Punaluu, but they considered the occurrence unlikely. I later considered the probability of occurrence of a tsunami as 0.85 (Cox, 1979), but this seems grossly overestimated. I now consider it very doubtful that there was a tsunami on 10-11 October at Punaluu.

The reports of effects at Hilo similar to those of 10-11 October at Punaluu, clearly relayed at least second hand by Captain Mosher to the Star, are even more subject to suspicion than the reports of the effects at Punaluu. There is little reason to believe that any significant disturbance occurred at Hilo.



### Punaluu, 17 and 24 November

Choppy seas and churning water are not uncommon at Punaluu, and even seas sufficiently high to capsize a boat at the landing probably occur at least annually. The unusual aspect of the experience at Punaluu on 17 November reported by the officers of the "Mauna Loa" is, particularly, the sudden onset of the disturbance after a period of calm, and its brief duration, limited to 10 minutes according to the Star (20 Nov) or 15 minutes according to the Bulletin (20 Nov) and Advertiser (21 Nov).

Whether the disturbance occurred during the afternoon as reported by the Star or during the forenoon as reported by the Advertiser and Bulletin, it must have occurred on the rising tide. However, neither the high tide (at about 15:00) nor the low tide of the morning (at about 09:40) were the extremes of the day. The Honolulu marigrams, which show the highest tide of the day at 02:55, the higher of the low tides at 09:34, the lower of the high tides at 14:30, and the lowest tide at 20:06, indicates no more than the normal minor oscillations at a little less than 20 minute period. Although high winds were reported in Kaieiewaho channel on the night of the 16th there is no evidence of high winds along the Kau coasts on the 17th; and no earthquakes reported at the time.

Although the officers of the "Mauna Loa" considered the disturbances related to the eruption of Mauna Loa, which at the time (Bulletin, Advertiser) or somewhat later (Star) emitted an especially dense column of smoke; and in spite of the reports of high winds on Hawaii, it seems virtually certain that the waves were of meteorological origin and probably related somehow to the "tremendous swells from the northwest" encountered by the "Ke Au Hou" in Kaieiewaho channel between Kauai and Oahu on the night of the 16th of November. At any rate there is no reason to suppose that the disturbance represented either a storm surge or a tsunami.

None of the newspapers reported a disturbance at Punaluu on the 24th of November when according to Hitchcock (1909) one occurred there. The duration of the disturbance he reported was the same as that reported by the Star for the disturbance of the 17th and the only inconsistency between the two accounts is the time of appearance of the large column of smoke from Mauna Loa that, according to Hitchcock, occurred at the same time as the marine disturbance but, according to the Star, was seen later in the day.

Cox and Morgan rightly considered that Hitchcock's report related to a disturbance occurring on some other date than that given by Hitchcock, but it was clearly the disturbance of 17 November and not that of 29 November as they suggested. There is no reason to suppose that there was another disturbance at Punaluu, similar to that of 17 November but occurring a week later.

### "Tidal wave" of 29 November and other disturbances of 27-30 November

The newspaper and other early descriptions of the marine disturbances reported at various places from the 27th to the 30th of November are briefly summarized in Table 3 and the reported times of occurrence, durations, heights, extents of inundation, and effects reported for the "tidal wave" of the 29th are summarized in Table 4.

In considering the identification of the waves of the 29th and the several days before and after that date, account must be taken, not only of the published descriptions of the waves and their effects, but also of the contemporary weather and seismic conditions, the marigraphic evidences of the waves, and Wilson's anecdotal account of the event at Pelekunu, Molokai.

#### Implications of contemporary seismic conditions and weather, and general duration and distribution of disturbances

There is no evidence of high winds in Hawaii during the period, from the 27th to the 30th of November, and on the 29th, the date of occurrence of the highest waves of the period, there were reports of a steady south wind at Kalaupapa, Molokai (Bulletin, 7 Dec), not much wind at Honokohau or Koholalele, Hawaii (Star, 8 Dec), and no wind at Honokohau, Maui (Star, 5 Dec). Interpretation of the high waves of the period as seas of an extraordinary local storm can, therefore, be ruled out. Their interpretation as storm surges can be ruled out on the same grounds, and also because what was reported in most accounts was a series of high waves and not a solitary wave. However, the identification of the high waves of the period as the swell from some distant storm of extraordinary size cannot be ruled out. Except for the reports of rough water at the South Kona ports of Hoopuloa

and Napoopoo on the 29th, all of the reports of extraordinary waves on the 27th to 30th emanated from north coasts of the islands, suggesting that, if the waves represented a distant swell, the storm responsible for its generation was in the North Pacific. The moderate gale of the 25th and full gale of the 26th experienced by the "Rosecrans", probably not far out of San Francisco on her way to Honolulu, might well have represented a part of such a storm. The continuance of unusually high waves from the 27th when the waves capsized a boat at Honoipu, on the north coast of Hawaii and were breaking over the landing at Kukuihaele on the northeast coast, until the 30th when the very rough water still made landing difficult at Kawaihae on the northwest coast, can be accounted for only if, during most of this period, the waves represented a distant swell. It may be assumed, therefore, that the unusual waves of the 27th and 28th were those of a swell generated by a North Pacific storm of exceptional intensity, and the only question is whether on the 29th there was, in addition a tsunami.

No earthquake of consequence was reported anywhere in Hawaii during the period, and there is no record of a major earthquake anywhere in the Pacific during or just before the period. The only event listed in the Pacific tsunami record is that of the 29th, and the only evidence suggesting the occurrence of a tsunami on that date is that from Hawaii. If the waves represented a local tsunami, it must have been one generated by some process such as submarine slumping that was not associated with a notable earthquake. If they represented a distant tsunami, its source must have been along some North Pacific coast from which reports were unlikely to be noted in the geophysical literature.

Neither the exact time nor the exact location of the track washout "between Kooalauloa and Waianae Point" on Oahu were reported, and it is not clear that the actual inundation causing the washout was observed. One possible location of the washout is the south coast of Kaena Point, where the roadbed was inundated by the April 1946 tsunami. However, it may have been Kaena Point that the Star (30 Nov) referred to as Waianae Point, and if so the washout must have been further north. Places at Kawaihoa and on the north shore of Waimea Bay are more likely to have been the locations of the washout if it resulted from a swell from the north and would fit better the Monthly Weather Report statement that it was on the north shore of Oahu. At any rate, although the track washout was coupled by Lydecker (Mo. Weath. Summ.) with the disturbance recorded on the Honolulu tide gage that he considered had some volcanic or seismic source, there is no evidence to rule out the attribution of the washout to still larger waves of the swell that had already been of unusual size for two days.

