Earthquakes in Hawaii:

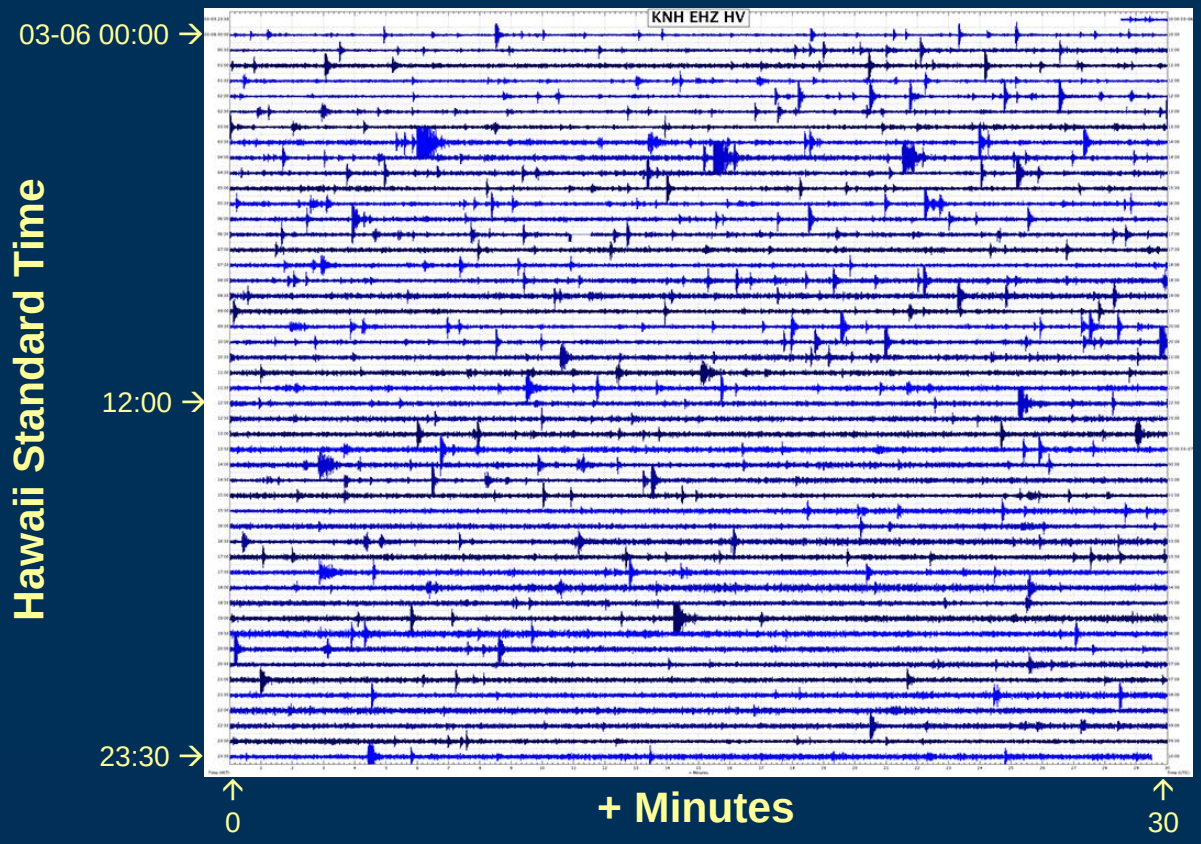
What you need to know

U.S. Department of the Interior
U.S. Geological Survey

Prepared by: Janet L. Babb
Hawaiian Volcano Observatory

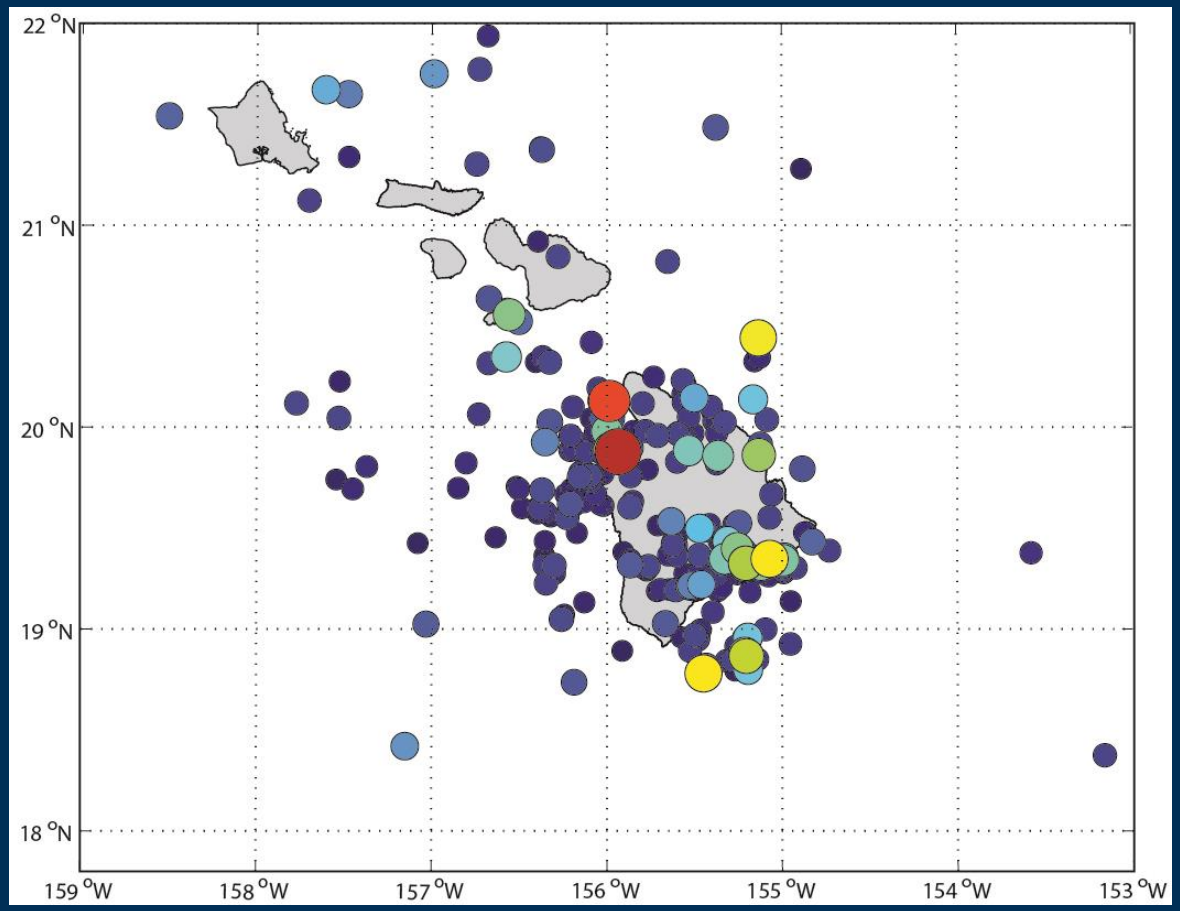
The **State of Hawaii** experiences **thousands of earthquakes** every year.

Most of these earthquakes are closely related to volcanic processes in Hawaii, and are so small they can be detected only by seismometers.



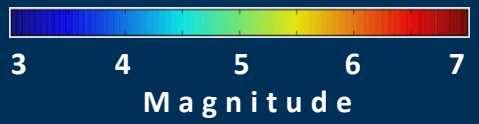
More than 500 earthquakes were recorded by a nearby seismometer during the Kamoamoa fissure eruption along Kīlauea's East Rift Zone on March 6, 2011.

Many earthquakes are strong enough to be felt on one or more islands.



