



# This way to the Tsunami Boat And the 2014 Earthquake - Tsunami Room



HOW TO SURVIVE EARTHQUAKES AND TSUNAMIS IN NORTHERN CALIFORNIA

Redwood Coast  
Tsunami Work Group  
a member of the  
Earthquake Country Alliance  
*We're all in this together*



HUMBOLDT STATE UNIVERSITY



Featuring a real tsunami debris boat and remember the  
1964 tsunami and the 1964 flood



# The Most Important Take Home Message



## 1) SURVIVE THE EARTHQUAKE

You can't survive the tsunami if you don't make it through the earthquake first. If you are outside, just drop down to the ground and stay put - try to avoid power lines, tree limbs and anything that could fall.

## 2) KNOW YOUR ZONE

Are you in a tsunami zone? If YES, then head to high ground or inland away from the coast as soon as you can safely walk. Do take the time to put on your shoes - walking on debris strewn streets can be hazardous. If you aren't in a hazard zone - stay where you are.

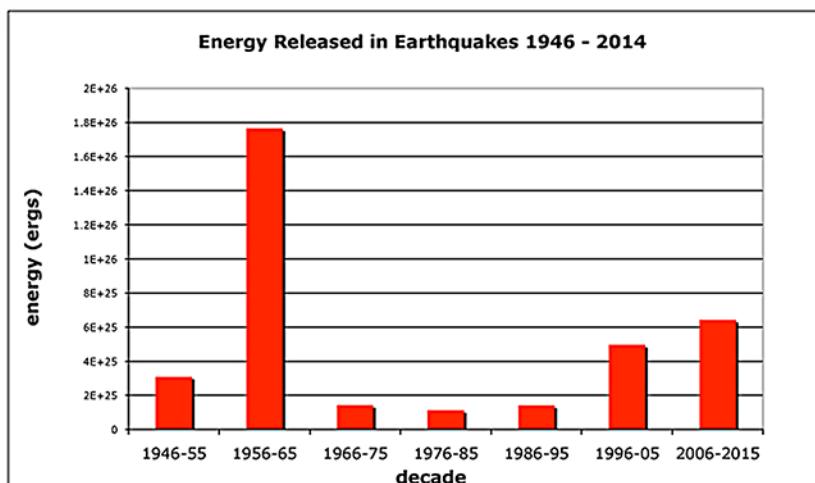
## 3) TSUNAMIS ARE TRICKY

Tsunamis can come from directions you don't expect and just when you think it's all over, another big surge may arrive. The first surge won't be the biggest and it's not uncommon for waves to arrive for 12 hours and sometimes much longer. Stay away from the coast until officials say it is safe to return

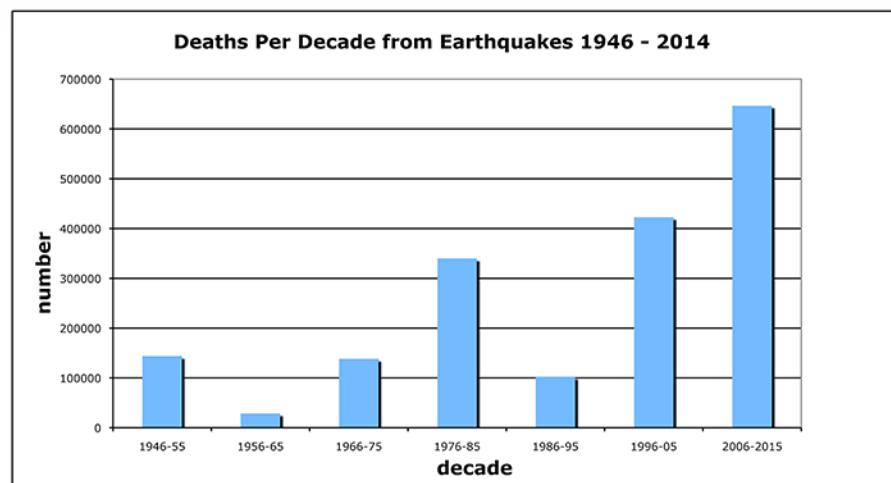


# Are earthquakes increasing? Probably not.

In the past decade, there have been two earthquakes in the magnitude 9 range and two others larger than magnitude 8.6. In the 37 years between 1966 and 2003, the largest magnitude earthquake was only an 8.4. It sure seems like the number of earthquakes are increasing. One way to measure earthquake activity is by the energy released. The last ten years have been more active than the previous decades, but not as active as the decade of 1956 to 1965.



The best way to measure earthquakes activity is by the energy released. The decade between 1956 – 1965 was much more active than recent decades.