Nothing in the account of the experience of the "Eclipse" at Kawaihae on the northwest coast of Hawaii (Star, 3 Dec) suggests that the waves there on the evening of the 29th and on the 30th represented anything but the extraordinary swell. The report that they began to break in eight fathoms of water would suggest a trough-to-crest height of 30 to 35 feet.

Although the waves at Koholalele Landing on the northeast coast of Hawaii were considered by the Star (8 Dec) to represent "the same tidal wave that visited Oahu, Molokai, and Maui on November 29", there is nothing in the account to suggest that the personnel of the "Ka Moi" who reported them considered them anything other than an extraordinary sea or swell, and it is not clear, indeed, that the report referred to waves occurring on the 29th. The report that "the sea swept over the top of the crane that stood 40 feet in height at the landing" (Star, 8 Dec; Lydecker, Mo. Weath. Summ.) probably referred to dense spray rather than solid water.

Only the waves at Pelekunu on the north coast of Molokai and those at Honokohau on the north coast of West Maui seem to have been considered by their observers to represent tidal waves, and the identification was made in only in the reports from Pelekunu and one of the two reports from Honokohau, that of Kuhns (Star, 5 Dec).

#### Implications of reports from Honokohau and Pelekunu

The Kuhns account, and that in the Herald (3 Dec) agree that there were three large waves at Honokohau and that the third and largest had a height of 30 feet. The Herald account indicates that the height was "ascertained by measuring the mark left by the sea on the side of the pali" (clearly one of the cliff sides of Honokohau valley, the method employed in modern post-event tsunami runup surveys. It also provides a 25-foot estimate for the height of the first wave. The two accounts disagree as to the arrival time of the first of the large waves; only the Herald account suggests arrival times for the second and third waves; and in that account the arrival time of the second suggested by the reported interval after the first is identical to the reported arrival time for the third. It seems certain only that the three large waves arrived during a 2- or 3-hour period beginning at about 10:00 or 11:00.

Table 3. Reported marine disturbances, 27-30 November.

	Fri., 27th	Sat., 28th	Sun., 29th	Mon., 30th
<u>Hawaii</u>				
Kau		(Date?) <sup>a)</sup> Smooth water: "Mauna Loa" ( <u>Bulletin</u> , 1 Dec; <u>Advertiser</u> , 2 Dec; <u>Star</u> , 1 Dec)		
S. Kona Hoopuloa			(Date?) <sup>a)</sup> Rough water, waves over wharf: "Mauna Loa" <u>Bulletin</u> , 1 Dec; <u>Star</u> , 1 Dec; <u>Advertiser</u> , 2 Dec)	
Napoopoo			(Date?) <sup>a)</sup> Rough water, difficult landing: "Mauna Loa" ( <u>Bulletin</u> , 1 Dec; <u>Star</u> , 1 Dec; <u>Advertiser</u> , 2 Dec)	
N. Kona Keauhou			(Date?) <sup>a)</sup> Less rough: "Mauna Loa" ( <u>Bulletin</u> , 1 Dec; <u>Advertiser</u> , 2 Dec)	
Kailua			(Date?) <sup>a)</sup> Less rough: "Mauna Loa" ( <u>Bulletin</u> , 1 Dec; <u>Star</u> , 1 Dec; <u>Advertiser</u> , 2 Dec)	
S. Kohala Kawaihae			Very rough water difficult landing: "Eclipse" ( <u>Star</u> , 1 Dec)	Continued rough water, difficult landing: "Eclipse" ( <u>Star</u> , 3 Dec)
N. Kohala Honoipu		Rough water, difficult landing. Toward evening, 3 monster waves, boat capsized: "Eclipse" ( <u>Star</u> , 3 Dec; <u>Advertiser</u> , 4 Dec)		
Hamakua Kukuihaele		(Date?) <sup>a)</sup> Heavy swells breaking over landing: "Iwalani" ( <u>Advertiser</u> , 30 Nov)		

Koholalele		(Date?) Tidal wave: "Ka Moi" ( <u>Star</u> , 8 Dec); (Mo. Weath. Sum.)
<u>Maui</u>		
Unspecified		Tidal wave inundation: Rudolf (1905)
Kahului		Tidal wave: (Mo. Weath. Sum.)
Honokohau	High surf ( <u>Herald</u> , 3 Dec);	Tidal wave: ( <u>Herald</u> , 3 Dec); Kuhns ( <u>Star</u> , 3 Dec); (Mo. Weath. Sum.)
<u>Molokai</u>		
Unspecified		Tidal wave inundation: Rudolf (1905)
Halawa		Tidal wave: Wilson ( <u>Advertiser</u> , 3 Dec; <u>Gazette</u> , 4 Dec)
Pelekunu		Tidal wave: Wilson ( <u>Star</u> , 2 Dec; <u>Advertiser</u> , 3 Dec; <u>Gazette</u> , 4 Dec)
Kalaupapa		Tidal wave: Wilson ( <u>Star</u> , 2 Dec; <u>Advertiser</u> , 3 Dec; <u>Gazette</u> , 4 Dec); Nathaniel ( <u>Bulletin</u> , 7 Dec); (Mo. Weath. Sum.)
<u>Oahu</u>		
Unspecified		Tidal wave inundation: Rudolf (1905).
Honolulu		Marigraphic disturbance: Lydecker ( <u>Star</u> , 30 Nov); (Mo. Weath. Sum.)
Kaena Pt.(?)		Track washout <sup>b)</sup> : ( <u>Star</u> , 30 Nov, 2 Dec); (Mo. Weath. Sum.)
<u>Kauai</u>		
Kilauea	Northern swells preventing freight transfer: "Ke Au Hou" (Advertiser, 30 Nov)	

Notes:

- a) Date approximated from probable itinerary of "Mauna Loa" and "Iwalani."  
b) Date not specified in Star, 30 Nov., but stated to be same as Pelekunu event in Star, 2 Dec.