*Locations of the 414 magnitude-**3.0** and stronger earthquakes that were recorded during the past decade **(2003–2012).***

Color and size of dots reflect earthquake magnitude:

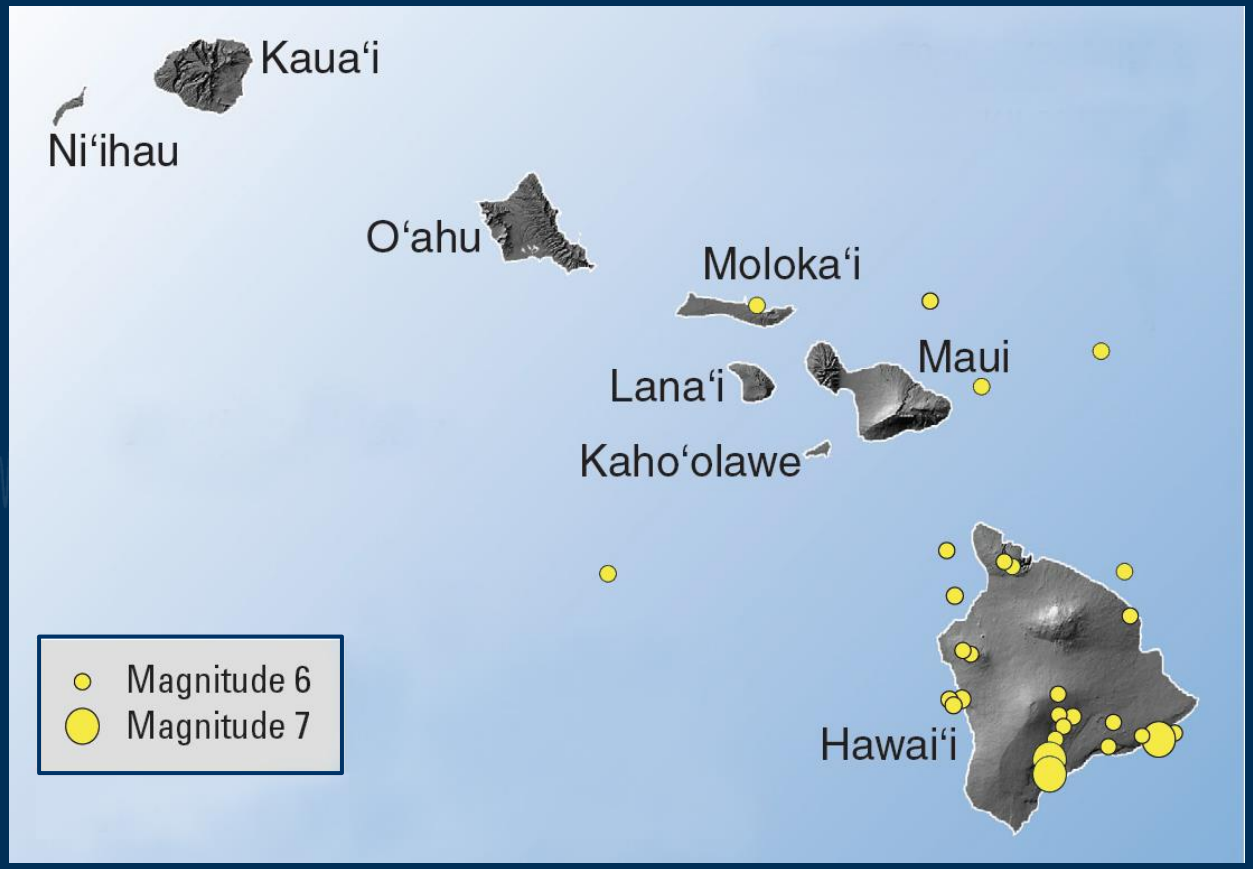


Source: USGS Hawaiian Volcano Observatory

USGS

Some earthquakes are large enough to cause damage and impact residents across the State of Hawaii.

Since 1868, more than 30 magnitude-**6.0** or greater earthquakes have rattled the islands.



Source: USGS Fact Sheet 2011-3013 (http://pubs.usgs.gov/fs/2011/3013)

Two ways to measure or describe earthquakes:

Magnitude and **Intensity**

USGS

Magnitude

Measures the maximum ground motion recorded by a seismometer.

The amount of seismic energy released during an earthquake is related to its magnitude.

A unit increase in magnitude corresponds to a ~ 30-fold increase in released energy.

Compared to a **M-3.0** earthquake…

- a **M-4.0** earthquake releases ~ 30 times more energy!
- a **M-5.0** earthquake releases ~ 1,000 times more energy!!
- a **M-6.0** earthquake releases ~ 30,000 times more energy!!!
- a **M-7.0** earthquake releases ~ 1,000,000 times more energy!!!!

USGS

Intensity

Describes what people experience during an earthquake—
the effects of shaking on structures and the extent of damage.

Intensity values (Roman numerals) are assigned using the
Modified Mercalli Intensity Scale:

INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X–XII
SHAKING	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very Light	Light	Moderate	Moderate/ Heavy	Heavy	Very Heavy

Maximum intensity values are often highest near an earthquake epicenter and decrease with distance from the source.
What you experience (intensity) depends on your location relative to the epicenter.

USGS

Comparison of maximum intensity and magnitude:

Typical Maximum Intensity	Description of Shaking and Damage	Magnitude
I	Not felt except by a very few under especially favorable conditions.	1.0 – 3.0
II	Felt only by a few persons at rest, especially on upper floors of buildings.	3.0 – 3.9
III	Noticeably felt by persons indoors, especially on upper floors. Many people do not recognize it as an earthquake. Parked cars may rock slightly. Vibrations similar to passing truck.	
IV	Felt indoors by many, outdoors by a few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like truck striking building. Parked cars visibly rock.	4.0 – 4.9
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.	
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.	5.0 – 5.9
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by drivers in moving cars.	
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.	6.0 – 6.9
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.	
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.	7.0 and higher
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.	
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.	

USGS

Source: USGS Magnitude/Intensity Comparison (http://earthquake.usgs.gov/learn/topics/mag_vs_int.php)

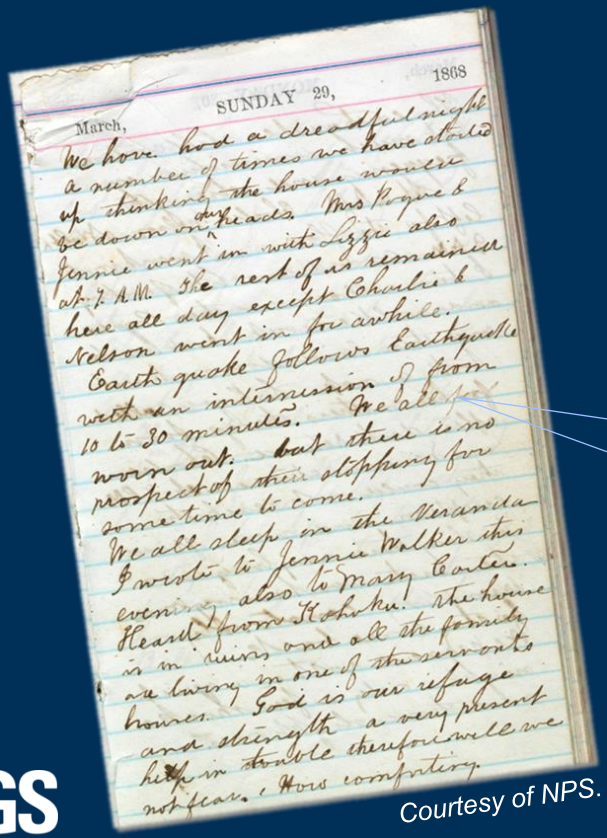
Hawaii’s most destructive earthquakes since 1868

USGS

1868 April 2

Magnitude: Estimated at **7.9** (pre-dates the development of magnitude scales)

Location: Ka‘ū District, Island of Hawai‘i


March, SUNDAY 29, 1868

We have had a dreadful night
a number of times we have started
up thinking the house would
be down on our heads. Mrs Rogers &
Jennie went in with Lizzie also
at 7 A.M. The rest of us remained
here all day except Charlie &
Nelson went in for awhile.
Earthquake follows Earthquake
with an intermission of from
10 to 30 minutes. We all are
worn out. but there is no
prospect of their stopping for
some time to come.
We all sleep in the Veranda
I wrote to Jennie Walker this
evening also to Mary Carter.
Heard from Hohoku. the house
is in ruins and all the family
are living in one of the servants
houses. God is our refuge
and strength a very present
help in trouble therefore will we
not fear. How comforting.

Courtesy of NPS.

Strong foreshocks—including a magnitude-7.0 earthquake on March 28—and thousands of aftershocks shook the island for days.

“A dreadful night…. Earthquake follows earthquake …. We’re all worn out.”

Diary of Annie Brown Spencer, Ka‘ū, Hawai‘i, March 29, 1868.

USGS

The April 2, 1868, earthquake was the largest in Hawaii's recorded history—equivalent in size to the 1906 San Francisco earthquake in California.

Waiʻōhinu church in Kaʻū, Hawaiʻi, destroyed by the 1868 earthquake.
Photo by H.L. Chase, courtesy of the Hawaiian Historical Society.

