STATE OF CALIFORNIA – THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, GOVERNOR

CALIFORNIA COASTAL COMMISSION

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August 26, 2005

TO: Commissioners and Interested Parties

FROM: Susan Hansch, Chief Deputy Director
Lesley Ewing, Sr. Coastal Engineer

SUBJECT: **WORKSHOP on CALIFORNIA'S TSUNAMI PREPAREDNESS**

Staff is pleased to provide the following materials in support of the September 15, 2005 Workshop on California's Tsunami Preparedness.

2005 Tsunami Workshop Agenda

Glossary of Tsunami Terms and Acronyms; excerpted from NOAA's Pacific Marine Environmental Laboratory web site and NOAA's International Tsunami Information Center.

Tsunami. Article from *Coast and Ocean*, Autumn 2002 by Kevin Knuuti and Lesley Ewing.

Tsunami Bulletins: Information, Warning, Watch and Advisory; excerpted from the International Tsunami Information Center web site.

National Tsunami Hazard Mitigation Program; 2-page brochure.

Tsunami Ready; 2-page brochure.

Tsunami Safety Plan for Redwood Oceanfront Resort Project in Crescent City (CDP-A-1-CRC-00-033)

Recommendations on Land Use Planning for Tsunamis; prepared for the California Seismic Safety Commission.

List of Internet Sites Providing Tsunami Information.

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2005 Tsunami Workshop

(Estimated Time: 1 hour)

1. Introduction to the Workshop

2. Lessons from the two recent tsunami events
   Lesley Ewing, Sr. Coastal Engineer, California Coastal Commission
   - Indian Ocean Tsunami
   - 14 June Earthquake

3. Tsunamis and the California Experience
   Lori Dengler, Ph.D., Department Chair, Geology Department, Humboldt State University
   - Sumatran tsunami, overview, geology and relate to Cascadia
   - Tsunamigenic sources in California and major California tsunamis

4. Current Approach to tsunami preparedness, Detection and Alerts
   Rich Eisner, Coastal Region Director, Governor's Office of Emergency Services
   - Maps of inundation and run-up areas
   - Use of maps for evacuation planning
   - DART System
   - Tide Gauges and near-field sensors
   - Communication network for Warnings, Watches and Alerts

5. Education
   Nancy Dean, TsunamiReady Program, National Weather Service
   - TsunamiReady Program
   - Basic tsunami information (phone books, hotel pamphlets, etc.)
   - Posters for fairs, weather station information
   - Tsunami warning signs
   - Evacuation signs

6. Future Efforts at Federal and State Level
   Mark Johnsson, Ph.D., Staff Geologist, California Coastal Commission
   - S. 50 and Seismic Safety Commission Recommendations
   - CCC Role in Permitting and LCP Planning for tsunamis

7. Future Efforts at the Regional and Local Level
   Lesley Ewing, Sr. Coastal Engineer, California Coastal Commission
   - Bay Area Regional Coordination
   - County Plans

8. Discussion/Questions

GLOSSARY OF TSUNAMI TERMS and ACRONYMS

Compiled from information in:
http://www.pmel.noaa.gov/tsunami-hazard/terms.html (1) and
http://www.prh.noaa.gov/itic/library/pubs/glossary/glossary.html (2)

Amplitude (tsunami): Usually measured on a water level record, it is: **1.** the absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed water level at the time, **2.** half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often an amplitude modified in some way by the response of the tide gauge (2).

Amplitude (maximum): Usually measured on a water level record, it is half the value of the maximum peak-to-trough excursion, corrected for the change of tide between that peak and trough (2).

Arrival Time: Time of arrival, usually of the first wave, of the first wave of the tsunami at a particular location (1).

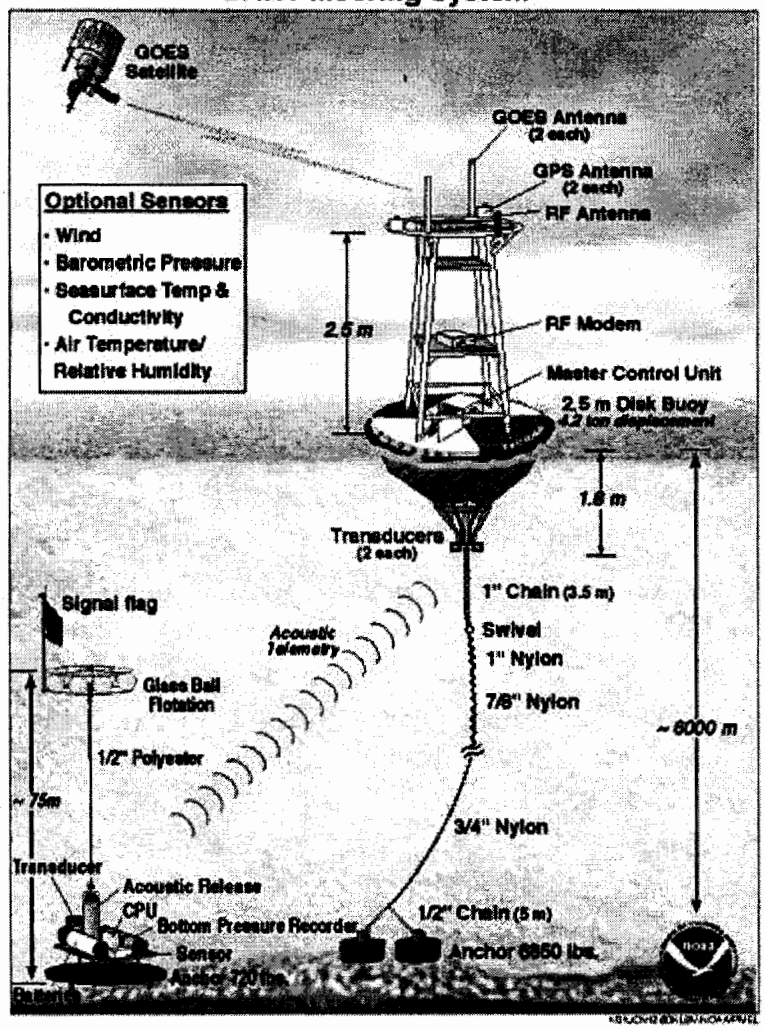
Bore: Traveling wave with an abrupt vertical front or wall of water. Under certain conditions, the leading edge of a tsunami wave may form a bore as it approaches and runs onshore. A bore may also be formed when a tsunami wave enters a river channel, and may travel upstream penetrating to a greater distance inland than the general inundation (1).

CREST: Consolidated Reporting of EarthquakeS and Tsunamis, a project funded through the Tsunami Hazard Mitigation Federal/State Working Group to upgrade regional seismic networks in AK, WA, OR, CA, and HI and provide real-time seismic information from these networks and the USNSN to the tsunami warning centers (1).

Crest Length: The length of a wave along its crest. Sometimes called crest width (2).

DART: Deep Ocean Assessment and Reporting of Tsunamis (DART) Project is an ongoing effort to maintain and improve the capability for the early detection and real-time reporting of tsunamis in the open ocean. DART systems consist of an anchored seafloor bottom pressure recorder (BPR) and a companion moored surface buoy for real-time communications. An acoustic link transmits data from the BPR on the seafloor to the surface buoy. The data are then relayed via a satellite link to ground stations, which demodulate the signals for immediate dissemination to NOAA's Tsunami Warning Centers, NDBC, and PMEL. The moored system is shown in the accompanying figure.

DART Mooring System



Courtesy of PMEL

Drop: The downward change or depression in sea level associated with a tsunami, a tide, or some long term climatic effect (2).

Elapsed Time: Time between the maximum level arrival time and the arrival time of the first wave (2).

Far-Field Tsunami: Source of the tsunami is more than 1,000 km away from area of interest and travel time is greater than 2 hours. See also teletsunami.

Harbor Resonance: The continued reflection and interference of waves from the edge of a harbor or narrow bay which can cause amplification of the wave heights, and extend the duration of wave activity from a tsunami (1).

Horizontal Inundation: Distance between the inundation line and the shore, generally measured perpendicularly to the shore (2).

Intensity: Extreme strength, force or energy (2).

Inundation: The depth, relative to a stated reference level, to which a particular location is covered by water (1).

Inundation Area: An area that is flooded with water (1).

Inundation Line: Inland limit of wetting, measured horizontally from the mean sea level (MSL) line. The vegetation line is sometimes used as a reference. If it can be determined that it is more than 10 feet from the MSL line, adjust; otherwise, ignore. In tsunami science, the landward limit of tsunami runup (2).

ITIC: International Tsunami Information Center established in 1965. Monitors international activities of the Pacific Tsunami Warning Center and assists with many of the activities of ICG/ITSU (1).

Leading Wave: First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in water level, and in some cases an elevation or rise in water level (2).

> **leading-depression wave**: Initial tsunami wave is a trough, causing a draw down of water level (1).
>
> **leading-positive wave**: Initial tsunami wave is a crest, causing a rise in water level. Also called a leading-elevation wave (1).

Local/Regional Tsunami: Source of the tsunami within 1000 km of the area of interest. Local or near-field tsunami has a very short travel time (30 minutes or less), mid-field or regional tsunami waves have travel times on the order of 30 minutes to 2 hours. Note: " Local" tsunami is sometimes used to refer to a tsunami of landslide origin (1).

Magnitude: A number assigned to a quantity by means of which the quantity may be compared with other quantities of the same class (2).

Maremoto: Spanish term for tsunami (1).

Marigram (or mareogram): Tide gage recording showing wave height as a function of time (1).

Marigraph (or mareograph): The instrument which records wave height (1).

Maximum Inundation: Maximum horizontal penetration of the tsunami from the shoreline. A maximum inundation is measured for each different coast or harbor affected by the tsunami (2).

Maximum Run-up: Maximum difference between the elevation at the maximum tsunami penetration (the inundation line) and sea-level at the time of the tsunami attack. A maximum run-up is measured for each different coast or harbor affected by the tsunami (2).

Mean Height: Average height of a tsunami measured from the trough to the crest after removing the tidal variation (2).

Mean Lower Low Water (MLLW): The average low tide water elevation often used as a reference to measure runup (1).

Near Field Tsunami: A tsunami from a nearby source, generally less than 200 km away. A local tsunami is generated by a small earthquake, a landslide or a pyroclastic flow (2). See also Local/Regional Tsunami.

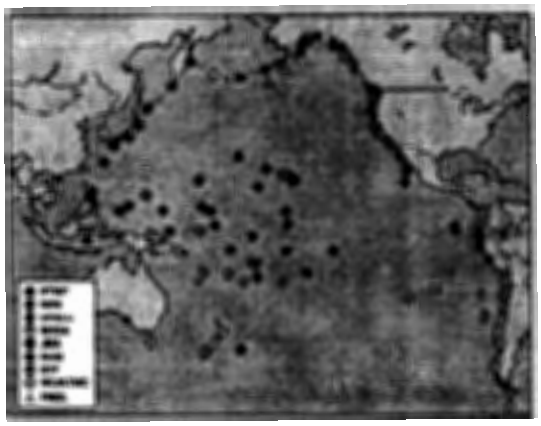
NEIC: National Earthquake Information Center. The NEIC, run by the US Geological Survey, has a mission to rapidly determine location and size of all destructive earthquakes worldwide and to immediately disseminate this information to concerned national and international agencies, scientists, and the general public (Source: http://wwwneic.cr.usgs.gov/).

Normal Earthquake: An earthquake caused by slip along a sloping fault where the rock above the fault moves downwards relative to the rock below (1).