Table 4. Reported characteristics of reported "tidal wave" of 29 November.

Place	Source of report		Description	Time or duration	Height (or range), feet	Inundation beyond high water mark, feet	Effects
<u>Hawaii</u>							
Koholalele	"Ka Moi"	<u>Star</u> , 8 Dec	Northerly swell		40		Overtopped crane, carried boulders inland.
	Lydecker	Mo. Weath. Sum.	Heavy seas	Some hours	40		Overtopped crane, carried boulders inland.
<u>Maui</u>							
Kahului	Lydecker	Mo. Weath. Sum.	Tidal wave				
Honokohau		<u>Herald</u> , 3 Dec	Large waves	11:00 13:00	25 30		Destroyed stone walls & 2 houses.
	Kuhns	<u>Star</u> , 5 Dec	Tidal wave	-(1st wave) 10:00 (2nd wave) ? (3rd wave) ?	30		Report of damage obliterated; 2 men nearly caught.
	Lydecker	Mo. Weath. Sum.	Tidal wave				
<u>Molokai</u>							
Halawa to Kalaupapa	Wilson	<u>Advertiser</u> , 3 Dec <u>Gazette</u> , 4 Dec	Flooding Smooth water offshore.	2 hrs.			

Pelekunu	Wilson	<u>Star</u> , 2 Dec	Sudden rush. Series of big rollers increasing in size.	14:00	250	Inundation of houses 130 ft. inland of high water mark. Water checked by stone wall.
	Wilson	<u>Advertiser</u> , 3 Dec <u>Gazette</u> , 4 Dec	Tidal wave		250	Inundation of houses, flooding of taro patches.
	Lydecker	Mo. Weath. Sum.	Tidal wave			
	Wilson	Fox, anecdote	Tidal wave?	Time for escape before major inundation.		Destruction of stone wall, inundation of house.
Kalaupapa	Wilson	<u>Star</u> , 2 Dec	Tidal wave			Freight could not be landed.
	Wilson	<u>Advertiser</u> , 3 Dec <u>Gazette</u> , 4 Dec				2 houses washed away
	Nathaniel	<u>Star</u> , 7 Dec	Rough seas	Beginning at 08:00 and lasting all day.	40-50	Building shifted, wall destroyed, rocks carried away, cemetery inundated.
<u>Oahu</u>						
Honolulu	Lydecker	<u>Star</u> , 30 Nov Mo. Weath. Sum.	Unusual disturbance.			Unusual disturbance recorded on tide gage.
	Marigram		28-minute oscillation. More irregular	Beginning at about 08:20 Beginning at about 09:20	(0.15)	
			Oscillations	10:00 - 16:00	(0.12)	
"Between Waianae Point and Koolauloa"	Lydecker	<u>Star</u> , 30 Nov Mo. Weath. Sum.	Heavy waves			Railroad track washed out.

All of the accounts of the event at Pelekunu, those in the newspapers as well as the anecdotal account, seem to have originated with John Wilson. In the account in the Star the "tidal wave" was described as a "series of big rollers" of successively larger size running "fully 250 feet further inshore than the highest tide mark" and inundating houses 150 feet from the tide mark, the "sudden rush of waters" occurring at about 14:00. As an engineer and surveyor, Wilson was probably referring to the "high water mark" or "kahakai" (mark of the sea) forming the seaward boundary of property — the vegetation line marking the ordinarily farthest inland limit of wave wash, and not the high tide line. The Advertiser and Gazette added that taro patches were flooded. The report in the latter two papers that there was flooding "all along the coast from Kalaupapa to Halawa" presumably refers to the overall period during which there were high waves, and not the duration of inundation of a single wave. The report in the same two papers that at the time there was "smooth water in the ocean a quarter of a mile from shore" which probably refers to Pelekunu, is consistent with the identification of the waves as those of a tsunami.

In themselves, other aspects of the newspaper accounts of the waves and wave effects at Honokohau of a first unusual wave at 10:00 and the occurrence of the highest wave there and at Pelekunu between 12:00 and 14:00 would be consistent with a tsunami distant origin. The highest wave of a tsunami of local origin is unlikely to arrive as much as two hours after the first arrival at the same place.

The minimum apparent wave period suggested by the Honokohau reports, about 60 minutes, would be long even for a distant tsunami, and the maximum, about 90 minutes, would be extraordinary. Wilson's anecdotal account of the event at Pelekunu suggesting lapse of at least a few minutes between a recession and the succeeding inundation is not inconsistent with an apparent wave period typical of tsunamis, but would not, in itself, suggest a period even as long as 60 minutes.

#### Implications of reports from Kalaupapa

Because Wilson's anecdotal account clearly indicate that he was at Pelekunu on the 29th, the reports that he submitted to the newspapers on their effects at Kalaupapa, 7 miles to the west, must have been second hand, and the only eye-witness account of the waves at Kalaupapa was that of Nathaniel (Bulletin, 7 Dec). Except for the more or less definite initiation of the unusual wave action at 08:00 that he reported, his account is more consistent with the hypothesis that the waves represented an extraordinarily large swell than with the hypothesis that they represented a tsunami. If the waves were those of a tsunami arriving at Kalaupapa at 08:00, the major inundation at Pelekunu would be expected to occur much earlier than 14:00 and the highest wave would be expected to arrive at Honokohau much earlier than even 13:00. The hypothesis that the waves represented a swell is, however, inconsistent with the report that the water was smooth a quarter of a mile offshore, even if that report referred to conditions at Pelekunu.

The effects described by Nathaniel could have been caused by a swell with runup heights with no more than half the estimate of 40 or 50 feet he provided, which seems much more likely to represent the trough-to-crest height of the swell as it peaked just offshore.