Shaking: Extremely violent in south Hawaiʻi (Maximum Intensity **XII**)

Extent: Felt throughout the State of Hawaii

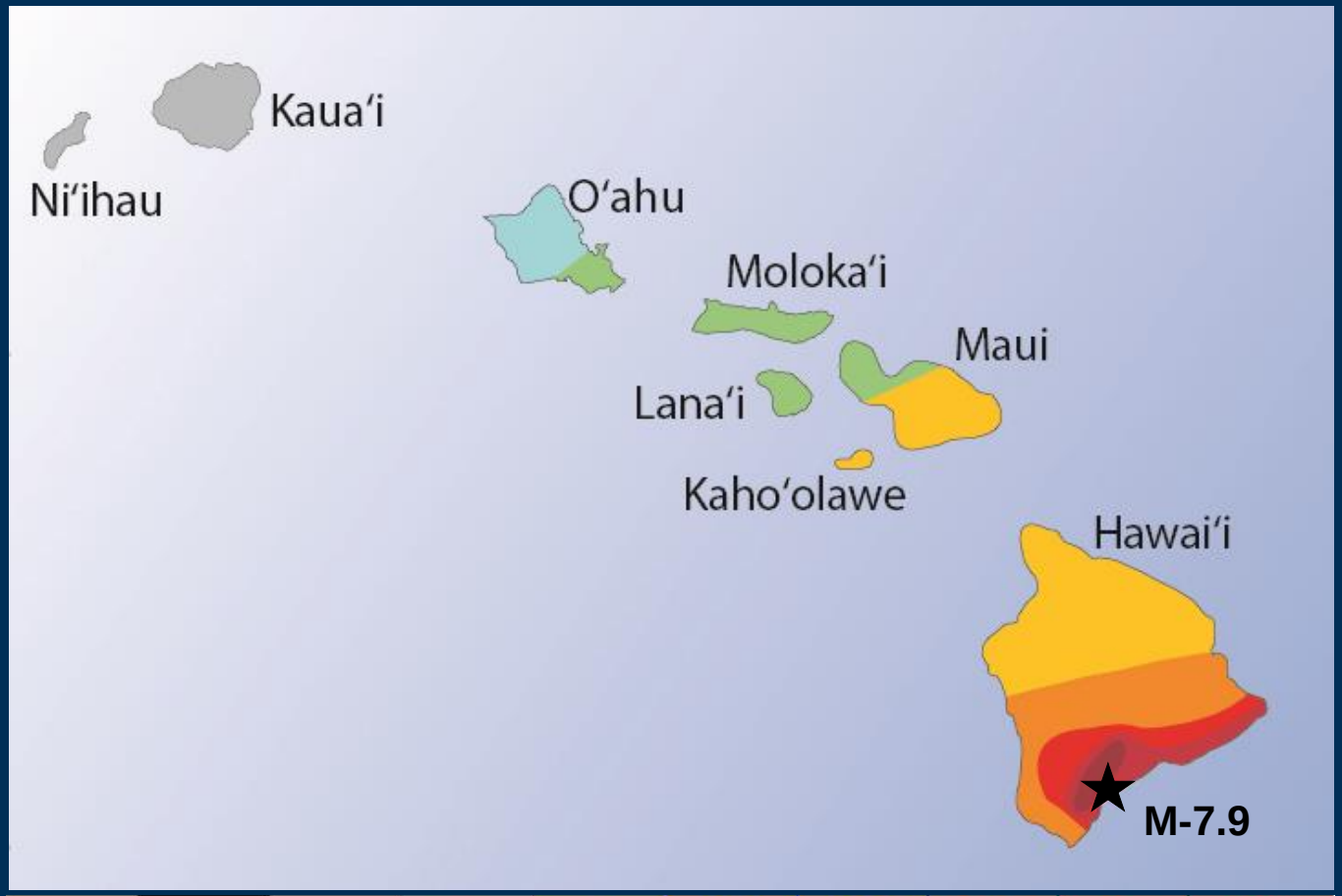
Damage: Very heavy along Hawaiʻi's south coast; moderate in Maui County

This shaking and damage can be depicted on an earthquake intensity map.

USGS

Earthquake Intensity Map — April 2, 1868

Using the Modified Mercalli Intensity Scale, colors on the map reflect the shaking and damage experienced by residents throughout the islands during the 1868 earthquake.



INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very Light	Light	Moderate	Moderate/ Heavy	Heavy	Very Heavy

Modified from: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

USGS

The April 2, 1868, earthquake…

- destroyed houses, toppled stone walls, opened ground cracks, and threw people off their feet.
- killed at least 77 people.

Source: Titus Coan, Scribner's Monthly, 1871

- generated a **tsunami**. A wave up to 18 m (60 ft) high along the Kaʻū-Puna coast resulted in 46 deaths.
- triggered multiple **landslides**, including one in Kaʻū's Wood Valley, where 31 people died.
- induced short-lived **eruptions** on Kīlauea and Mauna Loa.

If this earthquake occurred today, damages could cost as much as:

$ 500 million

Source: *PDC's Hawaii HAZUS Atlas*
http://apps.pdc.org/hha/html/hzssummary.jsp

USGS

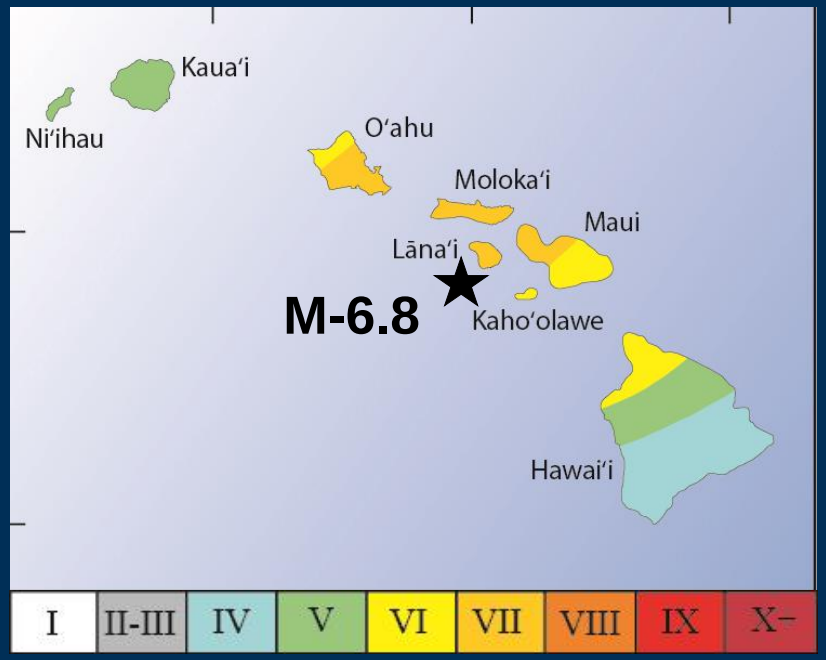
1871 February 19

Shaking: Very strong from East Maui to O‘ahu

Extent: Felt throughout the State

Damage: Extensive in Maui County—some houses uninhabitable, stone walls and fences down, ground cracked open, rockfalls and landslides blocked roads and trails.

Moderate damage on O‘ahu and minor damage on Hawai‘i.



Modified from: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

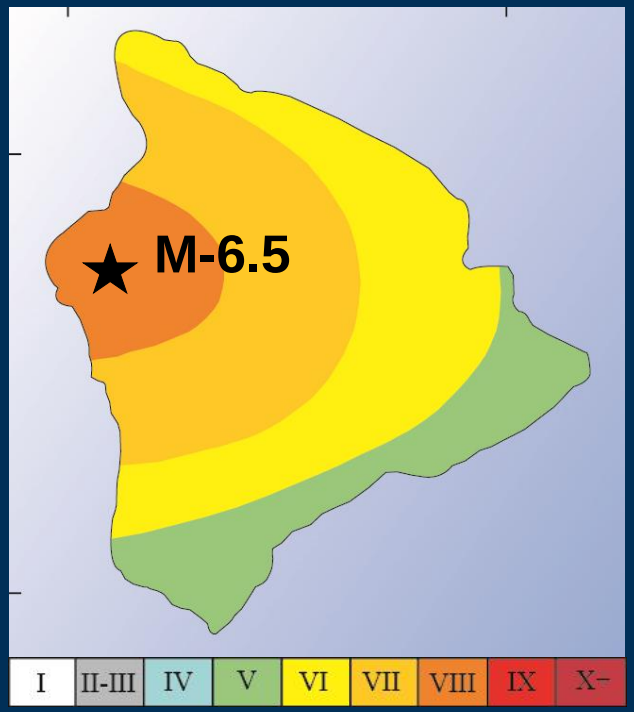
USGS

1929 October 5

Shaking: Severe on Hualālai

Extent: Felt as far away as O‘ahu

Damage: Heavy in West Hawai‘i—houses, water tanks, stone walls fences, and roadways damaged, some beyond repair.