PDC: Pacific Disaster Center. An information processing center to support emergency managersin the Pacific region. Funded by the U.S. Department of Defense (1).

PTWC: Pacific Tsunami Warning Center. Originally established in 1948 as the SSWWS, located in Ewa Beach near Honolulu. Responsible for issuing warnings to Hawaii, to U.S. interests in the Pacific **other than the west coast and Alaska**, and to countries located throughout the Pacific. PTWC is the headquarters of the operational Tsunami Warning System (TWS) in the Pacific and works closely with other regional national centers in monitoring seismological and tidal stations and instruments around the Pacific Ocean, to evaluate potentially tsunamigenic earthquakes. PTWC is operated by the United States National Weather Service. (http://www.nws.noaa.gov/pr/ptwc) (1 and 2)

PTWS: Pacific Tsunami Warning System. PTWS is the operational Tsunami Warning System in the Pacific (2).



Tsunami Warning System Sea Level Gauges (2).

Period: The length of time between two successive peaks or troughs. May vary due to complex interference of waves. Tsunami periods generally range from 5 to 60 minutes (1).

Rise: The upward change or elevation in sea level associated with a tsunami, a hurricane, a tide, or some long term climatic effect (2).

Runup: Maximum height of the water onshore observed above a reference sea level. Usually measured at the horizontal inundation limit (1).

Run-up: (1) Difference between the elevation of maximum tsunami penetration (inundation line) and the sea-level at the time of the tsunami attack.

(2) Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami attack, etc., and measured ideally at a point that is a local maximum of the horizontal inundation.

(3) In practical terms, run-up is only measured where there is a clear evidence of the inundation limit on the shore (2).

Significant Wave Height: The average height of the onethird highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period. Also characteristic wave height (2).

Seiche: A standing wave oscillating in a partially or fully enclosed body of water. May be initiated by long period seismic waves, wind and water waves, or a tsunami (1).

Spreading: When reference is made to tsunami waves, it is the spreading of the wave energy over a wider geographical area as the waves propagate away from the source region. The reason for this geographical spreading and reduction of wave energy with distance traveled, is the sphericity of the earth. The tsunami energy will begin converging again at a distance of 90 degrees from the source. Of course tsunami waves propagating across a large ocean undergo other changes in energy configuration due to refraction, primarily, but geographical spreading is also very important depending upon the orientation, dimensions and geometry of the tsunami source (2).

Strike-slip Earthquake: An earthquake caused by horizontal slip along a fault (1).

SSWWS: Seismic Sea Wave Warning System, the original tsunami warning center established in 1948 after the April 1, 1946 tsunami killed 159 in Hawaii (1).

Teletsunami: Source of the tsunami more than 1000 km away from area of interest. Also called a distant-source or far-field tsunami (1).

THRUST: The project for Tsunami Hazard Reduction Using System Technology, sponsored by the Office for U.S. Foreign Disaster Assistance/Agency for International Development. A comprehensive program to mitigate tsunami hazards in developing countries (1).

Thrust Earthquake: An earthquake caused by slip along a gently sloping fault where the rock above the fault is pushed upwards relative to the rock below. The most common type of earthquake source of damaging tsunamis (1).

Tidal Wave: Common term for tsunami used in older literature, historical descriptions and popular accounts. Tides, caused by the gravitational attractions of the sun and moon, may increase or decrease the impact of a tsunami, but have nothing to do with their generation or propagation. However, most tsunamis (initially) give the appearance of a fast-rising tide or fast-ebbing as they approach shore and only rarely as a near-vertical wall of water (1).

TIME: The Center for the Tsunami Inundation Mapping Effort, to assist the Pacific states in developing tsunami inundation maps (1).

Travel Time: Time (usually measured in hours and tenths of hours) that it took the tsunami to travel from the source to a particular location (1).

Tsunami: A Japanese term derived from the characters "tsu" meaning harbor and "nami" meaning wave. Now generally accepted by the international scientific community to describe a series of travelling waves in water produced by the displacement of the sea floor associated with submarine earthquakes, volcanic eruptions, or landslides (1).

Tsunami Damage: Loss or harm caused by a destructive tsunami. More specifically, the damage caused directly by tsunamis can be summarized into the following: 1) deaths and injuries; 2) houses destroyed, partly destroyed, inundated, flooded, or burned; 3) other property damage and loss; 4) boats washed away, damaged or destroyed; 5) lumber washed away; 6) marine installations destroyed, and; 7) damage to public utilities such as railroads, roads, electric power plants, water supply installations, etc. Indirect secondary tsunami damage can be: 1) Damage by fire of houses, boats, oil tanks, gas stations, and other facilities; 2) environmental pollution caused by drifting materials, oil, or other substances; 3) outbreak of disease of epidemic proportions which could be serious in densely populated areas (2).

Tsunami Generation: Tsunamis are generated primarily by tectonic dislocations under the sea which are caused by shallow focus earthquakes along areas of subduction. The upthrusted and downthrusted crustal blocks impart potential energy into the overlying water mass with drastic changes in the sea level over the affected region. The energy imparted into the water mass results in tsunami generation which is energy radiating away from the source region in the form of long period waves (2).

Tsunamigenic: Having generated a tsunami: a tsunamigenic earthquake, a tsunamigenic landslide (2).

Tsunami Propagation: Tsunamis travel outward in all directions from the generating area, with the direction of the main energy propagation generally being orthogonal to the direction of the earthquake fracture zone. Their speed depends on the depth of water, so that the waves undergo accelerations and decelerations in passing over an ocean bottom of varying depth. In the deep and open ocean, they travel at speeds of 500 to 1,000 kilometers per hour (300 to 600 miles per hour). The distance between successive crests can be as much as 500 to 650 kilometers (300 to 400 miles); however, in the open ocean, the height of the waves is generally less than a meter (3 feet) even for the most destructive teletsunamis, and the waves pass unnoticed. Variations in tsunami propagation result when the propagation impulse is stronger in one direction than in others because of the orientation or dimensions of the generating area and where regional bathymetric and topographic features modify both the wave form and rate of advance. Specifically tsunami waves undergo a process of wave refraction and reflection throughout their travel. Tsunamis are unique in that the waveform extends through the entire water column from sea surface to the

ocean bottom. It is this characteristic that accounts for the great amount of energy propagated by a tsunami (2).

TsunamiReady: A National Weather Service (NWS) initiative that promotes tsunami hazard preparedness as an active collaboration among Federal, state and local emergency management agencies, the public, and the NWS tsunami warning system. This collaboration supports better and more consistent tsunami awareness and mitigation efforts among communities at risk. The TsunamiReady program is based on the NWS StormReady model. (Source: http://www.stormready.noaa.gov/tsunamiready/index.htm)

Tsunami Velocity or Shallow Water Velocity: The velocity of an ocean wave whose length is sufficiently large compared to the water depth (i.e., 25 or more times the depth) can be approximated by the expression: $c = \sqrt{(gh)}$

Where: **c** is the wave velocity; **g** is the acceleration of gravity; and **h** is the water depth.

Thus, the velocity of shallow-water waves is independent of wave length L. In water depths between ½ L and 1/25 L it is necessary to use a more precise expression:

$$c = \sqrt{\left((gL/2\pi)[\tanh(2\pi h/L)] \right)}$$

In the open ocean a tsunami is less than a few feet high at the surface, but its wave height increases rapidly in shallow water. Tsunami wave energy extends from the surface to the bottom in the deepest waters. As the tsunami attacks the coastline, the wave energy is compressed into a much shorter distance creating destructive, life threatening waves (2).

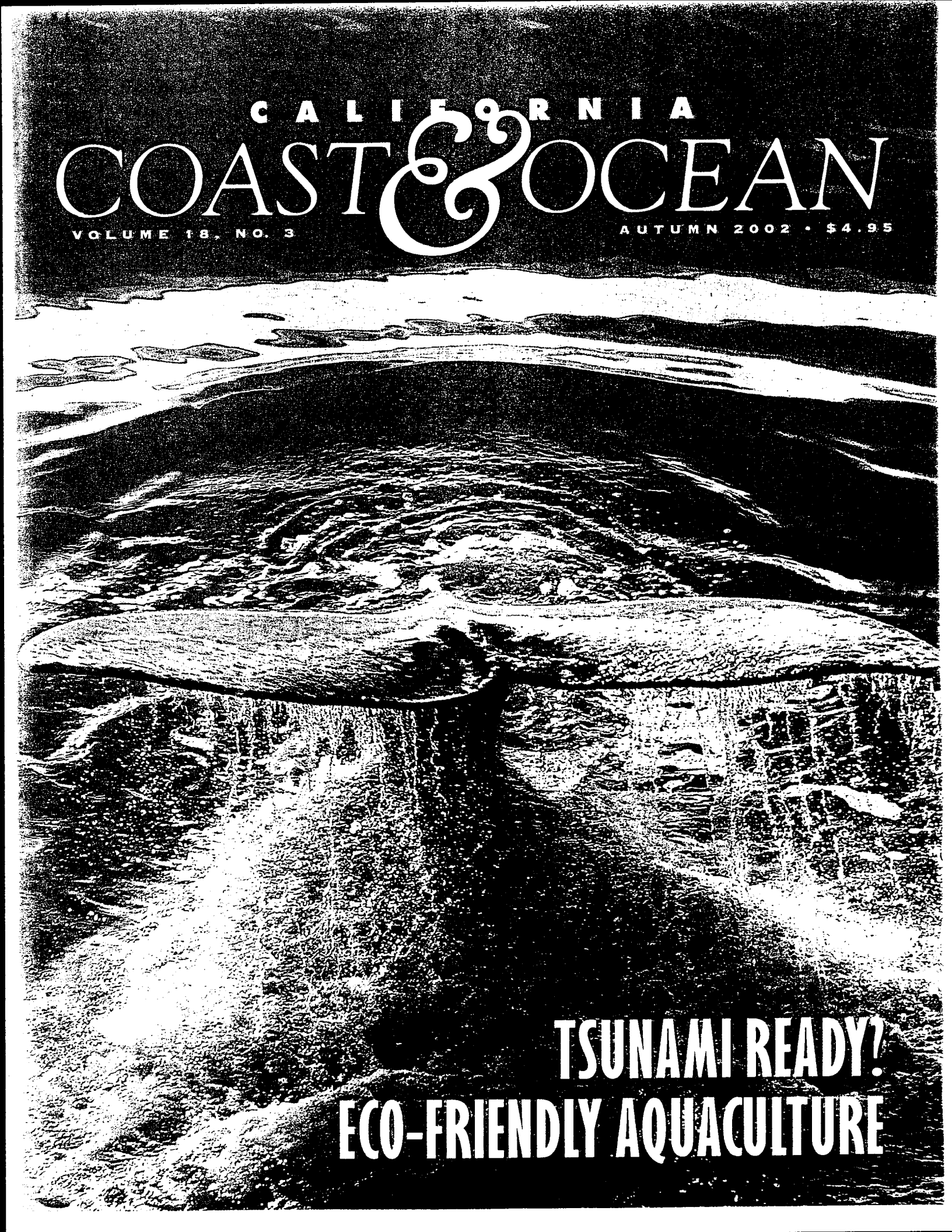
TWS: Tsunami Warning System, organization of 26 Pacific Member States which coordinates international monitoring and warning dissemination. Operates through ICG/ITSU (1)

USNSN: United States National Seismic Network, operated by the USGeological Survey. Monitors, in real-time, magnitude (M)>5 earthquake activity worldwide and M>3 in conterminous US. (1).