#### Implications of Honolulu marigraphic evidence

From the Honolulu marigraphic record, Figure 11, it appears that the oscillation noted by Lydecker (Star, 30 Nov; Mon. Weath. Sum.) began about 08:20 on 29 November, 20 minutes after Nathaniel reported the beginning of high waves at Kalaupapa, Molokai (Star, 7 Dec), with a period of about 28 minutes; increased to a marigraphic range of about 0.15 feet range after about an hour but became more irregular due to the superposition of oscillations of shorter period; and continued thereafter with varying marigraphic range until 30 November at about 07:00. From 10:00 to 13:00 on the 29th when the highest waves were inundating Honokohau, Maui (Herald, 3 Dec), and between 14:00 and 16:00 when the highest waves occurred at Pelekunu, Molokai (Star, 2 Dec), the marigraphic range was about 0.12 feet. The reported high waves of other dates correlate poorly with the marigraphic record. For example, during most of 27 November, when rough water was reported on the Hamakua coast of Hawaii (Star, 3 Dec), the marigraphic trace was smooth, although during the evening when the roughest water was reported, a noticeable oscillation was recorded. The trace for most of 28 November, when the water was already reported rough at Honokohau (Herald, 3 Dec), is smooth, although during the afternoon an oscillation is again noticeable.

No part of the marigraphic trace closely resembles the typical marigraphic record of the initial part of a well-recorded tsunami. However, marigraphic records of tsunamis often do not show the

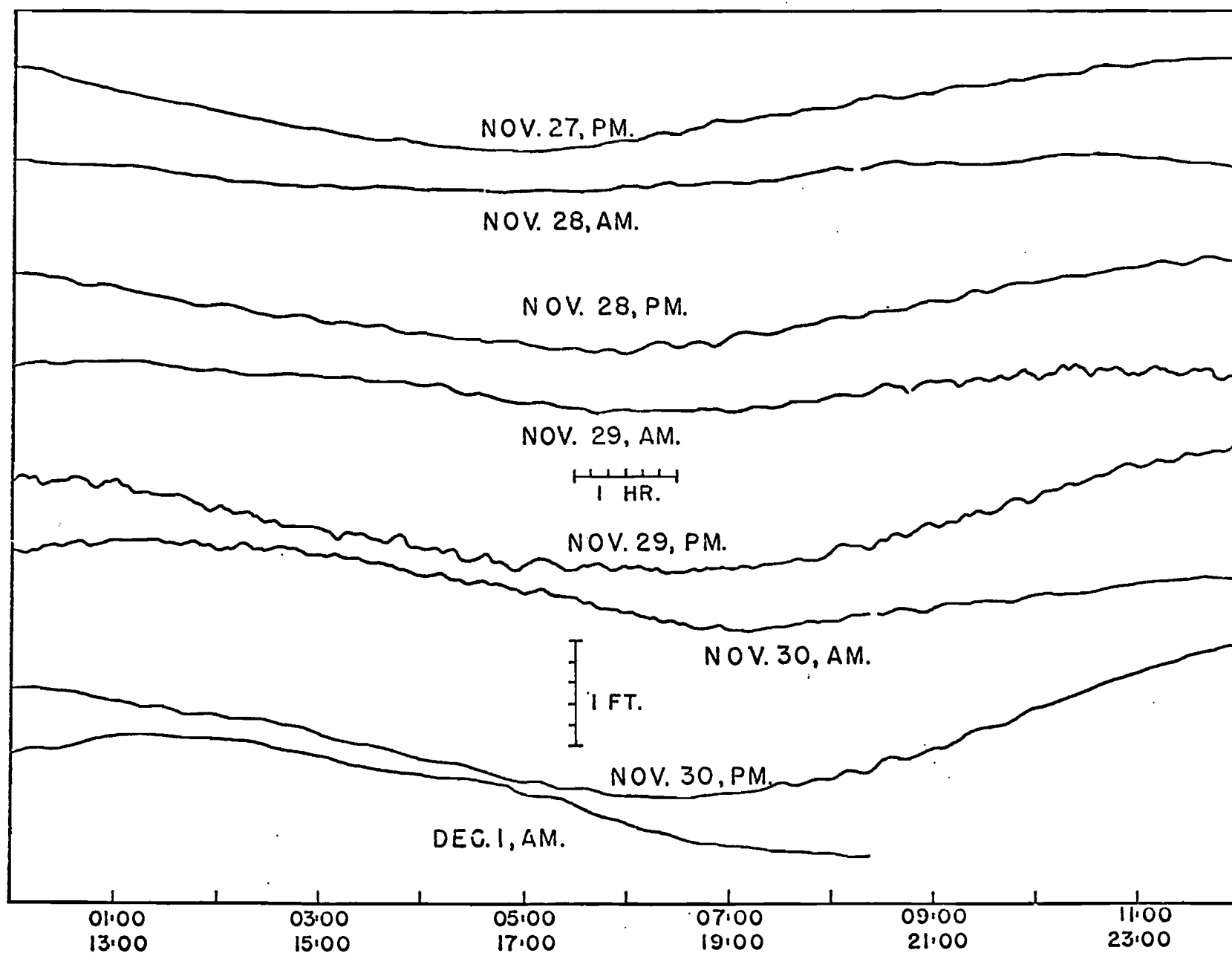


Figure 11. Honolulu marigram, 27 November - 1 December 1903.



typical form where the tsunami amplitude is small, and the increase in frequency of the oscillations recorded during the morning of 29 November is characteristic of tsunami marigraphic records. The actual range of the oscillations with periods of 30 minutes or less must have been considerably larger than the damped ranges indicated on the marigram, perhaps several times as large, and out of the range of normal oscillations. Even the 28-minute oscillations might possibly be explained as the result of resonance in the harbor induced by an incoming swell of much shorter period. Considering the actual range that they probably had in the harbor, however, they would be more easily accounted for as resulting from a tsunami.

#### Implications at San Francisco marigraphic evidence

Even during the quieter intervals throughout the period from 27 November to 1 December, oscillations of about 5-minute period with ranges sometimes approaching 0.01 feet were recorded on the San Francisco marigram. The intervals during which oscillations of longer period and greater range were recorded are noted in Table 5. For convenience of comparison with the Honolulu reports of unusual waves, the times of occurrence of the more distinctive oscillations are shown in the table in Hawaiian Standard Time (HST) as well as the Pacific Standard Time used for the San Francisco tide gage. None of the times indicated in the table are exact, because even the onset of the distinctive oscillations was in most cases gradual. The records of the beginning of none of the distinctions oscillations resembles the beginning of a typical tsunami record.