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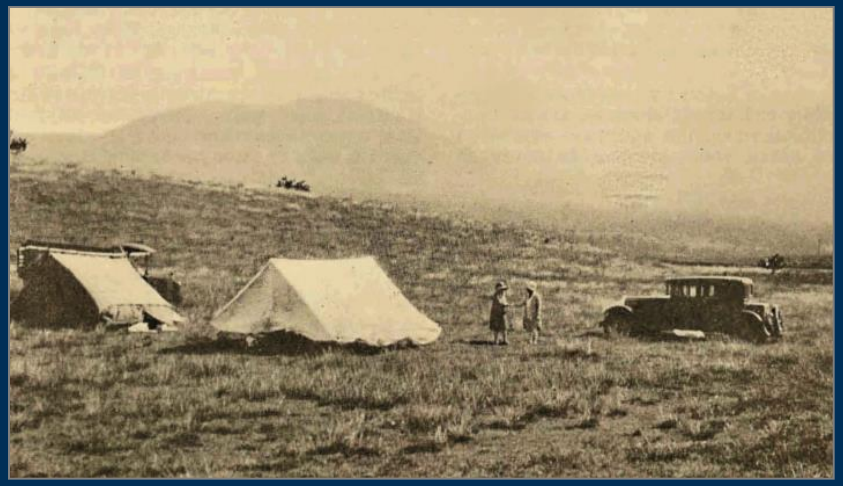


More than 6,200 foreshocks and aftershocks rattled the Hualālai area—including a M-6.2 earthquake on September 25. Fearing that their homes would collapse, some ranch residents camped out near Pu‘uwa‘awa‘a in West Hawai‘i. *USGS photo.*

USGS

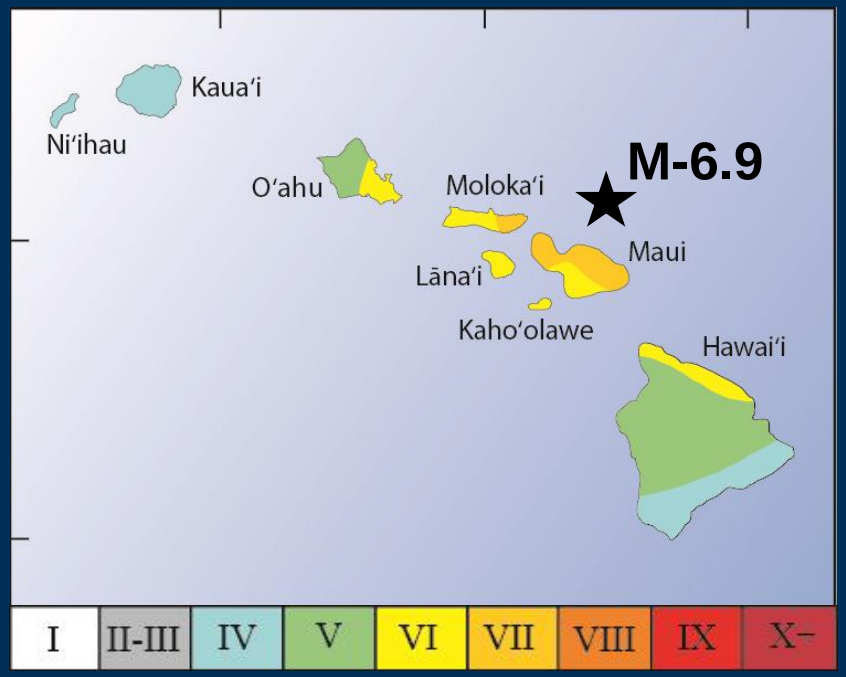
1938 January 22

Shaking: Severe on Maui

Extent: Felt throughout the State

Damage: Heavy on north coast of Maui—oil pipelines and water tanks burst, landslides blocked roads, stone walls collapsed, and ground cracks ruined roads.

Minor damage from north Hawai‘i to Kaua‘i.



Modified from: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

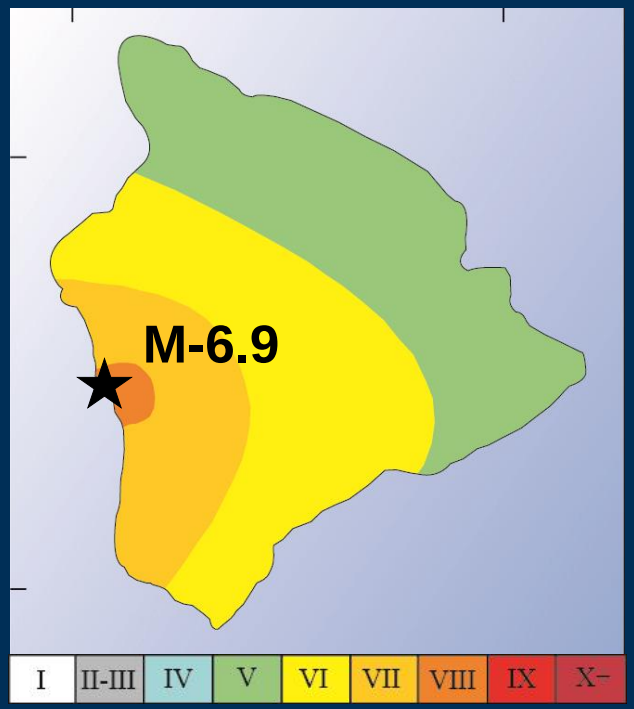
USGS

1951 August 21

Shaking: Severe in West Hawai‘i

Extent: Distinctly felt as far away as O‘ahu

Damage: Roads badly cracked and blocked by rock slides, electric and telephone service disrupted, and ~200 water tanks collapsed in central Kona District. Generated a small local tsunami, but no significant wave damage.



Modified from: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

Collapsed water tank at Hōnaunau School in South Kona, Hawai‘i. USGS photo.

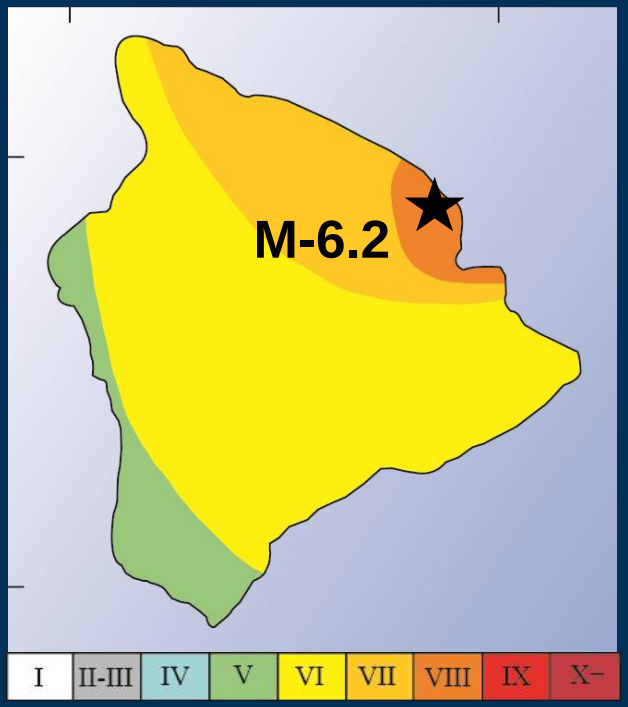
1973 April 26

Shaking: Severe in north Hawai‘i

Extent: Felt on all islands

Damage: Estimated at $5.75 million. East Hawai‘i declared a disaster area—water and electric service disrupted; rockslides blocked roads; homes and businesses damaged.

Injuries: At least 11 people injured in Hilo and Waimea.



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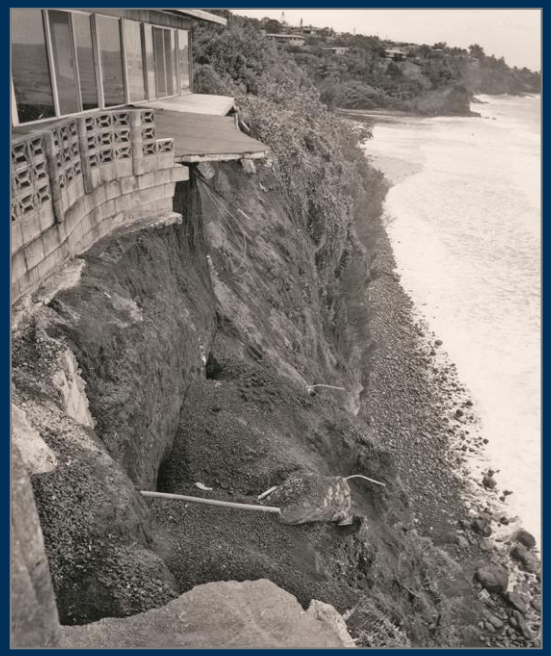


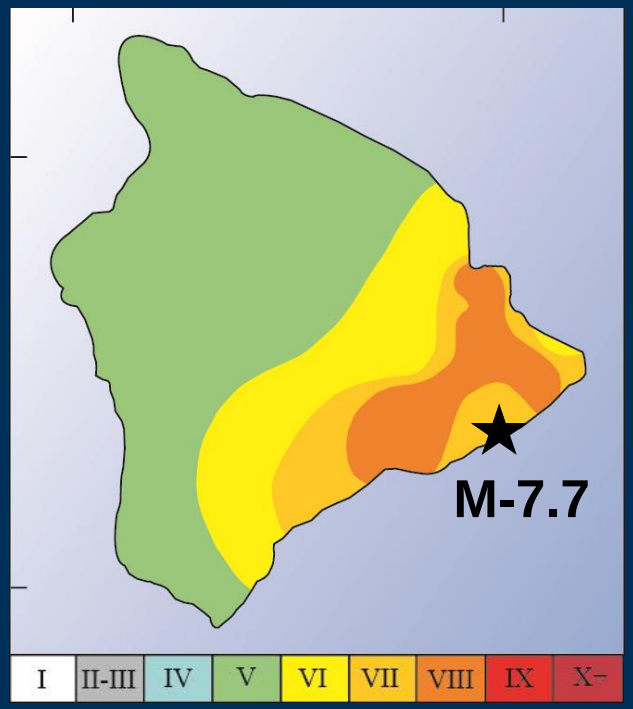
Coastal damage on the Island of Hawai‘i.
Photo by Larry Kadooka, Hawai‘i Tribune-Herald.