Earthquake casualties don't correlate with the energy released! Casualties may be on the rise because of increased population and more people living in vulnerable places.

# The water disasters of 1964

1964 was a wild and woolly year for the North Coast of California. In the early morning hours of March 28, tsunami waves triggered by the great 1964 magnitude 9.2 Alaska earthquake killed 11 in Del Norte County and destroyed Crescent City's harbor and downtown. Surges also wreaked havoc along the Mendocino coast and in Noyo harbor. Less than nine months later, the Christmas flood drenched much of California and the Pacific Northwest, killing at least 19 people in California, and causing at least \$100 million in damages in Humboldt County alone.

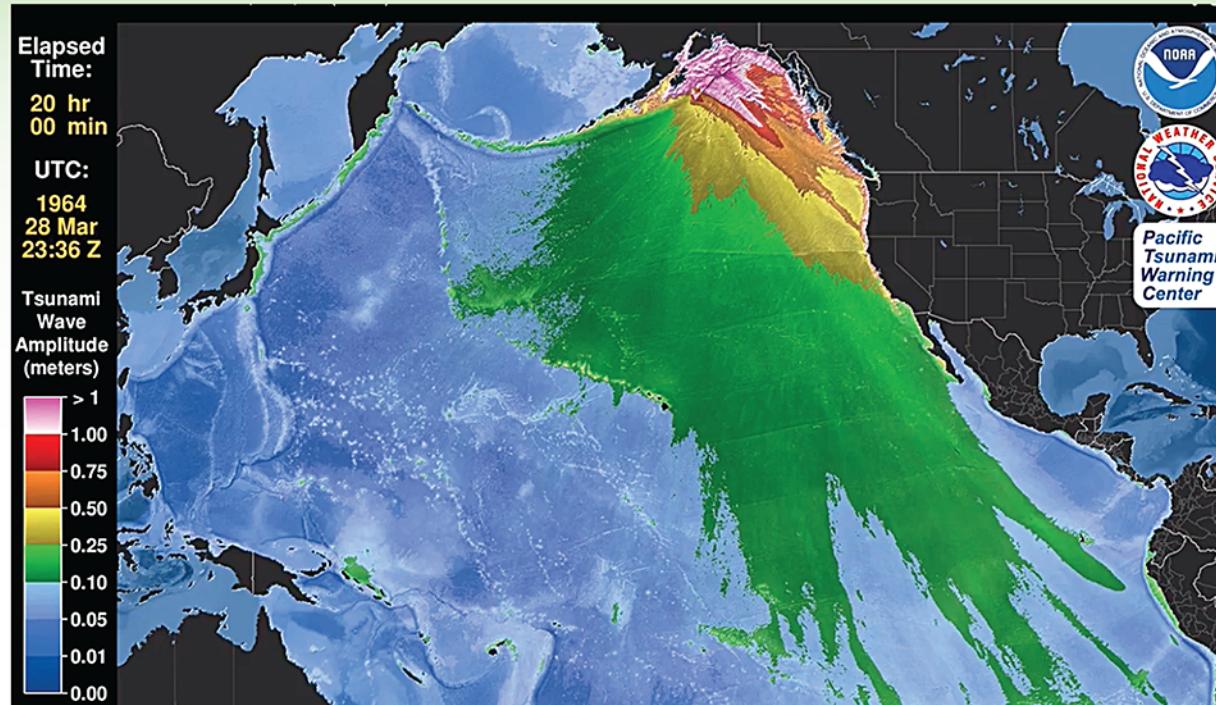


The tsunami piled up new trucks and cars at Nichols Pontiac just south of downtown Crescent City.



The town of Klamath in Del Norte County was wiped off the map in the Christmas Flood in December 1964.

# The Great Alaska Earthquake of 1964 is important



The earthquake produced a tsunami that caused damage along the entire Pacific Northwest Coast. It was the second worst historic natural disaster for North Coast California - only the Christmas floods of 1964 killed more people.

**It's only a matter of time before a similar event will strike again**

## Lessons from the 1964 tsunami

We live in the same subduction setting as Alaska. In 1964, a magnitude 9.2 earthquake sent a tsunami that took about four and a half hours to travel to us. Some day the Cascadia subduction zone will produce a magnitude 9 earthquake. It will take as little as ten minutes for the first tsunami waves to reach our coast.