The highest of the oscillations recorded at San Francisco during the period occurred on 29 November. However, the difference between the approximate time of beginning of any one of the distinctive oscillations and the reported time of beginning of any one of the no difference between the apparent time of beginning of an oscillation distinctive on the San Francisco marigrams and the reported time of beginning of unusual waves in Hawaii corresponds to a possible difference between the arrival times at the two places of a tsunami or any other train of long-period waves with a definite beginning. The greatest difference in the case of such a train of waves is about 5 hours, and if it originated closer to Hawaii than to San Francisco it would arrive in Hawaii before it arrived in San Francisco. However, the highest of the oscillations at San Francisco began, for example, at about 01:30 HST on 29 November, 6½, 8½, and 12½ hours, respectively, before the earliest reported observation of unusual waves at Kalaupapa, Honokohau, and Pelekunu on that date.

The distinctive oscillations at San Francisco seem best interpreted, therefore, as resulting from resonances in the San Francisco Bay and entrance or on the continental shelf induced by an incoming swell of longer period.

#### Conclusions as to wave identification

In summary, there is no reason to suppose that the unusual waves of the 27th and 28th of November represented anything but a very large swell from an extraordinary storm somewhere in the North Pacific. It is reasonable to suppose that the swell continued noticeable on the 29th and even the 30th. The strongest evidence that, in addition, there was a tsunami on the 29th is constituted by:

- a) the long apparent wave periods suggested by: i) the newspaper accounts of the event at Honokohau; ii) Wilson's anecdotal account of the event at Pelekunu, and iii) the Honolulu marigram; and
- b) the report that, while the waves were inundating the Molokai coast, the water was smooth offshore.

However:

- a) Neither the marigram nor Wilson's account suggest an apparent wave period as long as those suggested by the Honokohau reports, the shortest of which is near the upper limit expectable or a tsunami;
- b) Although the times of wave arrival at Pelekunu and Honokohau could be considered mutually consistent if the waves were those of a distant tsunami, they are inconsistent with the time of initiation of a long-period disturbance recorded on the Honolulu marigram, with the time of initiation of unusual wave effects at Kalaupapa suggested by Nathaniel's report, and with the times of distinctive oscillations recorded at San Francisco;

**Table 5. Distinctive oscillations on San Francisco marigram,  
27 November to 1 December**

<b>HST</b>		<b>PST</b>		<b>Approximate periods (in min. and ranges in ft.) of distinctive oscillation</b>	
<b>Date</b>	<b>Time</b>	<b>Date</b>	<b>Time</b>		
<b>Nov 27</b>	<b>12:00</b>	<b>Nov 27</b>	<b>14:30</b>	<b>None</b>	
	<b>21:30</b>	<b>Nov 28</b>	<b>00:00</b>	<b>60 (0.1)</b>	
<b>Nov 28</b>	<b>02:45</b>		<b>05:15</b>	<b>20 (0.2)</b>	
	<b>03:15</b>		<b>05:45</b>	<b>7 (0.2)</b>	
	<b>04:30</b>		<b>07:00</b>	<b>None</b>	
	<b>08:50</b>		<b>12:20</b>	<b>20 (0.1)</b>	
	<b>09:30</b>		<b>14:00</b>	<b>20 (0.1), 60 (0.1)</b>	
	<b>12:45</b>		<b>15:15</b>	<b>60 (0.1)</b>	
	<b>14:00</b>		<b>16:30</b>	<b>None</b>	
	<b>16:25</b>		<b>18:55</b>	<b>30 (0.1)</b>	
	<b>18:00</b>		<b>20:30</b>	<b>None</b>	
	<b>21:15</b>		<b>23:45</b>	<b>60 (0.1), 12 (0.1)</b>	
	<b>22:45</b>	<b>Nov 29</b>	<b>01:15</b>	<b>8 (0.1)</b>	
	<b>23:55</b>		<b>02:25</b>	<b>10 (0.2)</b>	
<b>Nov 29</b>	<b>01:30</b>		<b>04:00</b>	<b>8 (0.3)</b>	
	<b>07:30</b>		<b>10:00</b>	<b>8 (0.2 to 0.3)</b>	
	<b>13:30</b>		<b>16:00</b>	<b>8 (0.1 to 0.2)</b>	
	<b>20:00</b>		<b>22:30</b>	<b>None</b>	
<b>Nov 30</b>	<b>05:30</b>	<b>Nov 30</b>	<b>08:00</b>	<b>7 (0.1)</b>	
	<b>07:00</b>		<b>09:30</b>	<b>None</b>	
	<b>15:00</b>		<b>17:30</b>	<b>7</b>	
			<b>22:15</b>	<b>8 (0.2)</b>	
	<b>23:30</b>	<b>Dec 1</b>	<b>02:00</b>	<b>8 (0.2 to 0.3)</b>	
<b>Dec 1</b>	<b>09:00</b>		<b>11:30</b>		

- c) The evidence for a long apparent period in Wilson's anecdotal account may be interpreted alternatively as evidence of wave setup increasing over several minutes;
- d) The long-period oscillations recorded at San Francisco were probably the result of resonance induced by a shorter period swell, and those recorded at Honolulu might have been also;
- e) The three high waves reported Honokohau might simply have been the highest observed, between which there were others less remarkable; and
- f) If the waves at Kalaupapa at 08:00 represented a swell, the report that the water was smooth offshore later in the day must either be discounted entirely or interpreted as meaning merely that there were no high short-period waves of local origin that could account for the inundation.

Considering all of the evidence together, and the alternative interpretations that are possible of those part of the evidence suggesting the occurrence of a tsunami, although I earlier considered that the "tidal wave" of the 29th was probably a tsunami (Cox and Morgan, 1977; Cox 1978), I now consider that it more probably represented simply an increase in the size of the swell that was already unusually large on the 27th and 28th, rather than a tsunami.

If there was a tsunami, its source was more probably distant from Hawaii than local. One generated, for example, off the Aleutian Islands, might have accompanied an earthquake that would have escaped general notice at the time. If the "tidal wave" did represent a local tsunami, the most probable generating mechanism was a slump on the steep submarine slope north of Molokai that neither resulted from nor caused a notable earthquake.