1975 November 29

Shaking: Severe in Puna District

Extent: Felt across the State

Damage: $4.1 million *(including tsunami damage)*. Massive ground cracking and landslides damaged roads. Homes shifted off foundations. Structural and equipment damage at businesses.



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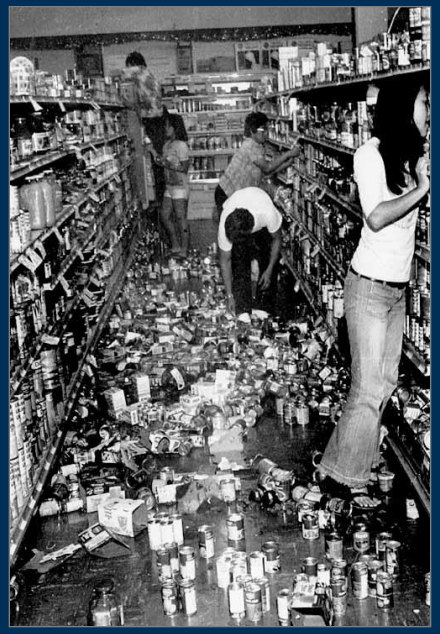


Chain of Craters Road, Hawai'i Volcanoes National Park. USGS photo.

Impact on Hilo, Hawai'i, supermarket. Photo by Larry Kadooka, Hawai'i Tribune Herald.

If this earthquake occurred today, damages could cost as much as:

$ 500 million

The November 29, 1975, earthquake generated a devastating **tsunami**.

At Halapē, two campers died and 19 others were injured when the tsunami swept over them.

The coastline subsided by as much as 3.5 m (11 ft) during the earthquake, submerging Halapē's coconut grove in seawater.

Red pack marks the extent of the tsunami inundation at Halapē. *USGS photo.*

The tsunami—with waves up to 14.6 m (48 ft) high—caused extensive damage on the Island of Hawai'i's south coast.

A Punalu`u house demolished by the 1975 tsunami.
Photo by David Shapiro, Honolulu Star-Bulletin.

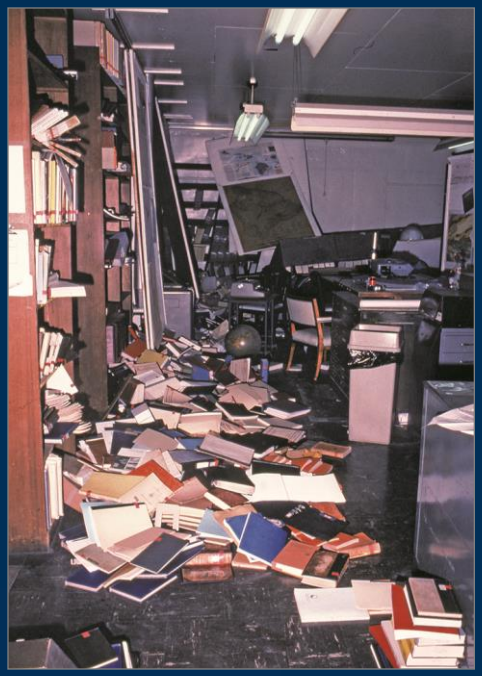
1983 November 16

Shaking: Violent in Volcano area

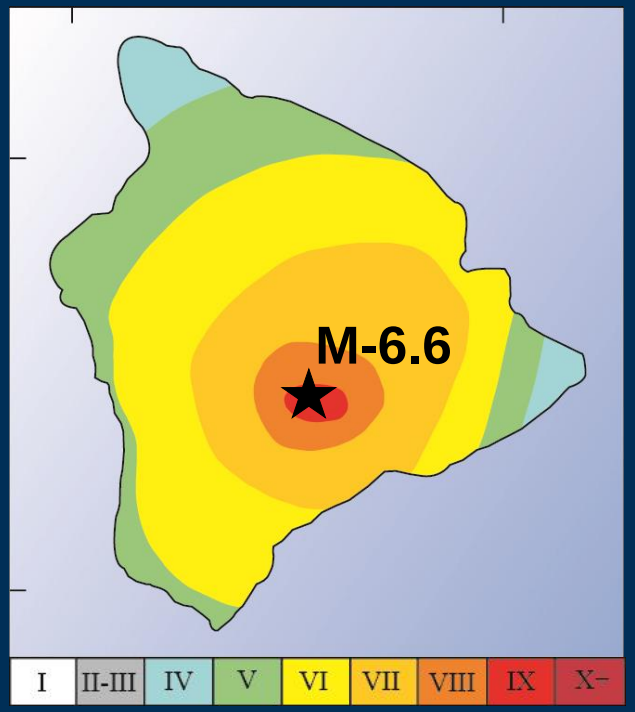
Extent: Felt as far away as Kauai

Damage: Estimated at $7 million in 1983. Houses moved off foundations, roads heavily cracked and temporarily closed, water tanks and chimneys collapsed, landslides and severe ground failures occurred in many areas.

Injuries: At least 6 people injured.



Damage in the Hawaiian Volcano Observatory library. USGS photo.



Modified from USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

If this earthquake occurred today, damages could cost as much as:

$ 200 million

1989 June 25

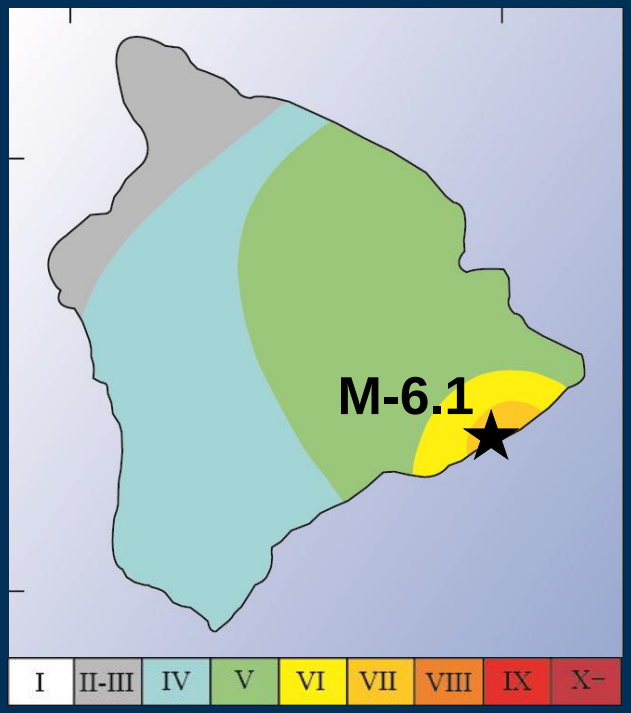
Shaking: Strong in southeast Puna District

Extent: Felt as far away as O‘ahu

Damage: Estimated at $1 million in 1989. Several homes collapsed; many others suffered significant structural damage.

Generated a small local tsunami, but no wave damage was reported.

Collapsed home in Kalapana, Hawai‘i. *USGS photo.*



Modified from: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

If this earthquake occurred today, damages could cost as much as:

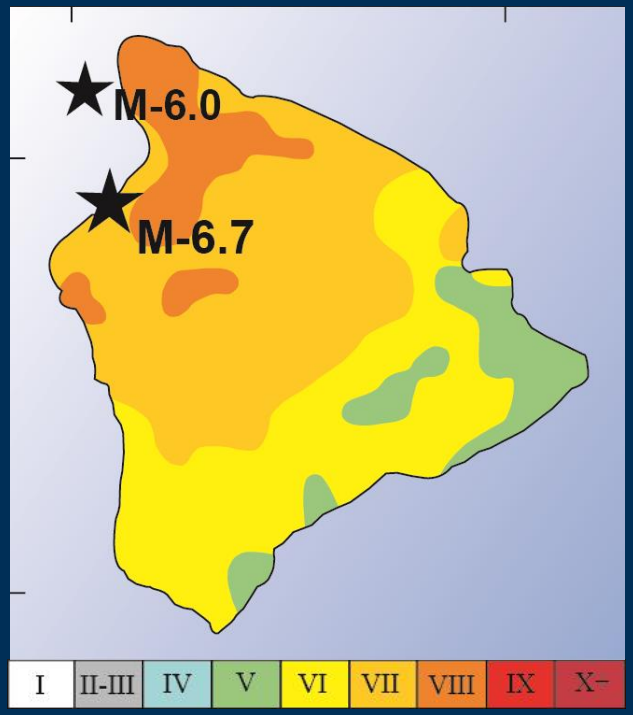
$ 300 million

2006 October 15

Shaking: Strong to severe in North Kona and Kohala Districts

Extent: Felt throughout the State

Damage: Heavy damage to Kawaihae harbor, homes, hotels, roads, and bridges; extended power outage on O‘ahu; landslides blocked roads.