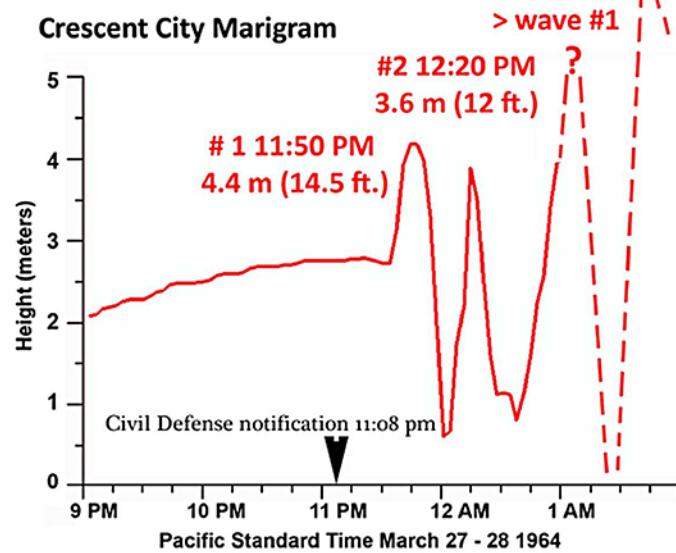


This two story school was offset by a thrust fault. There are many similar faults in Humboldt County.

**Alaska's experience will help us prepare for the next Cascadia earthquake.**

# Lessons from the 1964 tsunami

The first wave was not the biggest! The first wave was not a recession with the water first going out. The first wave arrived at about 11:45 pm and raised the water about 4 feet above the high tide. It flooded the coastal area as far as Front Street in Crescent City.

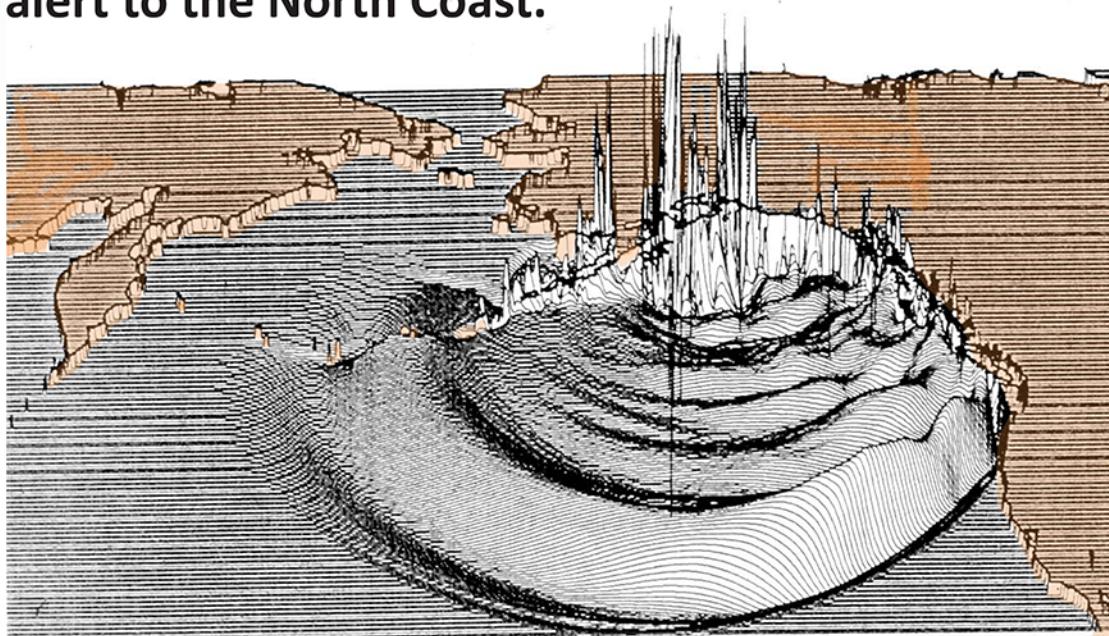


This is a marigram (water level recording) from the tide gauge at Citizens Dock in Crescent City during the 1964 tsunami. The recording begins at 9 PM PST on March 27. The tide was at a height of seven feet and still rising. High tide was at 11 PM. Even though the earthquake occurred at 7:28 PM, it took three and a half hours for an official alert bulletin to reach Crescent City (arrow). The first tsunami surge at 11:50 PM raised the water a little more than four feet above the tide. It caused flooding to Front Street, almost the exact same flooding caused by the 1960 Chilean tsunami only four years earlier. The second surge arrived a half hour later and was smaller. Over forty minutes passed with no observable wave activity and many people thought the tsunami was over and returned to the coastal area. They were caught by a third surge that was much bigger. It knocked over the tide gauge. The rest of the marigram (dashed line) is based on eye witness accounts. The fourth surge was the largest and caused most of the damage. The tide was still high and the 16 foot tsunami riding on top of the tide brought the peak water height to 22 feet.