For statistical purposes, I would suggest use of the following probabilities of identification of the waves and their sources:

	Event dates	
	27-28 November	29 November
Tsunami		
Local		0.10
Distant		0.30
Total		0.40
Swell from distant storm	1.00	0.60
Total	1.00	1.00

#### Conclusions as to places affected and runup heights of the possible tsunami

If there was a tsunami on 29 November, the only effects definitely attributable to it were there at Pelekunu, Molokai, and Honokohau, Maui. As indicated earlier, the effects at Kalaupapa, Molokai, even if there were a tsunami, may be attributable to the swell continuing from 27 November. Although the occurrence of the "tidal wave" at Kahului, Maui, was reported in the Monthly Weather Summary, there are no newspaper reports confirming its observation there.

The only evidence definitely suggesting the occurrence of a tsunami as well as the swell on Oahu is that of the Honolulu marigram. The waves responsible for the railroad track washout might have been the swell, and the location of the washout is uncertain.

Although the waves reaching more than 40 feet above sea level at Koholalele on the Hamakua coast of Hawaii were considered in the Star (8 Dec) to represent the "tidal wave", it is not completely certain that the waves in question even occurred in the 29th, and the high waves reported on the South Kona, South Kohala, and North Kohala coasts on the 29th might have represented the swell rather than the possible tsunami.

Table 6. Reported marine disturbances, 14-19 December.

	Mon-Wed, 14-16 Dec	Wed-Fri, 16-18 Dec	Sat, 19 Dec
<b><u>Maui</u></b>			
Makena		(18th at night) Comber toppled a clerk from a boat which was capsized by succeeding comber: ( <u>Gazette</u> , 22 Dec; <u>News</u> , 26 Dec)	Heavy seas wrecked wharf. Boat swept inland, another dashed on rocks: "Kinau"(?). ( <u>Star</u> , 30 Dec)
Keauwakapu			Tidal wave wrecked landing: "Lehua" ( <u>Star</u> , 30 Dec; Mo. Weath. Sum.)
<b><u>Hawaii</u></b>			
Kau	(Date?) Rough water: ( <u>Bulletin</u> , 22 Dec; <u>Advertiser</u> , 23 Dec; "Mauna Loa" <u>Star</u> , 23 Dec; <u>Gazette</u> , 25 Dec)	(Date?) Smoother: ( <u>Bulletin</u> , 22 Dec; <u>Advertiser</u> , 23 Dec; "Mauna Loa" <u>Star</u> , 23 Dec; <u>Gazette</u> , 25 Dec)	
Kona Unspecified		Rough water: ( <u>Advertiser</u> , 23 Dec; "Mauna Loa"? <u>Star</u> , 23 Dec; <u>Gazette</u> , 25 Dec)	
Hookena			Small-sized tidal wave, minor damage: "Mauna Loa" ( <u>Bulletin</u> , 23 Dec; <u>Advertiser</u> , 23 Dec; <u>Star</u> , 23 Dec; <u>Gazette</u> , 25 Dec; Mo. Weath. Sum.)

Recognizing that the 30-foot height of the highest wave of 29 November at Honokohau, Maui was determined by "measuring the mark left by the sea on the side of the pali", the treatment of the height by Cox and Morgan (1977) as a runup height of 30±2 feet above mean sea level is reasonable. The most probable locus of the measurement was on one of the pali's where the mark was probably highest, on the line of the beach crest, approximately 50 feet inland of the mean-sea-level shoreline on the beach.

Cox and Morgan's estimate of the runup height of the "tidal wave" at Pelehunu was probably about 13 feet msl. If it is (for reasons given in Cox, 1980) considered that the most probable value is the geometric mean of the limits of the possible range rather than the arithmetic mean, the smallest likely value may be estimated at 8 feet and the largest at 20 feet. As at Honokohau, the locus of the most probable value and range at Pelekunu reasonably be considered at the beach crest. Wilson's reports (Star, 2 Dec, Advertiser, 3 Dec, Gazette, 4 Dec) that the water ran 250 feet further inshore than the highest tide mark suggest inundation to about 300 feet inland of the mean-sea-level shoreline.

#### "Tidal wave" of 19 December and other disturbances, 14-19 December

The descriptions of the "tidal wave" that was reported to have occurred on 19 December and of other coastal disturbances reported in the period from 14-19 December are summarized in Table 6. The reports of rough water on the Kau and Kona coasts of Hawaii from 14 to 18 December are of interest principally in indicating that, during the period immediately preceding the reported occurrence of the tidal wave, there were high seas or swells although there are no reports of high winds in Hawaii during the period.

What was considered to have been the same "tidal wave" was reported to have been observed at Hookena on the Kona coast of Hawaii, and at Makena and Keawakapu on the south coast of Maui.

The accounts of the event at Hookena identified it only as a small "tidal wave" that did minor damage, and did not indicate an arrival time (Star, 23 Dec; Bulletin, 22 Dec; Advertiser, 23 Dec; Gazette, 25 Dec; Mo. Weath. Sum.).

One account of the event at Keawakapu, carried to Honolulu by the "Lehua", indicated that the wave arrived at 04:00 on 19 December, a Saturday (Star, 30 Dec). How the time was determined is not clear because the account indicates that no one was at the wharf at that time it was destroyed by the wave. The Monthly Weather Summary for December indicated only that the wave occurred early in the morning.

The incident involving the "Kinau" at Makena that the Star (30 Dec) attributed to the same "tidal wave" was reported in the Gazette (22 Dec) and the Maui News (26 Dec) to have occurred the previous evening. Whereas the Star reported the Makena wharf wrecked, one boat swept inland, and another dashed on the rocks, the Gazette and the News did not mention damage to the wharf and reported only one boat capsized.

No abnormal oscillations appear on the Honolulu marigram, for the period 18 to 20 December. The identification of the phenomena at Hookena, Makena, and Keawekapu as a "tidal wave" may be attributed to the occurrence of the much larger "tidal wave" of 29 November, less than three weeks earlier and the tendency to identify similarly the large waves of two events occurring in so short a time interval. The effects at all those places are no greater than might be expected from the waves of a severe storm. It is quite unlikely that a tsunami occurred on the 18th or 19th of December.