Water Level (maximum): Difference between the elevation of the highest local water mark and the elevation of the sea-level at the time of the tsunami attack. This is different from maximum run-up because the water mark is often not observed at the inundation line, but maybe halfway up the side of a building or on a tree trunk (2).

Wave Length: The horizontal distance between similar points on two successive waves measured perpendicularly to the crest. The wave length and the tsunami period give an information on the tsunami source. For tsunami generated by earthquakes, typical wave length range from 20 to 300 km. For tsunami generated by landslide, the wave length range from hundreds of meters to tens of kilometers (2).

WC/ATWC: West Coast/ Alaska Tsunami Warning Center, established in 1967 originally to issue warnings to Alaska of local tsunami events. WC/ATWC is now responsible for issuing warnings for any event likely to impact either Alaska, **the west coast of the US**, or the Pacific coast of Canada (1).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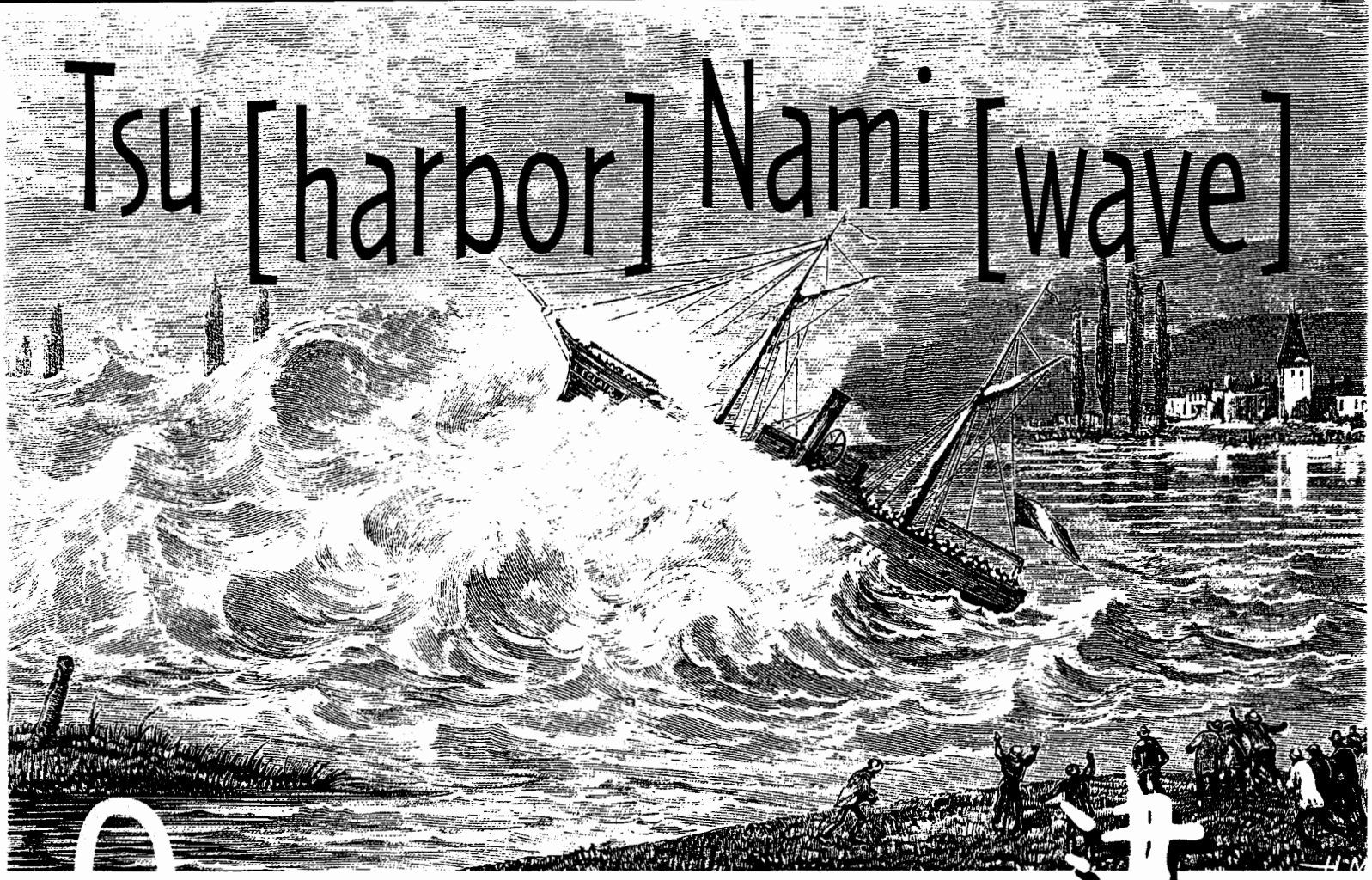
Tsu [harbor] Nami [wave]



KEVIN KNUUTI & LESLEY EWING

In March 28, 1964, a tsunami slammed into Crescent City, California. A series of waves pushed buildings off their foundations and into other buildings, and swept cars and structures out to sea. So strong were these walls of water that a 50,000-pound concrete tetrapod was knocked from its base by the force of a timber being carried along in the rushing tumult (this tetrapod is still on display at the south entrance to the city). The inundation extended 800 to 2,000 feet inland in the commercial and residential areas of the city, and a mile inland along a low intermittent stream. Water depths reached up to eight feet in city streets and 13 feet along the shoreline. Overall, Crescent City sustained more than $7.4 million in damage and 12 people lost their lives.

We've all heard of tsunamis. We think of them as being colossal, powerful, and unpredictable, much like earthquakes: coming as if from nowhere and capable of causing great devastation within minutes. Is it possible to anticipate these destructive events and take action? The National Oceanic and Atmospheric Administration (NOAA) thinks so and, as a result, in September NOAA certified Crescent City as California's first official "Tsunami Ready Community." Key elements of this designation are knowledge about tsunamis and a carefully developed plan that will be implemented when the next tsunami occurs.

Tsunamis are often improperly called "tidal waves." Tidal waves do exist. They are generated by the gravitational pull of the moon and sun, and we experience them as the daily rise and fall of the sea along our shores. A tsunami, in contrast, is a series of very long waves generated by a sudden dramatic event, such as an undersea earthquake (the most common cause), landslide, volcanic eruption, meteorite impact, or other event that causes a rapid rise or fall in the ocean surface at a specific location. In the case of an undersea earthquake, the ocean floor moves up or down, causing a bulge or depression in the water surface. As the bulge or depression comes to equilibrium with the surrounding water surface, it sends out a series of wave crests and troughs. In deep ocean, these waves are visually undetectable, being up to hundreds

A steamer in the Seine estuary, France, by Henri Meyer, 1881.

ILLUSTRATION: MARY EVANS PICTURE LIBRARY
CALLIGRAPHY BY JUN ISHIMURO

WEST COAST TSUNAMIS

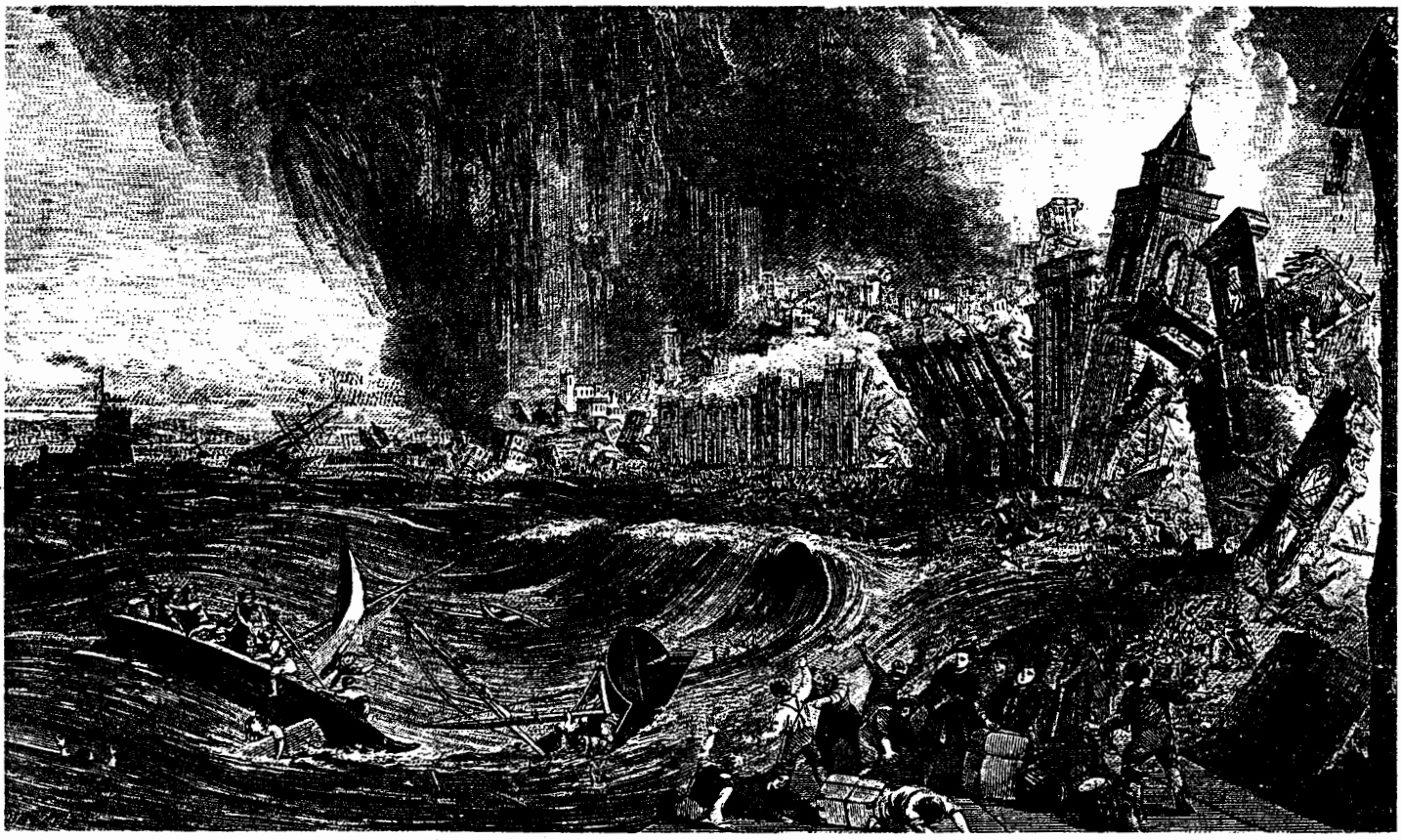
AT LEAST 64 tsunamis have struck the West Coast of North America over the last 265 years.

Time period	Number of recorded tsunamis
1737–1799	3
1800–1849	1
1850–1899	11
1900–1949	13
1950–1999	34
2000–02	2
Source: NOAA	

of miles long, often less than three feet high, and traveling at speeds up to 450 miles per hour.

As each wave of the tsunami moves away from its generation area, it bends according to changes in the ocean floor bathymetry, orienting its wave front closer to parallel with the shoreline. At the same time, it begins shoaling, or slowing down and growing higher. Because of the tremendous wavelength of a tsunami, a wave that was less than three feet high in the deep ocean could rise to more than 50 feet in shallow water. The form of the tsunami at the shoreline could be a series of bores (a rapid rise of the water surface in which the advancing water is preceded by a step-like turbulent face), a simple rise and fall of the water surface (similar to a rapid tide) or, in rare cases, a series of breaking waves.