Tsunamis are tricky and 1964 was no exception

# Lessons from the 1964 tsunami

The tsunami warning system did not work as well in 1964 as it does now. It took an hour and a half to for the single tsunami warning center in Hawaii to locate the earthquake. It took over three hours for the California civil Defense office to an alert to the North Coast.



This is a Japanese numerical model of the 1964 tsunami about three hours after the earthquake. The first tsunami waves have reached Oregon. This is about the time when Crescent City received its first bulletin from the California Civil Defense Office that a tsunami might be coming. The first waves arrived less than an hour

If a similar earthquake occurred today, the first alert bulletin would be issued in less than 5 minutes.

**Everyone needs to understand what tsunami bulletins mean**

# Lessons from the 1964 tsunami

- 29 city blocks flooded
- 91 homes damaged or destroyed
- 197 businesses affected, 42 destroyed



Orville Magoon's map of the inundation in Crescent City. Countours show water hieght above mean sea level or the ground surface in feet.

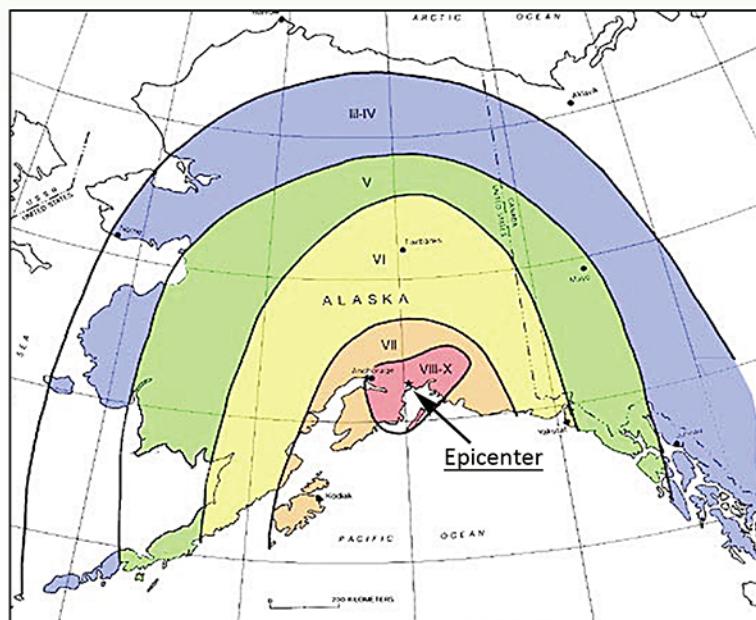


Air photos taken before and after the tsunami show the effects of the tsunami in the harbor area.

## What happened in Crescent City

# Lessons from the 1964 earthquake

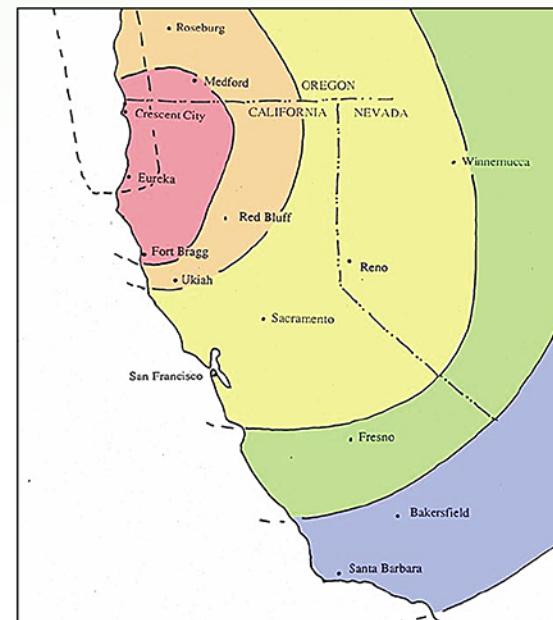
One of the most important lessons from the Alaska earthquake was the scale of ground shaking. Because the earthquake rupture was over 500 miles long and the slip was so large, it was felt throughout Alaska and in much of NW Canada.



Actual pattern of ground shaking during the 1964 Alaska earthquake (USGS).



Isoseismal maps show the pattern of ground shaking.



If the Alaska epicenter were in Humboldt County and we had the same pattern of shaking, the earthquake would cause severe damage in Redding, and strong shaking in San Francisco and Sacramento.

**If an earthquake similar to '64 Alaska occurred here, it would be felt in LA!**



# Lessons from the '64 Flood

"Isolated islands of humanity" and animals too! These cattle weren't the only ones left on their own and cut off from food, shelter and other essential needs. Waters were at or above flood stages in some areas for 20 days. It took rescuers weeks to reach more isolated regions.



Our modern society is just as vulnerable to isolation as the North Coast of 1964. Be prepared to be on your own for at least a week. If you live or work in a more remote area, you could be isolated for weeks.