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## Appendix A. Honolulu, Wailuku, and Hilo newspapers published in 1903.

Title	Publication		Abbreviated title
	Place	Schedule	
<u>The Evening Bulletin</u>	Honolulu	Afternoons daily except Sunday	Bulletin
<u>The Hawaii Herald</u>	Hilo	Weekly on Thursday	Herald
<u>The Hawaiian Gazette</u>	Honolulu	Tuesdays and Fridays	Gazette
<u>The Hawaiian Star</u>	Honolulu	Afternoons daily except Sunday	Star
<u>The Maui News</u>	Wailuku	Weekly on Saturday	News
<u>The Pacific Commercial Advertiser</u>	Honolulu	Mornings, daily	Advertiser
<u>The Weekly Hilo Tribune</u>	Hilo	Weekly on Friday	Tribune

## Appendix B. Parties ascending Mauna Loa to view the eruption of October–December 1903.

Party	Date(s) and Time(s) at summit	Viewpoint on Mokuaweo rim and route	Members of party	References		
				Informants (in parentheses if not party members)	Newspaper	Issue
(Party leaving Kilauea (?) on 12 Oct that did not reach summit)			Bowman, P.S. Clerk, M.	Elemakule, J. Madera, J.I.	Weight, M.G.	Herald Advertiser 15 Oct 13 Nov
I	October 13 14:00 to October 14 07:00	SE Kapapala	Bidgood, C.L. Guard, R.T. Kapoko, M.D. Haley, F.E. Holland, J.	Kiniaku, W.S. Little, J.H. McFadyean, J.S. Nawaki, A.K.	Ridgway, T.C. Wilson, B. Wilson, D.E. Wilson, H.E.	(Mosher) Bierbach & Thrum Guard Guard Ridgway Advertiser Bulletin Advertiser Herald 15 Oct 16 Oct 17 Oct 17 Oct 18 Oct 22 Oct
II	October 17 am for 2½ hrs	W ? (Reported as SE by Berndt) Kona	Berndt, E.A. Curts, J.R.	Lewis, A. Gartley, A.	Holt, B.G. Shingle, R.	Berndt Gartley Lewis (via Pond) Bulletin Star Advertiser Advertiser 20 Oct 20 Oct 24 Oct 27 Oct
III	October 17 15:00 to October 18 am	SE Kapapala	Dorland, P.E. Gerlach, H.A.	Giddings, C.J. Jones, ?	Kinakua, S. Lono, O.	(McStocker) Herald Advertiser 15 Oct 27 Oct
IV	October 19 09:50 to October 20 am	SE Kapapala	Easton, J.E. Howland, B.F.	Howland, J.H. Kelii, N.K.	Sisson, P. Ray, I.E.* (*turned back)	Easton Tribune 23 Oct
V	October 20 12:35 to October 21 07:00	SE Kapapala	Berry, (Ms) Q.N. Haworth, L.W.	Kiniaku, W.S. Knight, R.B.	Robertson, G.M. Wachs, D.M.	Haworth Bulletin Tribune Bulletin Bulletin Herald 20 Oct 23 Oct 23 Oct 24 Oct 29 Oct

VI	October 21 13:45 to October 22 07:00 + —	W Kona	Ackerman, (Ms) B. Ackerman, (Ms) M. Ackerman, W. Ea, (Ms) H. Edwards, E. Greenwell, A. Greenwell, H. Ka, C.	Ka, (Ms) H. Keka, J. Kilinahe, ? Kukea, C. Low, (Ms) E. Nahale, D. Naluahine, ? Paris, D.	Roy, (Ms) L. Roy, W. Stephens, (Ms) F. Wall, A. White, T.C. White, (Ms) T.C. Woods, ?	Wall Aungst White  Aungst	Tribune Advertiser Advertiser Bulletin Gazette	27 Oct 29 Oct 30 Oct 30 Oct 30 Oct
VII	October 26 p.m. to ?	W Kona	Fleming, D.T.	Douglas, ?		(Thielen)	Bulletin Star Bulletin Advertiser	30 Oct 10 Nov 16 Oct 21 Nov
VIII	November 5 13:30 to November 6 09:30	W Kona	Baldwin, H.A. Carr, C.	Carter, A.W. Nahale, D.	Thielen, G.P. White, T.C.	Thielen Thielen  Thielen	Star Advertiser Herald Gazette	10 Nov 11 Nov 12 Nov 13 Nov
IX	Approx. November 30	?	Castendyck, C.	Grace, ?	Metcalf, J.E.		Herald	3 Dec
X	Approx. November 30	N	Aubrey, A.C.	Beckley, H.	Ioani, ?	Beckley	Star	5 Dec
XI	December 7 to December 8	SE? Kapapala?	Dennis, W.E.	Juen, H.A.	Merriam, C.H.		Tribune Advertiser	11 Dec 14 Dec
XII	December 7 to December 8	W Kona	August, ? Baldwin, C.W.	Greenwell, F. Gomes, F.	Knudsen, E.A. guide	Baldwin	Advertiser	20 Dec

### Appendix C. Criteria for Distinguishing "Tidal" and Other Waves.

A problem is frequently encountered in determining whether historic events reported as representing tidal waves actually represented tsunamis of distant or local origin, storm surges associated with hurricanes, abnormally high seas associated with local storms or abnormally large swells associated with distant storms, or the inundation resulting from the "wave setup" of a series of exceptionally high seas or swells impinging on a coast.

The following criteria for distinguishing the various types of waves have been prepared taking into account not only the characteristics of tsunamis but oral and newspaper account descriptions of the waves and wave inundation resulting from the passage of Hurricane Iwa near Kauai in November 1982.