Minutes after the M-6.7 Kīholo Bay earthquake, a M-6.0 earthquake struck offshore of Māhukona, Hawai‘i.

A massive rockslide diverted the course of Honokāne Nui Stream in northeast Hawai‘i. USGS photo.

BIG ISLAND EARTHQUAKE

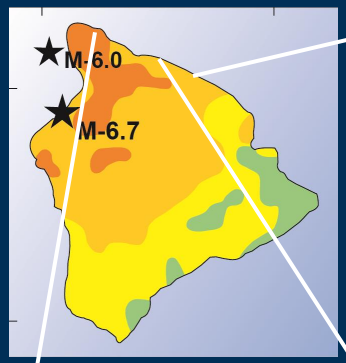
Hawaii Tribune Herald

October 31, 2006 | Proudly serving Hilo and the Big Island since 1923 | 50 cents

Quake damage may exceed $200M

Engineers assessing hard hit areas say initial estimate didn't include individual homes

Examples of damage on the Island of Hawai'i caused by the 2006 Kīholo Bay and Māhukona earthquakes.
USGS photos.



Highway 19, southeast of Kawāili Bridge.

Kalāhikiola Congregational Church, Kapa'au.

Honoka'a High School.

Bottom line…

Hawaii has a long history of destructive earthquakes.

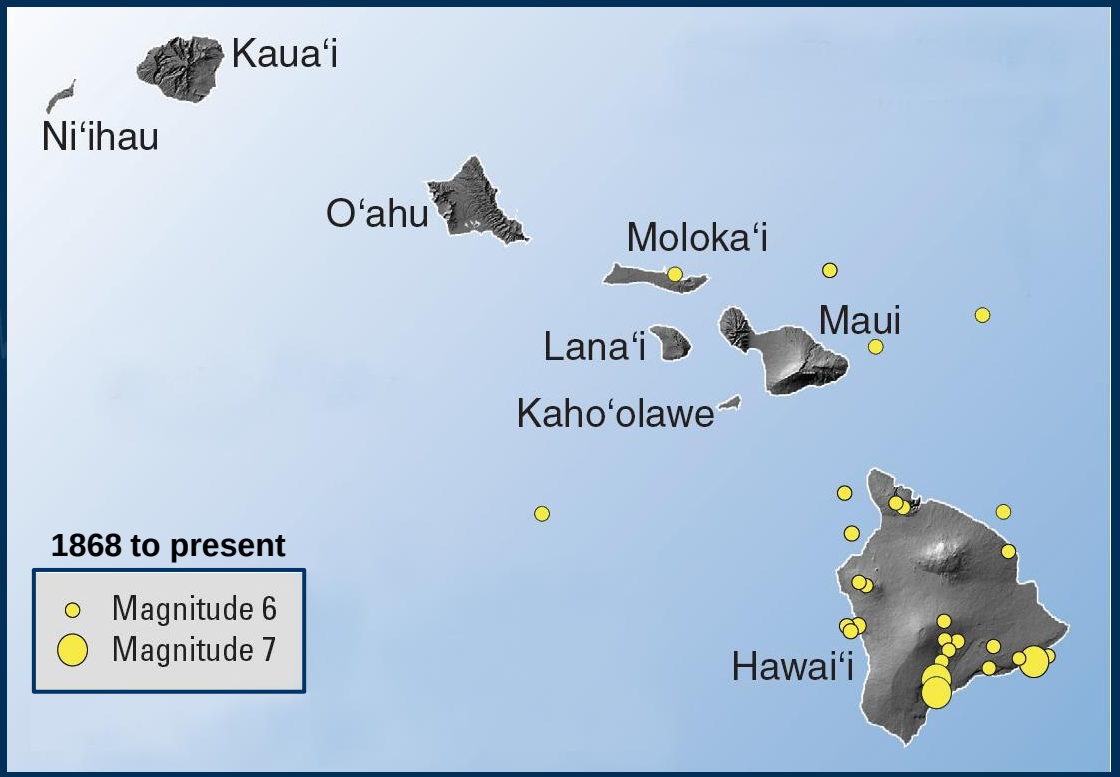
Hawaii's large earthquakes are equivalent in size to the strong earthquakes that occur along California's San Andreas fault. For example:

- 1906 San Francisco **(M-7.9)**
- 1989 Loma Prieta **(M-6.9)**
- 1994 Northridge **(M-6.7)**

USGS

Remember…

Large earthquakes can impact the entire **State of Hawaii**.



Source: USGS Fact Sheet 2011-3013 (http://pubs.usgs.gov/fs/2011/3013)

The probability of a destructive magnitude-6.5 or higher earthquake striking the Hawaiian islands:

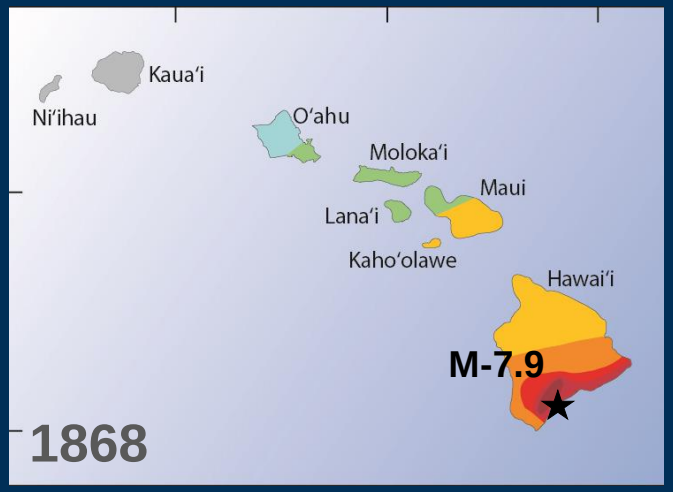
… in the next **10** years is 50%.

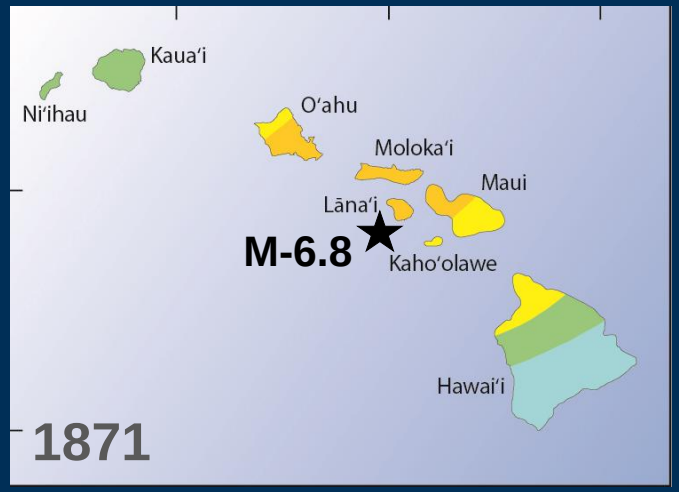
… in the next **20** years is 75%.

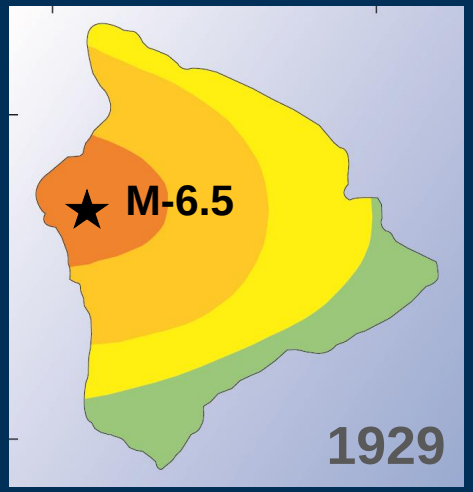
… in the next **50** years is 97%.