# Lessons from the '64 flood

Nearly two-thirds of the bridges in Northern California were destroyed or made unusable in the Christmas Flood. It is the most expensive disaster in Caltrans' history - even more costly than the 1972, 1989, and 1994 earthquakes.



Rio Dell Bridge, photo by R. Gillard



Original bears on the south side of the Klamath bridge



Bridge north of Rio Dell.

It took months to install temporary “bailey bridges”, and traffic was restricted in some areas for more than a year. All transportation to the north coast was cut off - to the north, to the south and to the east. The aircraft carrier USS Bennington was deployed from San Diego to provide emergency medical and relief assistance.

# The '64 tsunami and flood shared one problem

Both 1964 water disasters produced mountains of debris on the North Coast. For months, teepee burners disposed of the unusable woody material. Debris disposal will be more complicated when the next disaster strikes our area.



Debris piled in the Safeway parking lot following the March tsunami. Much of the damage was caused by debris bashing into structures.

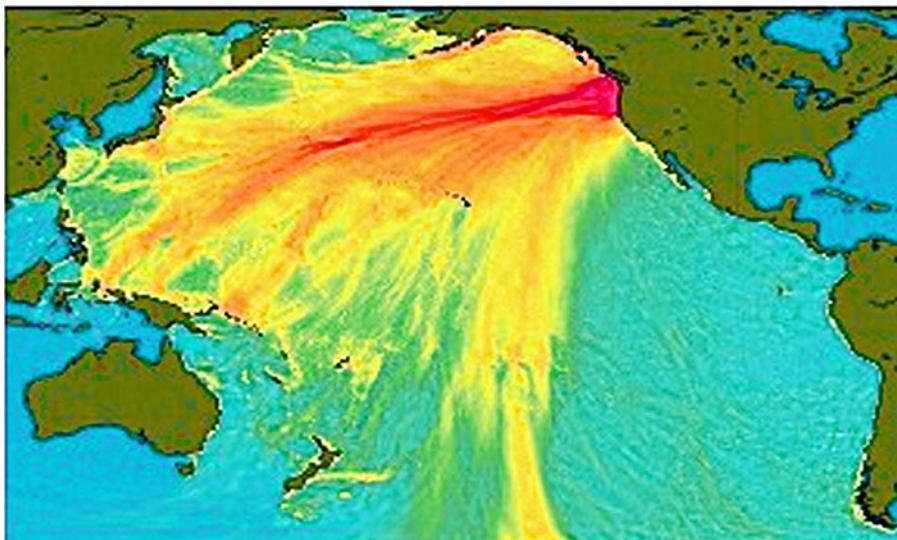


Crescent City's harbor was still choked with debris in early January 1965. Logs and other woody debris were swept down rivers and accumulated on beaches and in harbors.

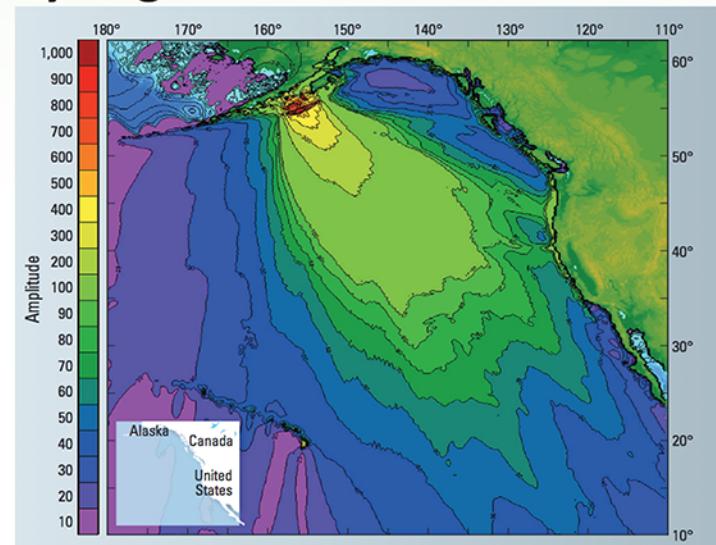
## Debris! Debris! Debris!

# Was 1964 the worst tsunami for the North Coast?

The 1964 tsunami was nearly the worst *distant* event that could strike us. The source was oriented to focus tsunami energy on our coast. The largest waves arrived close to high tide. The USGS SAFRR scenario found a similar-sized earthquake just west of 1964 could produce a slightly larger tsunami.



Modeled peak tsunami energy from a magnitude 9 earthquake on the Cascadia subduction zone. The first tsunami waves are likely to arrive as early as ten minutes after the earthquake.