	Tsunami		Waves of meteorological origin			
	Distant origin	Local origin	Storm surge	Sea of local origin	Swell of distant origin	Wave setup
<b>Characteristics at a site</b>						
Commencement of waves	Abrupt	Abrupt	Fairly abrupt	Gradual	Gradual	Fairly abrupt
Number of waves	Many	One to several	One	Many	Many	Single
Duration of disturbance	Several hours to a few days	A few to several hours	½ to 2 hrs.	—Many hours to several days-----		½ to 2 hrs.?
Apparent wave period or duration of single wave	-----15-60 minutes for several waves, decreasing to----- 20 min. or less later		30 to 120 min.	15 sec.	15 to 45 sec.	30 to 120 min.?
Position of highest wave in sequence	General 3rd to 7th or 8th	Generally first or second	—	—Near middle of sequence-----		—
<b>Characteristic distributions</b>						
Arrival times	————Consistent with tsunami celerity————		—Consistent with storm-center celerity— wave celerity		Consistent with	Consistent with arrival of unusually high seas or swells
Distribution of effects	Widespread; greatest on similarly oriented coasts, but observable on coasts with other orientations	Less widespread and with greater orientation dependence	Significant on a few coasts only	Widespread but at any one time significant only on coasts with similar orientation	Widespread but only on coasts with similar orientation	Significant on a few charts only
<b>Accompaniments</b>	Severe earthquake, coastal subsidence, and/or unusual waves, at distant coast	Severe earthquake, coastal subsidence, and/or coastal or submarine volcanic explosion or collapse, nearby	Exceptionally low atmospheric pressure, high winds, especially with considerable shift in direction, high seas, heavy rain	High winds, high seas offshore	Evidences of distant storm, high swells offshore	High seas or swells

Appendix D. Forecast tides for Honolulu, October-December, 1903.

Day	Height of higher tide, feet	October				Height of higher tide, feet	November				Height of higher tide, feet	December			
		Times					Times					Times			
		High tides		Low tides			High tides		Low tides			High tides		Low tides	
		Higher	Lower	Lower	Higher		Higher	Lower	Lower	Higher		Higher	Lower	Lower	Higher
1	1.4	12:30	01:00	19:21	06:15	1.3	01:28	13:20	19:26	07:37	1.4	01:37	13:20	19:14	08:16
2	1.4	13:12	01:37	19:46	07:08	1.5	02:01	13:57	19:58	08:21	1.8	02:15	14:06	19:54	09:10
3	1.4	13:58	02:09	20:12	07:54	1.6	02:42	14:35	20:29	08:58	2.0	02:52	14:51	20:30	09:48
4	1.4	02:38	14:49	20:48	08:22	1.8	03:10	15:12	21:02	09:40	2.1	03:30	15:39	21:08	10:30
5	1.4	03:00	15:08	21:15	09:12	1.9	03:49	15:51	21:35	10:25	2.1	04:10	16:28	22:50	11:15
6	1.4	03:30	15:40	21:42	10:19	1.9	04:24	16:36	22:11	11:14	2.1	04:51	17:20	22:32	12:02
7	1.5	04:03	16:12	22:13	11:05	2.0	05:05	17:22	22:50	12:07	2.0	05:35	18:20	23:22	12:49
8	1.6	04:40	16:49	22:45	11:54	1.9	05:50	18:21	23:35	13:01	1.9	06:20	19:28	01:36	—
9	1.7	05:22	17:30	23:20	12:53	1.8	06:40	19:22	—	14:02	1.8	07:08	20:43	14:25	00:18
10	1.7	06:08	18:30	—	14:07	1.7	07:34	20:52	15:02	00:29	1.6	08:01	21:48	15:14	01:33
11	1.7	07:02	19:27	00:01	15:07	1.6	08:35	22:22	16:00	01:40	1.4	09:12	22:50	16:01	03:11
12	1.6	08:04	20:56	00:54	15:27	1.5	09:41	23:25	16:50	03:25	1.6	23:52	10:28	16:48	04:48
13	1.6	09:12	22:32	02:01	16:40	1.4	11:00	—	17:35	05:02	—	—	11:30	17:34	06:15
14	1.5	10:26	23:48	17:40	03:33	1.2	00:13	12:11	18:19	06:19	1.5	00:46	12:31	18:21	07:28
15	1.5	11:33	—	18:25	05:10	1.4	01:03	13:03	19:02	07:24	1.8	01:32	13:24	19:02	08:30
16	1.5	12:32	00:42	19:04	06:25	1.6	01:47	13:50	19:40	08:20	1.9	02:15	14:13	19:41	09:24
17	1.4	13:33	01:24	19:45	07:28	1.8	02:30	14:33	20:15	09:13	2.0	02:55	14:57	20:21	10:10
18	1.4	14:20	02:01	20:25	08:15	1.9	03:12	15:10	20:50	10:03	2.1	03:33	15:37	20:58	10:50
19	1.6	02:45	14:59	21:00	09:01	2.0	03:48	15:49	21:25	10:50	2.1	04:06	16:18	21:34	11:22
20	1.6	03:24	15:37	21:29	09:51	2.0	04:25	16:30	21:57	11:33	2.0	04:40	17:00	22:10	11:53
21	1.7	04:04	16:16	22:00	10:40	2.0	05:02	17:14	22:31	12:15	1.9	05:10	17:52	22:45	12:22
22	1.8	04:45	16:53	22:33	11:29	1.9	05:38	18:10	22:07	12:56	1.8	05:42	18:48	12:55	23:26
23	1.8	05:27	17:33	23:07	12:18	1.8	06:15	19:16	23:48	13:40	1.7	06:15	19:50	13:31	—
24	1.8	06:07	18:24	23:42	13:14	1.6	06:54	20:25	14:23	—	1.6	06:59	20:33	14:06	00:14
25	1.7	06:54	19:30	—	14:10?	1.5	07:37	21:40	15:08	00:40	1.4	07:40	21:35	14:45	01:21
26	1.6	07:41	20:49	00:25	15:17	1.4	08:30	22:49	15:52	02:00	1.2	08:25	22:40	15:25	02:48
27	1.5	08:32	22:16	16:15	01:24	1.3	09:32	23:38	16:33	03:42	1.2	23:26	09:22	16:08	04:32
28	1.4	09:31	23:37	17:02	02:53	1.1	10:37	—	17:11	05:10	—	—	10:31	17:00	06:04
29	1.3	10:37	—	17:42	14:38	1.2	00:18	11:38	17:50	06:22	1.6	00:29	11:45	17:50	07:19
30	1.3	11:41	00:26	18:17	05:51	1.4	00:59	12:30	18:32	07:27	1.8	01:11	12:51	18:29	08:16
31	1.2	12:35	00:56	18:50	06:46						2.0	01:54	13:42	19:26	09:03