Certain predictions can be made about tsunamis. For example, because tsunamis are generated by a rapid rise or fall in the ocean surface, we know the earthquakes that generate tsunamis are generally those that occur on vertical displacement (dip-slip) geologic faults. Thus, the tectonic convergence (subduction) zones along the southern coast of Alaska (the source of the 1964 tsunami that struck Crescent City) and the Aleutian Islands, the northwest coast of South America, and southeast of Japan pose significant threats to California. Closer to California, the Juan de Fuca plate converges with and dips beneath the North American plate off the coasts of California, Oregon, and Washington. The area where these two plates also meet the Pacific plate (the Mendocino Triple Junction) is particularly prone



About 90 minutes after an earthquake in 1755, a tsunami swept up Portugal's North Tagus River and crashed into Lisbon's waterfront.

MARY EVANS PICTURE LIBRARY/ENGRAVING BY JUSTINE

to earthquakes. When seismic activity occurs in any of these areas, the risk of a tsunami goes up. Along the central and southern California coasts, the majority of the major fracture zones, including where the Pacific and North American plates meet, form transverse (strike-slip) faults that do not pose as great a threat.

Depending on the force of the generating event, as well as the nature of offshore bathymetry, shoreline geometry, and onshore topography, local tsunami inundation can vary greatly. At the shoreline, tsunami effects can range from a barely noticeable change in the water surface to astonishing rises in water level of over 90 feet, and can push inland thousands of feet. Tsunami waves cause damage by the obvious mechanisms of flooding and the force of the rapidly moving water, but may cause even more damage by the debris they forcefully carry.

Since 1737, according to NOAA data, 64 tsunamis have struck the west coast of the United States with 36 of these occurring in the last 52 years. The three most destructive occurred in 1946, 1960, and 1964. While the 1946 tsunami was barely noticed in California, both the 1960 and 1964 tsunamis left their marks on the state's northern coast. Each time a tsunami makes landfall, visual markers are left by the receding waters: debris lines, water marks on buildings and trees, matted vegetation, and so on. Researchers rely on clues like these to help vulnerable coastal communities prepare for the next large tsunami.

Orville Magoon grew up in Hawaii and witnessed the 1946 tsunami from a precarious perch in a palm tree. Years later, he was an engineer with the U.S. Army Corps of Engineers in San Francisco when both the 1960 and the 1964 tsunamis made landfall and both times he traveled to Crescent City, Eureka, and Fort Bragg to survey inundation contours, set high water markers, and do general damage surveys. During his surveys, he spoke with as many people as possible to get eyewitness accounts. His advice to future tsunami surveyors is to get to the site as soon as possible, as the inundation zones can be hard to map once visual clues have been disturbed. He also advises interviewing eyewitnesses as close to the time of the tsunami as possible, when their accounts are the most reliable.

Recent researchers have heeded Orville Magoon's advice. "Tsunamistas" worldwide have begun to coordinate their survey efforts in hopes of better understanding the general nature and impact of tsunamis and of helping affected areas prepare for these natural disasters. The International Tsunami Survey Team (ITST), composed of 40 scientists and more than 20 students from 15 different countries, has responded to all

IT HAPPENED DURING THE 1964 EARTHQUAKE AND TSUNAMI

ROBERT B. ATWOOD, editor and publisher of the *Anchorage Daily Times*, was practicing his trumpet when the earthquake struck. "It was quickly obvious that this earthquake was no minor one. . . . Things were falling that had never fallen before. I headed for the door, carrying my trumpet. . . . I saw walls weaving. . . . I watched my house scream and groan. . . . As I started to climb the fence into my neighbor's yard, the fence disappeared. Trees were falling in crazy patterns. . . . A chasm opened beneath me. . . . I was quickly on the verge of being buried. I couldn't pull my right arm from the sand. . . . I let go of my trumpet and my arm pulled free easily. . . . My neighbor's home slowly collapsed and slid into the chasm."

In Crescent City a young boy watched an elderly couple struggle against the flood waters. An empty car floated down the street and ran them over—they were never seen again.

An elderly woman was asleep when the waves demolished her house. Her bed floated up into an air space under the still-intact roof. She was found alive eight hours after the waters subsided.

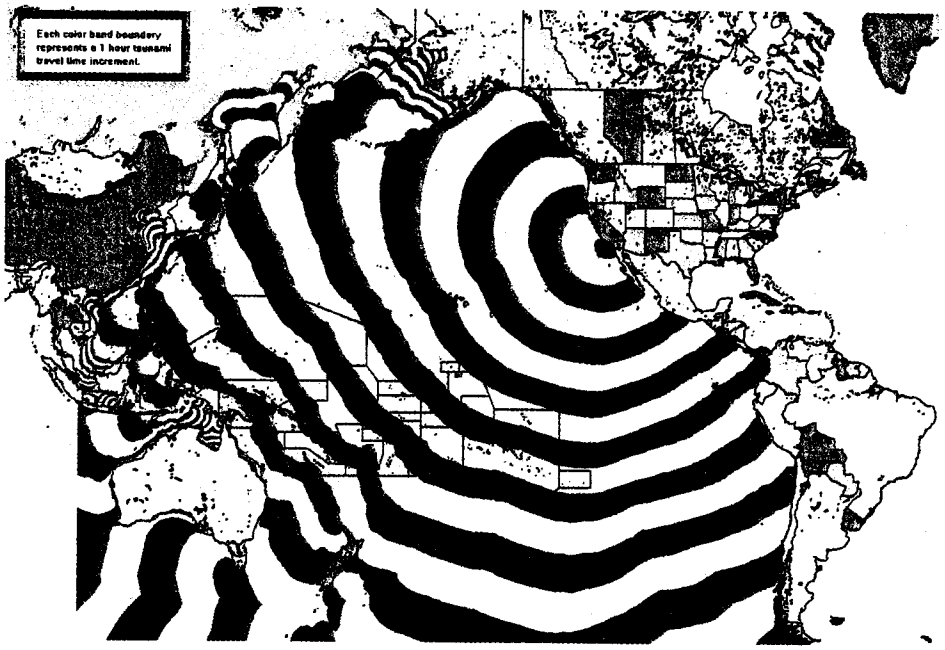
Chester Stygar and his wife and baby were also asleep when his wife heard a noise at the door. "I put my feet on the floor and there was a foot of water in the room. . . . I opened up the back door and all I could see was the ocean. The last time I saw the ocean out the back door it was a quarter of a mile away. I felt the whole building float up, like it was on a cloud. We didn't dare go out. . . . The house was rocking around and it was black and the gas started smelling. . . . A few minutes later we felt the house settle down. . . . This was like a bad dream and I just didn't know I was awake."

—from newspaper and wire service reports

Tsunami damage in Crescent City, 1964. Photo from the Oakland Museum of California's exhibit, "State of Emergency: Disaster Response in California," which continues through March 2003.

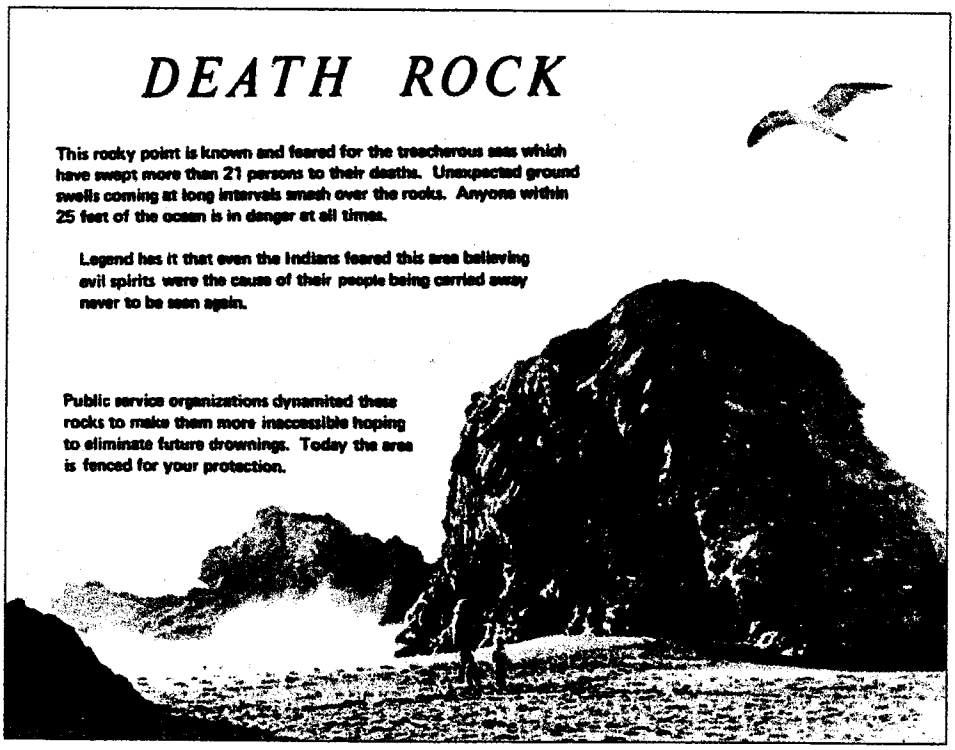
Scientists estimate how long it will take tsunamis generated in specific locations to reach other locations by calculating the speed with which the waves propagate over the varying ocean depths. They then use tsunami travel time maps to depict the results. This travel time map shows the length of time it would take a tsunami generated near Los Angeles to reach locations throughout the Pacific. Each band represents one hour of travel time.

Source: National Oceanic and Atmospheric Administration (NOAA)



NOT SO PACIFIC

ALTHOUGH THE VERY WORD "TSUNAMI" may evoke nightmarish images, far more people perish from other beach hazards. Off Sonoma Coast State Beach alone, 128 people have drowned since 1950. "In the south the dangers are more from riptides and underwater dropoffs; in the north, from sleeper waves," according to Rex Grady, who has many years of experience as a lifeguard in California. As Elizabeth Terwilliger, a beloved naturalist and teacher, repeated to generations of schoolchildren: "Never turn your back to the ocean!"



major tsunami disasters that have occurred since 1992. Lori Dengler, a professor of geology at Humboldt State University, has participated in several ITST surveys. According to Dengler, the team observes and documents tsunami effects, collects perishable data, and makes recommendations to both the affected country and the international community on future research, planning, and preparedness. The ITST surveys provide valuable information on what tsunamis can do.

Photographs of cars suspended in trees, rail ties driven through truck tires, etc., are powerful reminders of the forcefulness of these events. Even more important for future preparedness are the other survey results. The information on the extent of inundation can be used to anticipate impacts from similar tsunamis in other locations. However, we still are not able to predict when or where a tsunami may occur. Instead, scientists and engineers are identifying extreme inundation zones. Costas Synolakis and engineering students at USC are developing projections of the areas that could be at risk from a tsunami, and areas that would be safe. Projections have been completed for San Francisco, San Mateo, Los Angeles, and San Diego Counties, and the Santa Barbara–Ventura coast; projects for Monterey Bay will be completed soon. The state's Office of Emergency Services has funded this work and will use it for emergency response purposes and to provide information on safe areas and evacuation routes. These products are important in preparing for the next tsunami and for making communities Tsunami Ready.