Modeled peak tsunami energy for the SAFRR scenario - the worst case distant tsunami. The first tsunami waves will arrive in California over four hours after the earthquake..

**The largest tsunami in our area will come from a great earthquake on the Cascadia subduction zone - asteroid excepted!**



# Was 1964 the worst flood for the North Coast?

Probably not. Many conditions combined to make the Christmas flood of 1964 the flood of record for many Northern California and Oregon rivers. There was a fairly thick snowpack in the mountains when the “pineapple connection” (now called an atmospheric river) brought large quantities of warm rain to the region. Global warming may increase the strength of future atmospheric river patterns.



High flows on the Salmon River in 1964.

**Sea level rise makes bays and estuaries more vulnerable to the next 1964-sized flood**

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High flows on the Salmon River in 1964.

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# The Dry Lagoon Tsunami Boat

## The story of this boat

On June 2, 2014 a group of kayakers spotted something unusual on the Dry Lagoon beach. A small fiberglass boat was upside down on the beach, with great masses of barnacles attached. From the Japanese characters on the boat, they suspected it was brought here by the March 11, 2011 tsunami.



# The Dry Lagoon Tsunami Boat

Why do we think it is a “tsunami debris” boat?

1: The registration number MG-338397 links it to a small boat basin in Japan’s Miyagi Prefecture, one of the hardest hit areas of the 2011 tsunami



2: It is a “panga boat”. Panga boats are distinctive with a rounded, jutting-out prow, and open deck. They are the work horses of central and south America, Japan, Philippines and SE Asia but uncommon in North America. When not used, they are typically hoisted onto a concrete deck like these new boats in Iwate Prefecture.

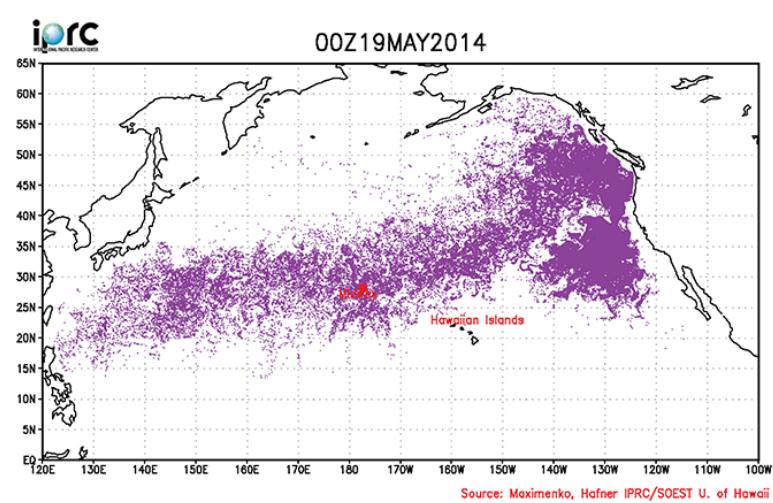
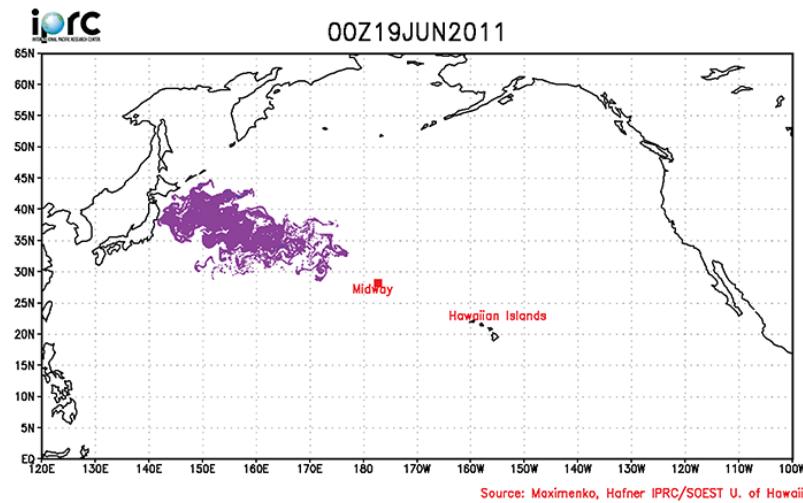


3: There are Japanese characters on the side of the boat. The Japanese pronunciation is TAI SHOU MARU and it means Big Win Boat. The Japanese Consulate in San Francisco is using the name and the registration number to locate the boat's owner.