Source: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

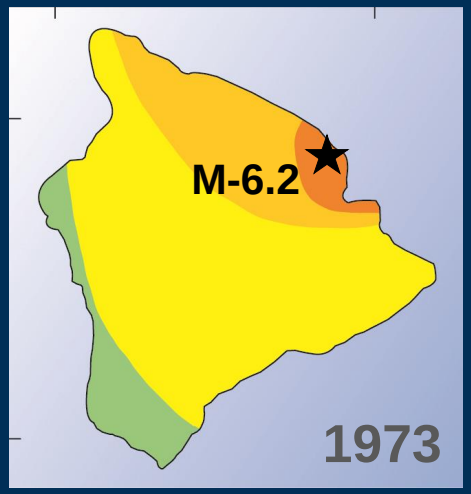
USGS

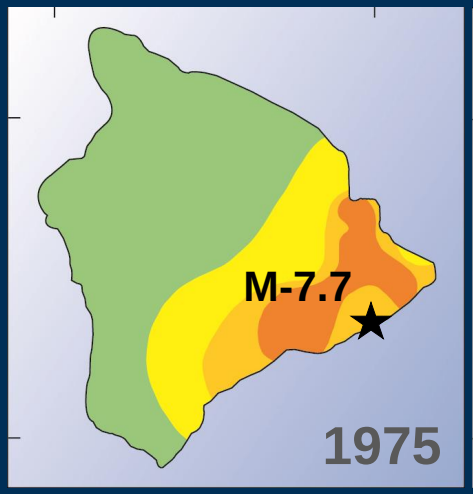


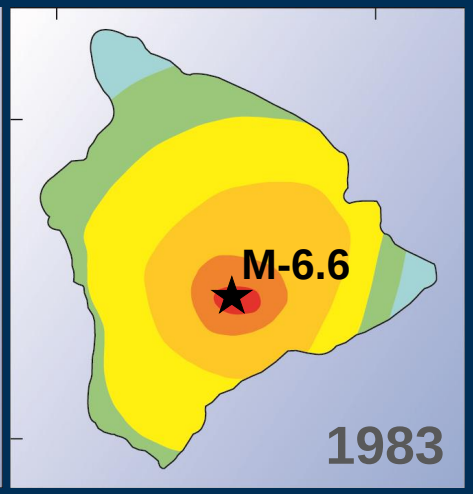


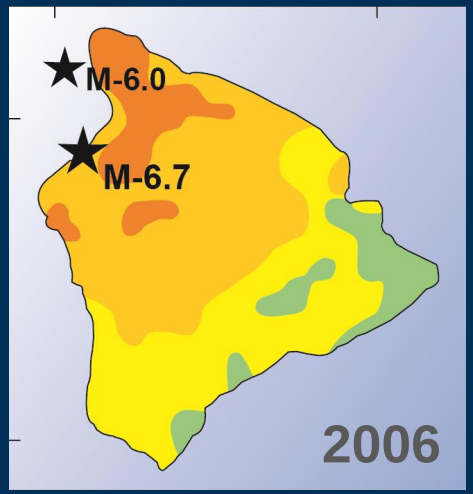


So… It's not **IF** a destructive earthquake will strike Hawaii, but **WHEN** the next one will happen.









Modified from: USGS Bulletin 2006 (http://pubs.er.usgs.gov/publication/b2006)

Do you know how to protect yourself during Hawaii's next big earthquake?

USGS

To reduce injury (or worse) during an earthquake, take these actions:

Source: http://www.shakeout.org/hawaii/dropcoverholdon/

USGS

If you're inside a building, stay there, *and …*

DROP to the floor (before the earthquake drops you)!

Take **COVER** under a sturdy table or desk!

HOLD ON to your shelter—and move with it until the shaking stops!

Photo: Humboldt State University (http://humboldt.edu/shakyground/)

USGS

If you're at or near the beach…

Drop! Cover! Hold on!
until the strong shaking stops.

Then…

quickly walk to higher ground—or inland—until you are at least 30 m (100 ft) above sea level, or beyond the marked tsunami hazard zone. Avoid steep cliffs and watch for falling rocks.

Strong earthquakes in Hawaii have generated **deadly tsunami**, so moving to higher ground after the next "big one" could save your life.

USGS

Practice makes perfect!

You are encouraged to practice

Drop! Cover! Hold on!

during…

Held annually – 3rd Thursday in October

USGS

ShakeOut began in California in 2008.

This earthquake drill is now global, with millions of people from around the world participating each year.

Hawaii joined **ShakeOut** for the first time in 2013. Details are posted on the **Great Hawaii ShakeOut** website:

www.shakeout.org/hawaii

USGS

ShakeOut Resources

Information on how to participate in **ShakeOut** and what to do during an earthquake is available online, including …

"Recommended Earthquake Safety Actions in Hawaii"

http://shakeout.org/hawaii/resources/

ShakeOut

The Great Hawaii ShakeOut

Annual Statewide Earthquake Drill

Individuals and Families

Register today at ShakeOut.org/hawaii

K-12 Schools and Districts

HOW TO PARTICIPATE

Recommended Earthquake Safety Actions in Hawaii

Federal, State, and local emergency management experts and other official preparedness organizations all agree that "**Drop! Cover! Hold On!**" is the appropriate action to take to reduce injury and death during earthquakes.

The **Great Hawaii ShakeOut** earthquake drill (http://shakeout.org/hawaii/) on October 17, 2013, is an opportunity to practice protecting yourself during an earthquake.

You cannot tell from the initial shaking of an earthquake if it will suddenly become intense, so…always, and immediately, Drop! Cover! and Hold On!

DROP! COVER! HOLD ON!

- **DROP** to the ground (before the earthquake drops you!)
- Take **COVER** by getting under a sturdy desk or table
- **HOLD ON** to your shelter and be prepared to move with it until the shaking stops

If a table or desk is not near you, drop to the ground and cover your head and neck with your hands and arms. If possible, crawl to an inside corner of the room. Stay in a crawling position to protect your vital organs and to be ready to move if necessary.

If you are unable to Drop! Cover! Hold On!: If you have difficulty dropping safely to the floor on your own, get as low as possible, protect your head and neck, and move away from windows or other items that can fall on you.

Guidelines on how to protect yourself in specific situations

If you are inside a building: Stay inside, and Drop! Cover! Hold on! until the shaking stops. Do not move to another location or outside. Moving outside can put you in greater danger than staying inside because exterior walls and windows often collapse. Trying to walk or run during strong shaking can also result in serious injury if you fall.

In bed: If you are in bed, stay there. Hold on and protect your head with a pillow. You are less likely to be injured by staying in bed. Broken glass on the floor has caused injuries to those who have rolled to the floor or tried to get to a doorway.

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Adapted from: Recommended Earthquake Safety Actions © Earthquake Country Alliance 2012

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Summary:

- ✓ Large, destructive earthquakes have impacted the State of Hawaii in the past—and will do so in the future.
- ✓ You must know how to protect yourself during an earthquake.
- ✓ Practice **Drop! Cover! Hold on!** so that you can react quickly during the next earthquake.
- ✓ The **Great Hawaii ShakeOut** is a good time to practice.

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Please

Join Us

for the Largest Earthquake Drill in Hawaiian History.

Annually – 3rd Thursday in October

The Great Hawaii ShakeOut™

Register at www.ShakeOut.org/hawaii

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Resources for more information about earthquakes in Hawaii

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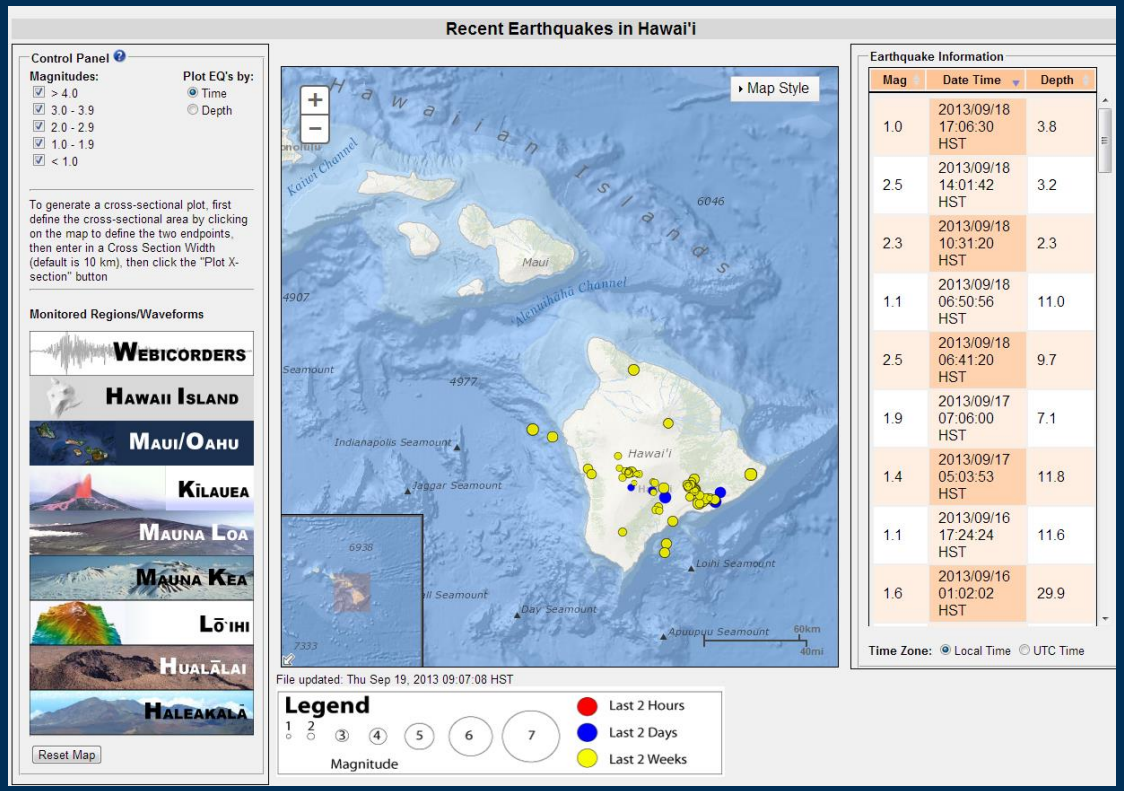
Recent Earthquakes in Hawaii

The **USGS Hawaiian Volcano Observatory** monitors earthquakes across the State of Hawaii.