So, what if a tsunami *is* generated out in some distant part of the ocean? Do the residents of coastal towns such as Crescent City really have a chance to escape in time? Often, yes. NOAA is currently deploying a network of ten offshore buoys (to be fully functional by 2003) to measure water surface elevation. While tsunamis cannot be detected easily by ships at sea, they can be detected by these buoys. If a slight increase or decrease in water level is observed over several monitoring intervals, these buoys automatically switch to tsunami-monitoring mode and begin sending frequent water-surface elevation information to Tsunami Warning Centers in Alaska and Hawaii. Once a tsunami is detected, these centers issue alerts or warnings to state Offices of Emergency Services and through the

LESLEY EWING

A tsunami warning sign in Crescent City

HOW TO SURVIVE A TSUNAMI

- If you feel an earthquake in a coastal area, duck, cover, hold, and watch for falling objects, then move to high ground. The earthquake may be your only warning that a tsunami is coming.
- If you see the ocean recede, do not go out to save stranded fish or sea life, since the incoming wave will move faster than you can run. There are two parts to any wave—the crest and the trough. Sometimes the trough of the tsunami will arrive first and a large withdrawal of water from the shore is a clue that a large wall of water may follow.
- If you hear an unusual roar or rumble, something like a freight train coming from the ocean, it may be a tsunami and you should go to higher ground.
- If lifeguards and emergency personnel tell you to evacuate the beach because of a possible tsunami, follow instructions immediately. Do not return to the beach until you are told it is safe to do so. A distant earthquake may have generated a tsunami. You might not feel the earthquake, but emergency responders will have been alerted by a tsunami watch.
- Do not try to surf a tsunami wave. These waves can carry tons of trash and floating debris that can be as dangerous as the waves themselves.
- When you think a tsunami may be coming, go to high ground. Do not return to low-lying areas until there is an official "all clear."

weather channel of the National Weather Service.

For tsunamis generated many miles from the shoreline, people in California localities such as Crescent City will have several hours to learn about the coming waves and should be able to move away from high-risk areas onto higher ground. For locally generated tsunamis, however, the first large wave may arrive soon after the generating event and well before a community-wide alert or warning can be announced. In these cases, local education and preparedness are essential. The main thing to do if you are in a tsunami-prone area and an earthquake strikes is to "duck, cover, hold," then immediately seek higher ground (see sidebar, "How to Survive a Tsunami").

Evidence from the 1960 and 1964 tsunamis, such as inundation contours and high water marks, have allowed scientists to predict where the greatest flooding might occur in Crescent City, and what areas will be less affected, should a tsunami hit again. The city was smart after the 1964 tsunami, in that it developed the area closest to the harbor as a park (permanent open space) and allowed reestablishment of downtown businesses mainly inland of Front Street. The city also erected tsunami evacuation route signs on many streets. Recently, when a new hotel was being considered for an area of Crescent City that may be at risk from tsunamis, the Coastal Commission required that the developer prepare a tsunami safety plan. An information sheet is to be placed in each guest room, and hotel staff is to be trained on how to respond to a tsunami warning or alert. Thus, when (not if) another tsunami hits, the destruction should be less serious than in past events.

While tsunamis are rare events, the "Hollywood" accounts of their destruction are based on the fact that tsunamis have occurred throughout history and have repeatedly caused great devastation and loss of life. Tsunamis have struck California in the recent past and will do so again in the future. Though they are difficult to predict, scientists have developed an international tsunami warning system and are actively working to map areas at risk. The tsunami warning system and maps, along with awareness, education, and well thought out plans of action will help minimize the damage caused by the next tsunami to strike California. Crescent City has relied on these key steps in its program to become the first Tsunami Ready community in California. Hopefully it will not be the last community to recognize and plan for this type of natural disaster. ■

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Lesley Ewing is a coastal engineer with the California Coastal Commission; lewing@coastal.ca.gov.

A tsunami hits a 19th century Japanese sailing ship. Artist unknown, engraved by E. Morieu

MARY EVANS PICTURE LIBRARY

TSUNAMI BULLETINS (Information, Warning, Watch, Advisory)

(Source: http://www.prh.noaa.gov/itic/tsunami_events/events.html)

Tsunami Warning / Watch / Advisory Warnings issued by the National Weather Service's tsunami warning centers are alphanumeric products providing tsunami warning, watch and advisory warning information for potentially damaging tsunamis. The center's operational objectives are to: a) locate and size major earthquakes in the Pacific basin, b) determine their tsunamigenic potential, c) predict tsunami wave arrival times and, when possible, run-up on the coast, and d) provide timely and effective tsunami information and warnings to the population of the Pacific to reduce the hazards of tsunamis, especially to human life.

These bulletins are prepared by each of two Tsunami Warning Centers. The West Coast/Alaska Tsunami Warning Center (WC/ATWC), located at Palmer, Alaska, issues tsunami bulletins to its Area of Responsibility (AOR) that is Alaska, British Columbia, Washington, Oregon, and California. It also has the primary responsibility for the detection, location, and magnitude determination of magnitude of potentially tsunamigenic earthquakes occurring in its AOR. The Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC). The PTWC, located at Ewa Beach, Oahu, Hawaii, has the responsibility for issuing tsunami bulletins to its AOR that includes Hawaii, all other U.S. interests in the Pacific, and most other countries within the Pacific and around its rim. It has the primary responsibility for the detection, location, and magnitude determination of magnitudes for potentially tsunamigenic earthquakes occurring anywhere in the Pacific Basin outside the WC/ATWC AOR.

Tsunami Warning - Indicates that a tsunami is imminent and that coastal locations in the warned area should prepare for flooding. The initial warning is typically based on seismic information alone. Earthquakes over magnitude 7.0 trigger a warning covering the coastal regions within 2 hours tsunami travel time from the epicenter. When the magnitude is over 7.5, the warned area is increased to 3 hours tsunami travel time. As water level data showing the tsunami is recorded, the warning will either be cancelled, restricted, expanded incrementally, or expanded in the event of a major tsunami (Source: http://www.tsunami.noaa.gov/terminology.html).

Tsunami Watch - An alert issued to areas outside the warned area. The area included in the watch is based on the magnitude of the earthquake. For earthquakes over magnitude 7.0, the watch area is 1 hour tsunami travel time outside the warning zone. For all earthquakes over magnitude 7.5, the watch area is 3 hours tsunami travel time outside the warning zone. The watch will either be upgraded to a warning in subsequent bulletins or will be cancelled depending on the severity of the tsunami (Source: http://www.tsunami.noaa.gov/terminology.html).

Tsunami Information Message: Information messages issued when smaller earthquakes (less than the warning threshold) may be felt near coastal areas. These messages are issued to assure coastal residents and emergency managers that there is no tsunami danger (Source: http://wcatwc.arh.noaa.gov/definition.htm).

Tsunami warning issued by WC/ATWC the evening of June 14, 2005

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WEPA41 PAAQ 150256
TSUWCA

TO      - TSUNAMI WARNING SYSTEM PARTICIPANTS IN
          ALASKA/BRITISH COLUMBIA/WASHINGTON/OREGON/CALIFORNIA
FROM    - WEST COAST AND ALASKA TSUNAMI WARNING CENTER/NOAA/NWS
SUBJECT - TSUNAMI WARNING BULLETIN - INITIAL
BULLETIN NUMBER 1
ISSUED 06/15/2005 AT 0256 UTC

...A TSUNAMI WARNING IS IN EFFECT FOR THE COASTAL AREAS
   FROM THE CALIFORNIA-MEXICO BORDER TO THE NORTH TIP OF
   VANCOUVER I.-BC. INCLUSIVE...

...A TSUNAMI WATCH IS IN EFFECT FOR THE COASTAL AREAS FROM
   THE NORTH TIP OF VANCOUVER I.-BC. TO SITKA-AK...

...AT THIS TIME THIS BULLETIN IS FOR INFORMATION ONLY FOR
   OTHER AREAS OF ALASKA...

EARTHQUAKE DATA
 PRELIMINARY MAGNITUDE - 7.4
 LOCATION -  41.3N  125.7W -  90 MILES NW OF EUREKA-CA.
                             300 MILES NW OF SAN FRANCISCO-CA.
 TIME     - 1851 ADT 06/14/2005
            1951 PDT 06/14/2005
            0251 UTC 06/15/2005

EVALUATION
 IT IS NOT KNOWN - REPEAT NOT KNOWN - IF A TSUNAMI EXISTS BUT A
 TSUNAMI MAY HAVE BEEN GENERATED.  THEREFORE PERSONS IN LOW
 LYING COASTAL AREAS SHOULD BE ALERT TO INSTRUCTIONS FROM THEIR
 LOCAL EMERGENCY OFFICIALS. PERSONS ON THE BEACH SHOULD MOVE TO
 HIGHER GROUND IF IN A WARNED AREA. TSUNAMIS MAY BE A SERIES OF
 WAVES WHICH COULD BE DANGEROUS FOR SEVERAL HOURS AFTER THE
 INITIAL WAVE ARRIVAL.

$$
PZZ130-131-133-134-132-135-150-153-156-110-250-210-255-350-
353-356-450-455-550-530-535-555-670-673-650-655-750-WAZ001-
002-005-006-007-008-009-010-011-013-014-015-016-021-ORZ001-
002-021-022-CAZ001-002-005-007-006-075-074-009-034-035-039-
040-046-041-042-043-150456-
COASTAL AREAS FROM THE CALIFORNIA-MEXICO BORDER TO THE
NORTH TIP OF VANCOUVER I.-BC. INCLUSIVE.

...A TSUNAMI WARNING IS IN EFFECT FOR THE COASTAL AREAS
   FROM THE CALIFORNIA-MEXICO BORDER TO THE NORTH TIP OF
   VANCOUVER I.-BC. INCLUSIVE...

ESTIMATED TIMES OF INITIAL WAVE ARRIVAL
CRESCENT CITY-CA 2029 PDT JUN 14   ASTORIA-OR       2154 PDT JUN 14
CHARLESTON-OR    2044 PDT JUN 14   TOFINO-BC        2157 PDT JUN 14
SAN FRANCISCO-CA 2123 PDT JUN 14   SAN PEDRO-CA     2200 PDT JUN 14
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SEASIDE-OR 2126 PDT JUN 14 LA JOLLA-CA 2214 PDT JUN 14
NEAH BAY-WA 2148 PDT JUN 14
$$
PKZ032-031-042-034-033-035-041-036-AKZ023-024-025-026-028-
029-027-150456-
COASTAL AREAS FROM THE NORTH TIP OF VANCOUVER I.-BC. TO
SITKA-AK.

...A TSUNAMI WATCH IS IN EFFECT FOR THE COASTAL AREAS FROM
THE NORTH TIP OF VANCOUVER I.-BC. TO SITKA-AK...

ESTIMATED TIMES OF INITIAL WAVE ARRIVAL
LANGARA-BC 2244 PDT JUN 14 KETCHIKAN-AK 2257 ADT JUN 14
SITKA-AK 2227 ADT JUN 14
$$
PKZ176-175-172-170-171-155-150-132-136-138-137-130-141-140-
120-121-129-127-125-126-128-052-051-053-022-012-043-013-
011-021-AKZ191-185-181-171-145-111-101-121-125-131-135-017-
020-018-019-021-022-150456-
COASTAL AREAS FROM SITKA-AK. TO ATTU-AK.

...TSUNAMI INFORMATION STATEMENT...

NO - REPEAT NO - TSUNAMI WATCH OR WARNING IS IN EFFECT FOR
THE COASTAL AREAS FROM SITKA-AK. TO ATTU-AK.