# The Dry Lagoon Tsunami Boat

## How did the boat get here?

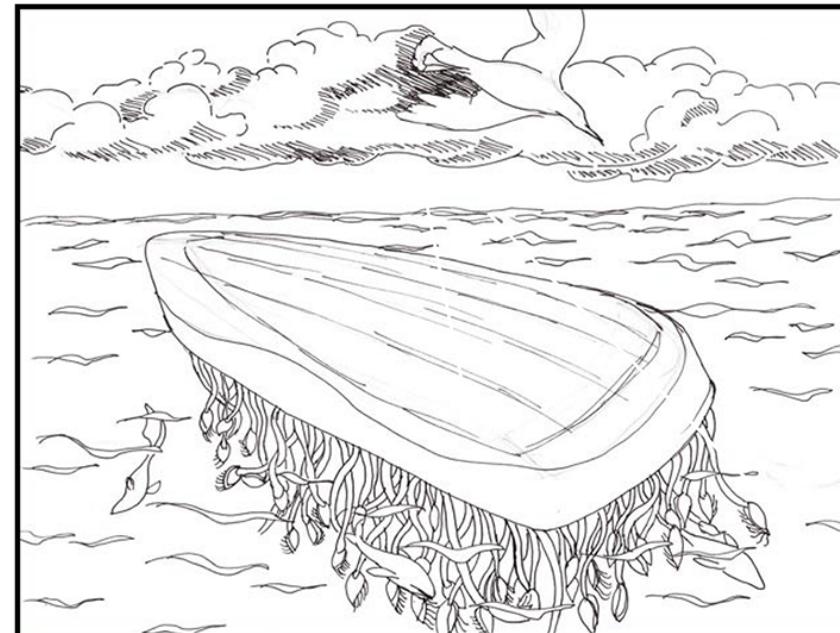
Thousands of boats were swept away in the tsunami of March 11, 2011. Initially the debris field was thick enough to be seen by satellites. The “Big Win Boat” was flipped upside down like the boat in this US Navy image.



# The Dry Lagoon Tsunami Boat

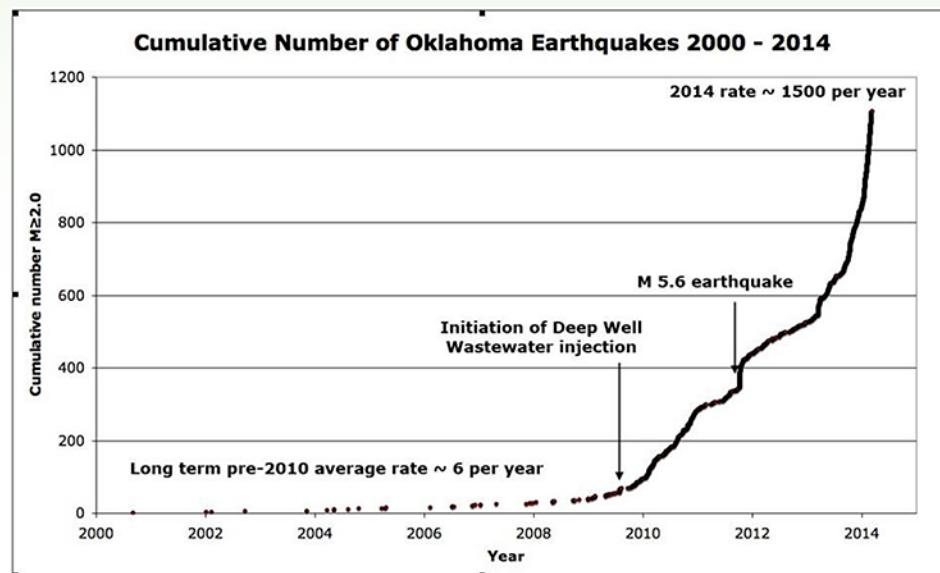
The boat was pulled by the tsunami far enough offshore to be caught in the Pacific Gyre, the great rotating current in the northern Pacific. After the first several weeks, the debris was too dispersed to be able to track. These two figures show an animation by the International Pacific Research Center at the University of Hawaii of the possible debris path. Tsunami debris including more boats may continue to arrive along the west coast for many years.