Information and real-time data about recent events are posted on the HVO website:



http://hvo.wr.usgs.gov/seismic/volcweb/earthquakes/

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Online resources:

Hawaiian Volcano Observatory (HVO) Website

http://hvo.wr.usgs.gov/

Information about Hawaiian volcanoes and earthquakes, photographs and videos, "Volcano Watch" articles, news releases, and more. Earthquake pages include:

Earthquakes

http://hvo.wr.usgs.gov/earthquakes/

Info on destructive earthquakes, seismicity, hazards, instrumentation, etc.

Recent Earthquakes in Hawaiʻi

http://hvo.wr.usgs.gov/seismic/volcweb/earthquakes

Real-time data on current earthquakes.

November 29, 1975, Kalapana Earthquake

http://hvo.wr.usgs.gov/earthquakes/destruct/1975Nov29/

Description of this magnitude-7.7 earthquake.

Pacific Tsunami Warning Center

http://ptwc.weather.gov/

Earthquake data and tsunami warning information.

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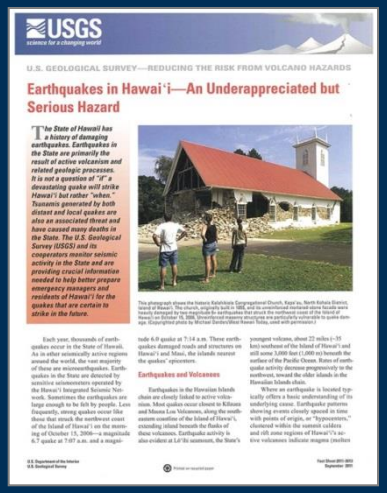
“Earthquakes in Hawai‘i—An Underappreciated but Serious Hazard”
http://pubs.usgs.gov/fs/2011/3013/
A USGS Fact Sheet about earthquake hazards and seismic monitoring in Hawaii.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U.S. GEOLOGICAL SURVEY—REDUCING THE RISK FROM VOLCANO HAZARDS

Earthquakes in Hawai‘i—An Underappreciated but Serious Hazard

The State of Hawaii has a history of damaging earthquakes. Earthquakes in the State are primarily the result of active volcanism and related geologic processes. It is not a question of "if" a devastating quake will strike Hawai‘i but rather "when." Tsunamis generated by both distant and local quakes are also an associated threat and have caused many deaths in the State. The U.S. Geological Survey (USGS) and its cooperators monitor seismic activity in the State and are providing crucial information needed to help better prepare emergency managers and residents of Hawai‘i for the quakes that are certain to strike in the future.

This photograph shows the historic Kalahikiola Congregational Church, Kapa‘au, North Kohala District, Island of Hawai‘i. The church, originally built in 1862, and its unreinforced masonry stone foundation were heavily damaged by the magnitude 6.7 earthquake that struck the northwest coast of the Island of Hawai‘i on October 15, 2006. Unreinforced masonry structures are particularly vulnerable to quake damage. (Copyrighted photo by Michael Sanders/Hawai Tribune, used with permission.)

Each year, thousands of earthquakes occur in the State of Hawaii. As in other seismically active regions around the world, the vast majority of these are microearthquakes. Earthquakes in the State are detected by sensitive seismometers operated by the Hawai‘i Integrated Seismic Network. Sometimes the earthquakes are large enough to be felt by people. Less frequently, strong quakes occur like those that struck the northwest coast of the Island of Hawai‘i on the morning of October 15, 2006—a magnitude 6.7 quake at 7:07 a.m. and a magnitude 6.0 quake at 7:14 a.m. These earthquakes damaged roads and structures on Hawai‘i and Maui, the islands nearest the quakes' epicenters.

Earthquakes and Volcanoes

Earthquakes in the Hawaiian Islands chain are closely linked to active volcanism. Most quakes occur closest to Kilauea and Mauna Loa Volcanoes, along the southeastern coastline of the Island of Hawai‘i, extending inland beneath the flanks of these volcanoes. Earthquake activity is also evident at Lō‘ihi seamount, the State's youngest volcano, about 22 miles (~35 km) southeast of the Island of Hawai‘i and still some 3,000 feet (1,000 m) beneath the surface of the Pacific Ocean. Rates of earthquake activity decrease progressively to the northwest, toward the older islands in the Hawaiian Islands chain.

Where an earthquake is located typically offers a basic understanding of its underlying cause. Earthquake patterns showing events closely spaced in time with points of origin, or "hypocenters," clustered within the summit caldera and rift zone regions of Hawai‘i's active volcanoes indicate magma (melten

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“Selected Images of the Effects of the October 15, 2006, Kīholo Bay-Māhukona, Hawai‘i, Earthquakes and Recovery Efforts” *http://pubs.usgs.gov/ds/506/*
Almost 600 images from 36 sites on the Island of Hawai‘i, where damage was the most concentrated by the 2006 earthquakes.

“The Story of the Hawaiian Volcano Observatory—A Remarkable First 100 Years of Tracking Eruptions and Earthquakes”
http://pubs.usgs.gov/gip/135/
The story of HVO’s founding in 1912, advances in monitoring tools and techniques, significant discoveries over the past century, and notable earthquakes and eruptions during HVO’s first 100 years.

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“Volcano Watch” articles about some of Hawaii’s most destructive earthquakes:

The Great Ka‘ū Earthquake of 1868
http://hvo.wr.usgs.gov/volcanowatch/archive/1994/94_04_01.html

"Seismic crisis" in 1929 includes magnitude-6 earthquakes beneath Hualālai
http://hvo.wr.usgs.gov/volcanowatch/view.php?id=192

Keep Maui's 1938 earthquake in mind
http://hvo.wr.usgs.gov/volcanowatch/archive/1999/99_04_08.html

The 1951 Kealakekua Earthquake
http://hvo.wr.usgs.gov/volcanowatch/archive/1994/94_08_21.html

The 28th anniversary of a very damaging (1973 Honomū) **earthquake**
http://hvo.wr.usgs.gov/volcanowatch/archive/2001/01_04_26.html

30th earthquake and accelerogram anniversary (of the 1973 Honomū earthquake)
http://hvo.wr.usgs.gov/volcanowatch/archive/2003/03_04_24.html

The Kalapana earthquake of 1975
http://hvo.wr.usgs.gov/volcanowatch/archive/1995/95_11_24.html

Aftershocks continue six months after the (2006) **Kīholo Bay Earthquake**
http://hvo.wr.usgs.gov/volcanowatch/archive/2007/07_04_19.html

Progress in the year following the (2006) **Kīholo Bay earthquake**
http://hvo.wr.usgs.gov/volcanowatch/archive/2007/07_09_27.html

Continued rumblings of the 2006 Kīholo Bay Earthquake
http://hvo.wr.usgs.gov/volcanowatch/archive/2008/08_12_24.html

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USGS Earthquake Hazards Program
http://earthquake.usgs.gov/
Information about earthquakes around the world, including historic events in specific states.

Hawaii Earthquake Information
http://earthquake.usgs.gov/earthquakes/states/?region=Hawaii

Frequently Asked Questions about Earthquakes
http://earthquake.usgs.gov/learn/faq/

USGS Earthquake Notification Service
https://sslearthquake.usgs.gov/ens/
Sign up for a free service that sends you automated notifications when earthquakes happen.

Did You Feel It?
http://earthquake.usgs.gov/earthquakes/dyfi/
Feel an earthquake? Report what you experienced with a few clicks of your computer mouse.
More info: *http://pubs.usgs.gov/fs/2005/3016/*

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The Great Hawaii ShakeOut™

www.shakeout.org/hawaii

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