FOR INFORMATION ONLY - ESTIMATED TIMES OF INITIAL WAVE ARRIVAL
YAKUTAT-AK 2317 ADT JUN 14 CORDOVA-AK 0007 ADT JUN 15
KODIAK-AK 2332 ADT JUN 14 DUTCH HARBOR-AK 0013 ADT JUN 15
JUNEAU-AK 2334 ADT JUN 14 COLD BAY-AK 0034 ADT JUN 15
SEWARD-AK 2339 ADT JUN 14 ADAK-AK 0038 ADT JUN 15
VALDEZ-AK 2357 ADT JUN 14 HOMER-AK 0044 ADT JUN 15
SAND PT.-AK 2358 ADT JUN 14 SHEMYA-AK 0119 ADT JUN 15
$$

THE PACIFIC TSUNAMI WARNING CENTER AT EWA BEACH HAWAII WILL
ISSUE BULLETINS FOR OTHER AREAS OF THE PACIFIC.

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS
WARRANT. THE TSUNAMI WATCH/WARNING WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION AND ETA SITES.

Tsunami Information Bulletin issued by WC/ATWC August 16, 2005

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WEPA43 PAAQ 160258
TIBWCA

TO      - TSUNAMI WARNING SYSTEM PARTICIPANTS IN
          ALASKA/BRITISH COLUMBIA/WASHINGTON/OREGON/CALIFORNIA
FROM    - WEST COAST AND ALASKA TSUNAMI WARNING CENTER/NOAA/NWS
SUBJECT - TSUNAMI INFORMATION BULLETIN
BULLETIN NUMBER 1
ISSUED 08/16/2005 AT 0258 UTC

...THIS TSUNAMI INFORMATION BULLETIN IS FOR ALASKA - BRITISH
   COLUMBIA - WASHINGTON - OREGON AND CALIFORNIA ONLY...

NO - REPEAT NO - WATCH OR WARNING IS IN EFFECT.

EARTHQUAKE DATA
 PRELIMINARY MAGNITUDE - 7.0
 LOCATION -  38.4N  141.8E - NEAR EAST COAST OF HONSHU, JAPAN
 TIME     - 1847 ADT 08/15/2005
            1947 PDT 08/15/2005
            0247 UTC 08/16/2005

EVALUATION
 BASED ON LOCATION AND MAGNITUDE THE EARTHQUAKE WAS NOT
 SUFFICIENT TO GENERATE A TSUNAMI DAMAGING TO CALIFORNIA -
 OREGON - WASHINGTON - BRITISH COLUMBIA OR ALASKA. SOME AREAS MAY
 EXPERIENCE SMALL SEA LEVEL CHANGES. IN AREAS OF INTENSE
 SHAKING LOCALLY GENERATED TSUNAMIS CAN BE TRIGGERED BY SLUMPING.

THE PACIFIC TSUNAMI WARNING CENTER WILL ISSUE TSUNAMI BULLETINS
FOR HAWAII AND OTHER AREAS OF THE PACIFIC.

THIS WILL BE THE ONLY BULLETIN ISSUED FOR THIS EVENT BY THE
WEST COAST AND ALASKA TSUNAMI WARNING CENTER UNLESS CONDITIONS
WARRANT. REFER TO THE INTERNET SITE WCATWC.ARH.NOAA.GOV
FOR MORE INFORMATION.
$$
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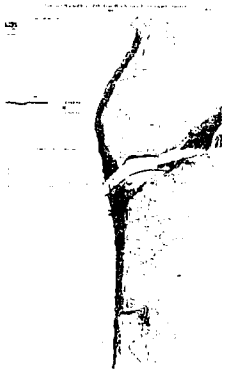
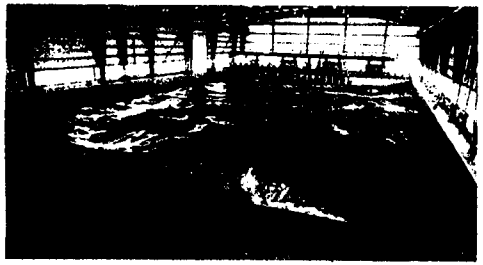
National Tsunami Hazard Mitigation Program

Hazard Assessment

Maps identifying the areas of likely tsunami flooding for at-risk communities will be constructed to guide local tsunami hazard planning. The tsunami inundation map for Gold Beach, Oregon, shown here, was created using a combination of numerical models assuming possible tsunami scenarios.





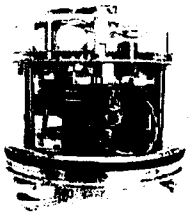
Oregon State University tsunami wave basin. World's largest facility supported by NSF.

Results to Date

- Inundation maps for 122 communities
- > 1.3 million at-risk residents (30% of total population)
- Evacuation maps for 23 communities

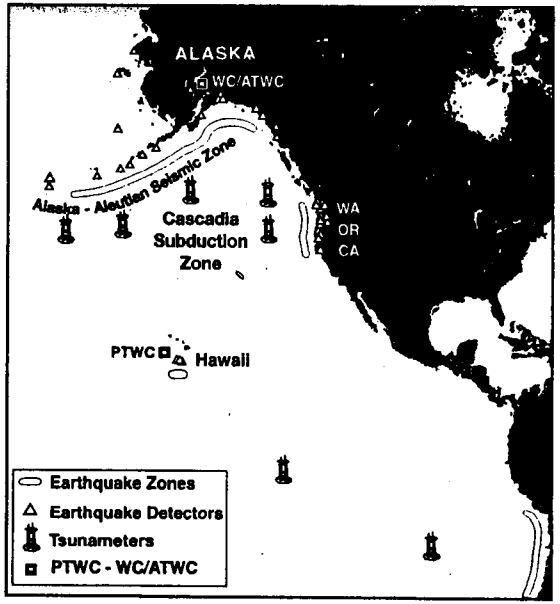
Warning Guidance

Earthquake Detection



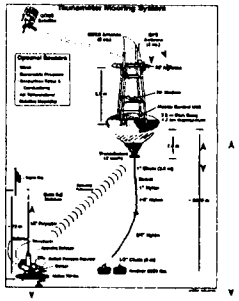
Seismometer

Real-time earthquake data

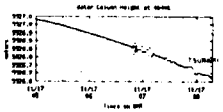


Real-time instruments to detect earthquakes and tsunamis

Tsunami Detection



Deep ocean tsunameters accurately measure tsunamis to forecast tsunami impacts



Real-time deep ocean tsunami data

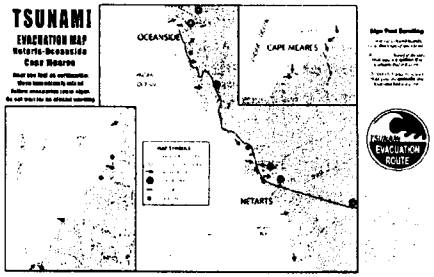
Results

- Earthquakes within U.S. - reduced time to determine location and magnitude from 8 to 2 minutes
- Earthquakes outside U.S. - reduced time to locate from 8-16 minutes to 1-12 minutes and time to determine magnitude from 5-55 minutes to 2-20 minutes
- Warning operations now use more appropriate magnitude scale for issuing warnings

Results

- Early detection of November 17, 2003, non-destructive tsunami avoided an evacuation of Hawaii, saving $68 million in lost productivity
- Data from tsunameter used to forecast, for the first time, tsunami in Hilo harbor for November 17, 2003, tsunami

Mitigation



Tsunami evacuation brochure for Netarts, Oregon, derived from inundation map

Tsunami evacuation road signs in Oregon

Results

- Warning messages: appropriate responder reaction increased from 4 in 10 to 8 in 10
- 7 in 10 indicate improvements since 1994 to their local warning plans
- 9 in 10 cited better planning and coordination as a factor for improvements

For further information on the program please visit

http://tsunami.gov

or contact

Jeff LaDouce (808) 532-6416
e-mail: *jeff.ladouce@noaa.gov*

For further information about specific elements of the program

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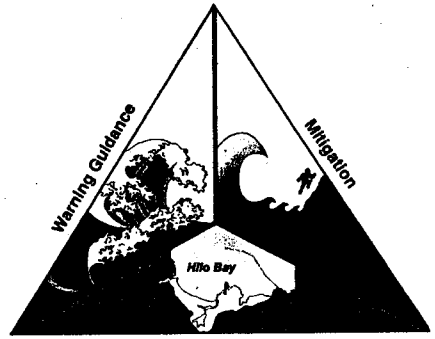
National Weather Service
Pacific Region Headquarters
737 Bishop St., Ste. 2200
Honolulu, HI 96813
phone (808) 532-6416
fax (808) 532-5569

The National Tsunami Hazard Mitigation Program



Hazard Assessment

A State/Federal Partnership created to reduce the impacts of tsunamis to U.S. Coastal areas by coordinating the state efforts of Alaska, California, Hawaii, Oregon, and Washington with the federal activities of the National Oceanic and Atmospheric Administration, the Federal Emergency Management Agency, the U.S. Geological Survey, and the National Science Foundation.

USGS FEMA

National Tsunami Hazard Mitigation Program Steering Group

Chairperson: Jeff LaDouce
NWS Pacific Region

NOAA

Eddie Bernard, Pacific Marine Environmental Laboratory
Frank González, Pacific Marine Environmental Laboratory
Landry Bernard, National Data Buoy Center
James Partain, NWS Alaska Region
Laura Kong, ITIC

DHS/FEMA

Chris Jonientz-Trisler, Region X
Michael Hornick, Region IX

USGS

Craig Weaver, National Earthquake Hazards Reduction Program
David Oppenheimer, Earthquake Hazards Team

NSF

Juan M. Pestana, NSF Tsunami Program Manager

Alaska

R. Scott Simmons, Alaska Division of Emergency Services
Roger Hansen, University of Alaska

California

Richard Eisner, Governor's Office of Emergency Services
Don Hoirup, Jr., California Geological Survey

Hawaii

Brian Yanagi, Hawaii State Civil Defense
Glenn Bauer, State Dept. of Land & Natural Resources
Sterling Yong, State Dept. of Land & Natural Resources

Oregon

George Priest, Department of Geology and Mineral Industries
Jay Wilson, Oregon Emergency Management

Washington

George Crawford, Washington Emergency Management
Timothy Walsh, Division of Geology and Earth Resources

Develop State/NOAA Coordination and Technical Support

West Coast/Alaska Tsunami Warning Center

NOAA/NWS
910 S. Felton Street
Palmer, Alaska 99645-6552
(907) 745-4212

Richard H. Hagemeyer Pacific Tsunami Warning Center

91-270 Fort Weaver Road
Ewa Beach, Hawaii 96706
(808) 689-8207

Warning Coordination Meteorologists (WCM)

Alaska

WFO Juneau
(907) 790-6803

WFO Anchorage
(907) 266-5117

Hawaii

WFO Honolulu
(808) 973-5272

Oregon

WFO Portland
(503) 261-9247

WFO Medford
(541) 773-1067

California

WFO Eureka
(707) 443-6484

WFO Monterey
(831) 656-1725

WFO Los Angeles/ Oxnar
(805) 988-6610

WFO San Diego
(858) 297-2107

Washington

WFO Seattle
(206) 526-6095

People who live on the coast of the Pacific Ocean are vulnerable to tsunamis. This natural phenomenon, usually caused by large earthquakes, can potentially impact every coastal community. Communities can rely on the National Weather Service's TsunamiReady program to help.

Communities receive two TsunamiReady signs upon meeting program criteria.

Is Your Community TsunamiReady?

What is TsunamiReady?

Through the TsunamiReady program, NOAA's National Weather Service gives communities the skills and education needed to survive a tsunami before, during and after the event. TsunamiReady helps community leaders and emergency managers strengthen their local tsunami operations.

TsunamiReady does not mean Tsunami Proof.