As the Big Win Boat continued to drift across the Pacific, it picked up passengers. Pelagic goose-necked barnacle larvae (*Lepas anatifera*) adhered to the parts of the boat under water and slowly grew. From the size of the barnacles, the boat had likely been in the water for more than a year. Fortunately these are the same kind of barnacles that live along our coast and not an invasive species. Drawing by Amy Uyeki



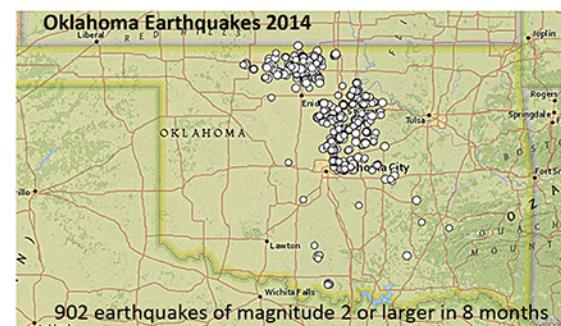
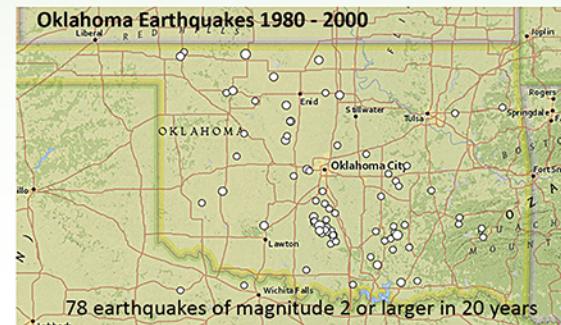
# What is happening in Oklahoma?

902 earthquakes of magnitude 2 or larger have been recorded in Oklahoma in 2014. This compares with only 78 earthquake in the twenty year period between 1980 and 2000! This year Oklahoma surpassed California as having the most felt earthquakes in the contiguous 48 states. What is going on?



This graph shows the cumulative number of earthquakes from 2000 to the present. What changed around 2009? The requirement that fluid wastes from oil and gas drilling be disposed in deep waste water wells. More waste water has been injected as fracking has increased.

**There are more than a million deep waste water well in the country and fewer than ten have shown increased seismicity. Scientists are trying to figure out why.**



The rate of earthquakes in Oklahoma increased 250 fold from 2014 compared to the long term pre 2010 rate.

# Notable quakes of 2014 (to date):

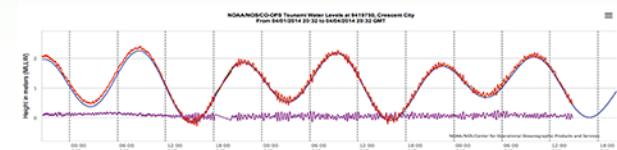
- **Deadliest quake:** August 3 M 6.1 Southern China, 617 deaths

Impacts exacerbated by dense population and earthen structures with no resistance to earthquake shaking.



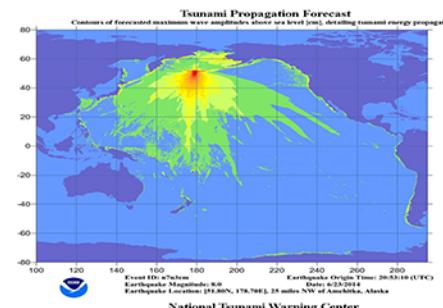
- **Largest quake:** April 1 M 8.2 Northern Chile, 5 deaths, tsunami

Only 5 deaths were attributed to this earthquake, a testimony to Chile's strong building codes and construction enforcement. The earthquake generated a tsunami with heights of 13 feet in Chile and damaged boat harbors. At Crescent City (right) it was only 6 inches.



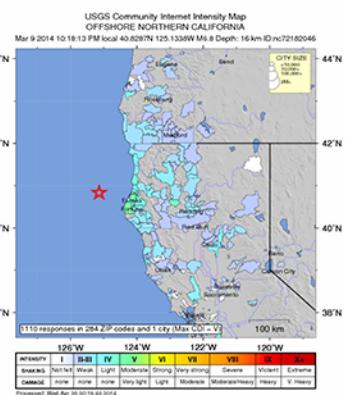
- **Largest US quake:** June 23 M 7.9 Aleutian Islands Alaska, no damage, small tsunami

This earthquake was centered in an unpopulated area and the tsunami energy was directed towards the open ocean. No damage from either the shaking or the tsunami.



- **Largest US quake in the lower 48:**

The March 9 magnitude 6.8 earthquake was located about 50 miles west of Eureka. It was felt by many on the North Coast and by some from south of San Francisco to Eugen Oregon. Fortunately the earthquake was too far offshore to cause damage and the strike-slip faulting produced no tsunami.



# Liquefaction lessons from New Zealand



The February 2011 magnitude 6.1 New Zealand earthquake caused unprecedented liquefaction including sand boils, settlement, uplift, and lateral spreading. More than 50% of the Christchurch area was affected. Liquefaction caused buildings and retaining walls to tilt or settle and numerous cars and trucks sunk into the mud and silt as the water gushed up. Liquefaction was the primary cause of damage to water and sewer lines, electricity and power, and roads and highways. In some areas the ground settled as much as three to six feet, making the land more susceptible to flooding and tsunami inundation.



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