TsunamiReady communities are better prepared to save lives from the onslaught of a tsunami through better planning, education and awareness. Communities have fewer fatalities and property damage if they plan before a tsunami arrives. No community is tsunami proof, but TsunamiReady can help communities save lives.

How can my community become TsunamiReady?

Encourage your community leaders to adopt the TsunamiReady program. Business leaders, civic groups, political leaders, and local government officials can be instrumental in helping their community to become TsunamiReady.

Some of the Criteria

To be recognized as TsunamiReady, here are some of the criteria that a community must meet:

- ✓ Establish a 24-hour warning point and emergency operations center
- ✓ Have more than one way to receive tsunami warnings and to alert the public
- ✓ Promote public readiness through community education and the distribution of information
- ✓ Develop a formal tsunami plan, which includes holding emergency exercises.

When seconds count... TsunamiReady communities are prepared!

Schools, playgrounds, hospitals, factories and homes are often built in areas vulnerable to tsunamis. The TsunamiReady Program, developed by the National Weather Service, is designed to help cities, counties and towns in coastal areas to reduce the potential for disastrous tsunami-related consequences.

TsunamiReady
NATIONAL WEATHER SERVICE

West Coast & Alaska Tsunami Warning Center
910 S. Felton St.
Palmer, AK 99645

Pacific Tsunami Warning Center
91-270 Ft. Weaver Rd
Ewa Beach, HI 96706

How can I learn more about TsunamiReady?

For more information about TsunamiReady, visit the TsunamiReady web site at

http://tsunami.gov

or Contact the Warning Coordination Meteorologist at your local NWS forecast office.

Find them at
www.stormready.noaa.gov/contact.htm

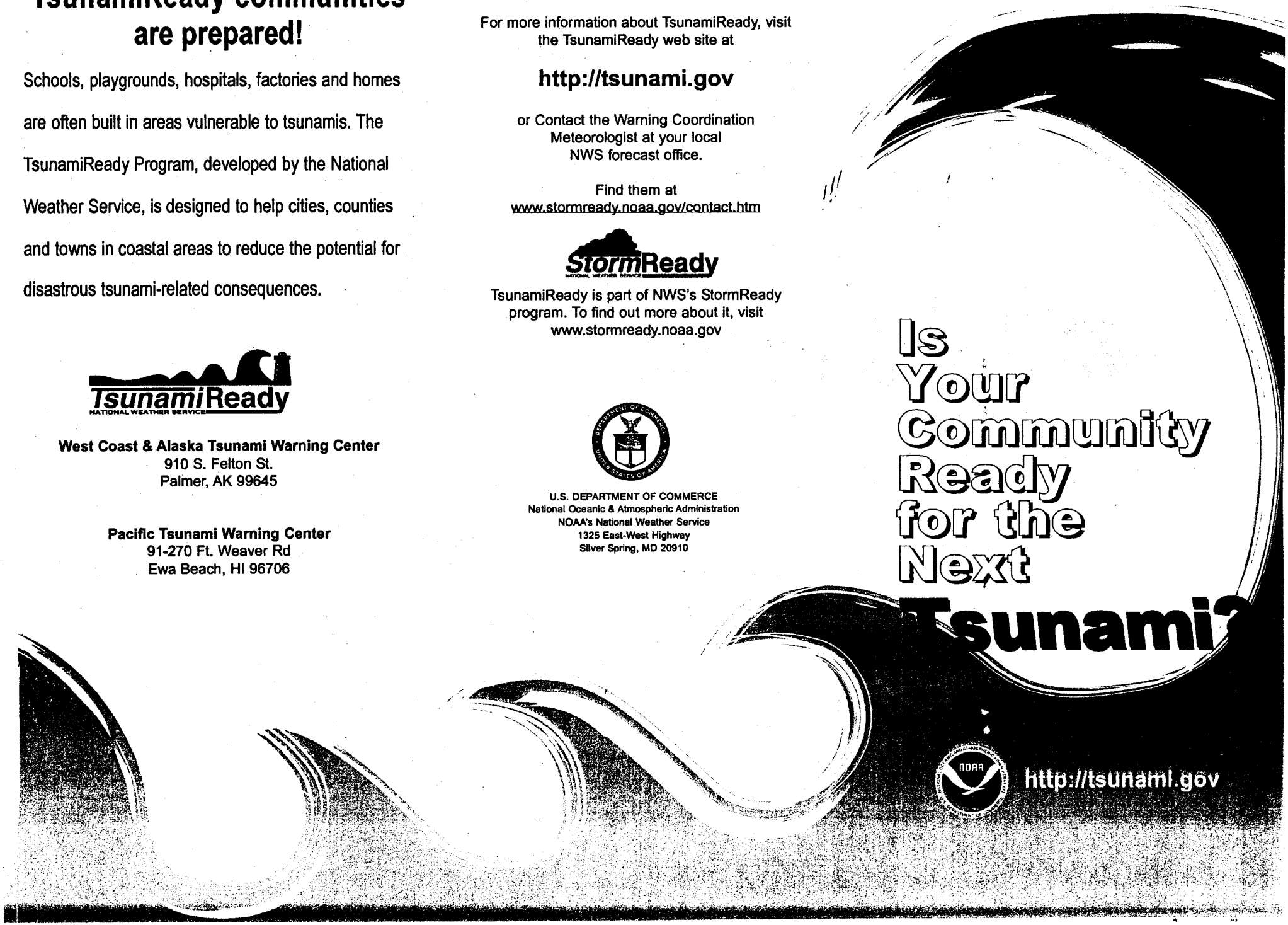
StormReady
NATIONAL WEATHER SERVICE

TsunamiReady is part of NWS's StormReady program. To find out more about it, visit www.stormready.noaa.gov

U.S. DEPARTMENT OF COMMERCE
National Oceanic & Atmospheric Administration
NOAA's National Weather Service
1325 East-West Highway
Silver Spring, MD 20910

TsunamiReady
NATIONAL WEATHER SERVICE

Is Your Community Ready for the Next Tsunami?



NOAA

http://tsunami.gov

Tsunami Safety Plan
For
REDWOOD OCEANFRONT RESORT Project In Crescent City

As Crescent City lies in the Tsunami evacuation zone, the management of REDWOOD OCEANFRONT RESORT LLC will commit itself to executing following Tsunami safety plan based on the requirements of the special conditions of California Coastal Commission's permit # A-1-CRC-00-033.

1. Tsunami information

A flyer containing following information with embossed Braille translation will be placed on the table in each of the guest rooms, meeting room, and restaurant.

A cassette with a tape containing following information will be made available to blind guest at the front desk.

Dear Guests,

Welcome to REDWOOD OCEANFRONT RESORT. We understand that one of the reasons why our honorable guests come to this oceanfront resort is to enjoy and appreciate the beautiful and spectacular view of the ocean. We also understand, as many of you do, that we living on the very edge of the ocean face the potential danger of yet another Tsunami attack. Since your lives and personal safety are the most important to us, we would like you to be aware that you are in a Tsunami evacuation zone and pay special attention to following information, which will save your lives in the event that a Tsunami strikes:

What is a tsunami?

A tsunami (pronounced tsoo-nah-mee) is a wave train, or series of waves, generated in a body of water by an impulsive disturbance that vertically displaces the water column. Earthquakes, landslides, volcanic eruptions, explosions, and even the impact of cosmic bodies, such as meteorites, can generate tsunamis. Tsunamis can savagely attack coastlines, causing devastating property damage and loss of life.

Tsunamis that strike coastal locations in the Pacific Ocean Basin are almost always caused by earthquakes. These earthquakes might occur far away or near where you live.

Some tsunamis can be very large. In coastal areas their height can be as great as 30 feet or more (100 feet in extreme cases), and they can move inland several hundred feet.

All low-lying coastal areas can be struck by tsunamis.

A tsunami consists of a series of waves. Often the first wave may not be the largest. The danger from a tsunami can last for several hours after the arrival of the first wave.

Tsunamis can move faster than a person can run.

Sometimes a tsunami causes the water near the shore to recede, exposing the ocean floor.

The force of some tsunamis is enormous. Large rocks weighing several tons along with boats and other debris can be moved inland hundreds of feet by tsunami wave activity. Homes and other buildings are destroyed. All this material and water move with great force and can kill or injure people.

Tsunamis can occur at any time, day or night.

Tsunamis can travel up rivers and streams that lead to the ocean.

What damage did tsunamis do to Crescent City?

Crescent City has experienced at least six tsunamis in the last 54 years (1946, 1952, 1975 1960, 1964 and 1992). The greatest tsunami rises, over 13 feet, struck Crescent City about 1:45 a.m. on March 28, 1964. This giant distant-source tsunami rolled into Crescent City, California from the Pacific under the cover of darkness during the early morning hours of March 28, 1964, and left in its wake eleven dead and three missing.

Twenty-nine city blocks were left in total or partial ruins, and the devastation extended for a distance of approximately two miles to the south of the city limits. Estimates of the cost for replacement of damaged or destroyed public and private properties were later placed at $16 million. A combined total of 289 businesses and homes were hit.

What the tsunami did to this hotel site?

This hotel site used to be the county's seaside hospital site. The 1964 Tsunami big waves never reached the seaside hospital, but they inundated its parking lot east of A Street, crossed A Street, and lapped up onto the northeastern most corner of the hospital lawn arriving not from the ocean to the west but from the bay margin to the east. Although the savage giant waves of 1964 did not come to where our hotel is now standing and despite the fact that the first floor elevation of this hotel is 17 ft MSL-higher than the 500-year flood boundary elevation of 16.4 ft MSL, we should not render ourselves complacent. Instead, we should prepare ourselves and heighten our vigilance for the potential danger of Tsunami attack.

What are our guests expected to do in the event of a tsunamis attack?

Be aware of the above-mentioned tsunami facts. This knowledge could save your precious life! Share this knowledge with your relatives and friends, especially people who are presently staying in the same hotel room with you. It could save their precious lives too.

If you hear there is a tsunami warning or feel earth shake, you should make sure that everybody staying with you in the same hotel room is aware of the warning and an imminent tsunami attack, immediately get out of the hotel building through the exit door nearest to your room in an orderly, calm and safe manner, follow the evacuation routes shown on the map to the higher ground or a safe place as designated outside evacuation zone on the map. The evacuation map is prepared by the City of Crescent City and attached hereto. You should also follow the advice of our trained hotel staff, and local emergency and law enforcement authorities.

If you are at the beach or near the ocean and you feel the earth shake, you should move immediately to higher ground. Do Not wait for a tsunami warning to be announced. Stay away from rivers and streams that lead to the ocean, as you would stay away from the beach and ocean if there were a tsunami. A regional tsunami from a local earthquake could strike some areas before a tsunami warning could be announced.

Tsunamis generated in distant locations will generally give people enough time to move to higher ground. For locally generated tsunamis, where you might feel that ground shake, you may only have a few minutes to move to higher ground.

2. Tsunami Evacuation

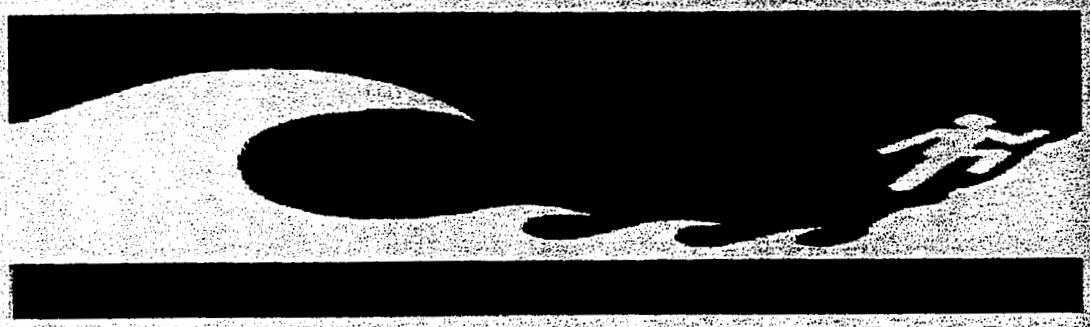
All hotel and restaurant staff on duty will be required to assist the evacuation of physically less mobile guests during a tsunami event.

3. Staff Training

The management will familiarize each and every staff with the locations of all the guest rooms accessible by the disabled guests and the tsunami evacuation routes shown on the map provided by the City of Crescent City.
The management will train hotel staff to give clear instructions to hotel guests regarding the evacuation routes in the event of a potential tsunami attack.
The management will make all staff understand that part of their job responsibilities is to assist the physically less mobile guests in the evacuation from the hotel site during a potential tsunami event.

TSUNAMI!

HOW TO SURVIVE THIS HAZARD IN THE CRESCENT CITY AREA



IF YOU FEEL A STRONG EARTHQUAKE WHEN YOU ARE ON THE COAST:

Dear Guests,

The coast is a wonderful place to visit and most of the time it is the ideal place for taking a walk on the beach, sunbathing, reading, playing volleyball, building sand castles, swimming, surfing or bodysurfing. One time when it may not be safe is right after major earthquakes. These events can cause a tsunami to form and in those rare cases you should leave the hotel or beach and move to high ground.

What is a tsunami?

A tsunami (pronounced tsoo-nah-mee) is a wave train, or series of waves, generated in a body of water by an impulsive disturbance that vertically displaces the water column. Earthquakes, underwater landslides, volcanic eruptions, explosions, and even the impact of cosmic bodies, such as meteorites, can generate tsunamis. Tsunamis can savagely attack coastlines, causing devastating property damage and loss of life.

Some tsunamis can be very large. In coastal areas their height can be as great as 30 feet or more (100 feet in extreme cases), and they can move inland several hundred feet. Tsunamis do not look like a classic wave when they reach the coast. The "crest" may take the form of a rising tide, a series of waves, a bore or a massive wall of water.

Tsunamis travel quickly. In the open ocean they can travel up to 500 miles per hour, on the coast they can travel faster than 15 miles per hour.

Tsunamis can occur at any time, day or night.

Tsunamis can travel up rivers and streams that lead to the ocean.

How can I know if a tsunami has been generated?

There are often clues that a tsunami has been generated. Use your senses!

- **Feel shaking** – coastal earthquakes may generate a tsunami. If you are on the coast and you feel an earthquake, that may be your best clue that a tsunami may be coming.
- **See the ocean recede** - There are two parts to any wave – the crest and the trough. Sometimes the trough of the tsunami will arrive first and a large withdrawal of water from the shore is a clue that a large wall of water may follow. Do not go out to save stranded fish or sea life, since the incoming wave will move faster than you can run.
- **Hear an unusual roar or rumble** – When the tsunami wave comes ashore, it often makes a low rumble or roaring noise. If you hear something like a freight train coming from the ocean, it may be a tsunami and you should go to higher ground.

- **Pay attention to lifeguards and emergency responders** – If a distant earthquake has generated a tsunami you will not feel the earthquake. Emergency responders will be notified of these events through a tsunami "watch" or "warning". If emergency personnel tell you should evacuate the beach because of a possible tsunami, follow their instructions and do not return to the beach till they tell you it is safe.

Can I surf a tsunami?
NO! Tsunami waves often carry a lot of trash and floating debris. The debris can be as dangerous as the waves themselves. Tsunami waves ARE NOT surfing waves.

What do I do if I am in the hotel and feel an earthquake?
This hotel is in an area that can be inundated by a tsunami. If you feel the earth shake, protect yourself from falling objects – DUCK, COVER, and HOLD. Once the shaking is over, you should make sure that everybody around you is aware that a tsunami may soon follow. As soon as it is safe, get out of the hotel building through the exit door nearest to your room. In an orderly, calm and safe manner, follow the evacuation routes shown on the attached map or go to a safe place outside the designated evacuation zone. You should also follow the advice of our trained hotel staffs, and local emergency and law enforcement authorities.

What if I am at the beach when I feel an earthquake?
If you are at the beach or near the ocean and you feel the earth shake, you should move immediately to higher ground. Do Not wait for a tsunami warning to be announced. A tsunami from a local earthquake could strike some areas before a tsunami warning could be announced. Stay away from rivers and streams since these areas can also be flooded by the tsunami. Travel to high ground.

When can I go back to my hotel room or to the beach?
A tsunami is a series of waves. Sometimes the biggest wave is first, but often the biggest and most dangerous weave will be the third of fourth wave to arrive. This may not arrive until an hour or more after the first wave. Once you have evacuated the beach and gone to high ground, wait there till an emergency responder or law enforcement authority tells you that the danger is over and it is safe to go back to the hotel or to the beach.

Do tsunamis happen all the time?
Large tsunamis are very rare, but there have been several destructive tsunamis in the past few decades. In 1964 there was a destructive tsunami in Crescent City and much of the downtown waterfront area was destroyed. The most damaged area is now a waterfront park. Scientists know the question is not IF these waves will come again, but WHEN.

So dear guests, on your next trip to the beach, don't forget to bring your sun lotion, some water, a hat, and pay attention. And remember too, tsunamis do not stop at the beach. They can travel far inland from the shoreline, so be alert whenever you are near the shore.

Our staffs go through annual training on many health and safety aspects, including tsunami evacuations, fire safety, first aid and others, to assure you the most enjoyable and relaxing visit possible. We hope this pamphlet answers most of your questions about tsunamis. Please ask our staff about tsunamis if you want more information. If we do not know the answers to your questions, we can try to find someone who can assist you.

Chers Clients,
La cote est magnifique a visite et la plus par du temps un endroit ideal pour une randonne sur la plage, prendre un bain de soleil, faire de la lecture, jouer au volley-ball, construire des châteaux de sable, pour nager, surfer ou body surf. La seule fois ou il ne serait pas SUR , cest après un. tremblement de terre majeur. Ces événements peuvent créer un tsunami, dans ces cas rares vous devrez quitter l'hôtel pour vous rendre dans les terres hautes.

Qu'est ce qu'est un tsunami?
Un tsunami (prononcée tsoo-hah-mee) est un train de vagues, ou une séries de vagues, générée dans l'eau par un impulsion de turbulences qui déplace verticalement une colonne d'eau. Tremblement de terre, déplacement de plaques sou marine, éruption volcanique, explosions, et même l'impacte d'élément cosmiques, tel que une météorites, peuvent générer des tsunamis. Les Tsunamis peuvent attaquer sauvagement le littoral, provocant des destructions de biens, blessant ou tuant des vies.

Certains tsunamis peuvent etre tres large, dans les zones côtières leurs hauteur peuvent dépasser 100 mètres ou plus (330 mètres dans les cas extrêmes), et peuvent allez jusqu'à plusieurs centaines de mètres dans les terres. Les tsunamis ne ressemblent pas aux vagues classiques quand ils touchent les cotes. La crête de la vagues peut prendre la forme d'une marée montante, une séries de vagues, un mur d'eau massif.
Les tsunamis avancent tres rapidement, sur l'océan ils peuvent allez jusqu'a plus de 750 km/h, sur les cotes ils peuvent atteindre plus de 25 km/h
Les tsunamis peuvent apparaître a n'importe quel moment de la journée ou de la nuit
Les tsunami peuvent remonte les courants et les rivières qui mènent a l'océan.

Comment puis je savoir si un tsunami a ete génere ?
Il y a souvent des indices qui indiquent qu un tsunami a été génere. Utilisez vos sens !
Sentez les secousses - les tremblements de terre côtiers peuvent produire un tsunami. Si vous êtes sur la côte et vous sentez un tremblement de terre, ce peut être votre meilleur indice qu'un tsunami peut venir
Voyez l'océan reculer - il y a deux parties sur les vagues. la crête et la cuvette. Parfois la cuvette du tsunami arrivera en premier et un grand retrait de l'eau du rivage est un indice qu'un grand mur de l'eau peut suivre. Ne sortez pas pour sauver la vie de poissons échoués ou autre forme de vie marine, puisque la vague entrante se déplacera plus rapidement que vous pouvez courir

Entendez un hurlement ou un grondement peu commun. Quand la vague de tsunami vient à terre, elle fait souvent un bruit sourd de grondement ou d' hurlement. Si vous entendez quelque chose comme un train de fret venant de l'océan, ce peut être un tsunami et vous devriez aller dans les terres hautes.

Prêter attention aux maître nageurs et aux responsables de secours. Si un tremblement de terre éloigné a produit d'un tsunami vous ne sentirez pas le tremblement de terre. Des responsables de secours seront avisés de ces événements par un "watch" ou "warning" de tsunami Si le personnel de secours dit que vous devriez évacuer la plage en raison d'un tsunami possible, suivez leurs instructions et ne revenez pas à la plage jusqu'à ce qu'ils vous disent que c'est sûr.

Est-ce que je peux surfer un tsunami?
NON! Les vagues de Tsunami portent souvent beaucoup de détritus et de débris flottant.
Les débris peuvent être aussi dangereux que les vagues elles-mêmes. Les vagues de Tsunami NE SONT PAS des vagues de surf

Qu'est-ce que je fais si je suis dans l'hôtel et ressens un tremblement de terre?

Cet hôtel est dans une zone qui peut être inonde par un tsunami. Si vous sentez la terre secouer, protégez-vous contre les chute d'objets. S'ACCROUPIR, SE COUVRIR, et NE PAS BOUGER. Une fois que la secousse est finie, vous devriez vous assurer que tout le monde autour de vous est prévenue qu'un tsunami peut bientôt suivre. Dès qu'il sera sûr, sortez du bâtiment de l'hôtel par la porte de sortie le plus près à votre pièce. De manière ordonné, calme et sûre, suivez les itinéraires d'évacuation montrés sur la carte jointe ou allez vers la zone sur d'évacuation extérieur indiquée. Vous devriez également suivre le conseil de nos personnels qualifiés d'hôtel, et des autorités locales d'application de secours et de loi.

Et si je suis à la plage et que je sens un tremblement de terre?
Si vous êtes à la plage ou vous approchez de l'océan et vous sentez la terre secouer, vous devriez vous déplacer immédiatement vers les terres plus élevées. N'attendez pas l'annonce d'un tsunami "Warning". Le tsunami d'un tremblement de terre local pourrait frapper quelques zones avant qu'un "Warning" de tsunami soit annoncé. Restez loin des fleuves et des jets puisque ces zones peuvent également être inondées par le tsunami. Voyage sur les terres élevées.

Quand est-ce que je peux retourner de nouveau à mon chambred' hôtel ou à la plage?
Un tsunami est une série de vagues. Parfois la plus grande vague est la première, mais souvent la plus grande et la plus dangereuse peut être le troisième de la quatrième vague à arriver. Cela peu se produire une heure voir plus après le passage de la première vague. Une fois que vous avez évacué la plage et êtes allés sur les terres élevées, attentez là jusqu' à que les responsables des secours ou les autorités locales vous indiquent que le danger est fini et qu' il est sûr d'aller de nouveau à l'hôtel ou à la plage.

Les tsunamis se produisent-ils souvent?
Les grands tsunamis sont très rares, mais il y a eu plusieurs tsunamis destructifs dans les dernières décennies. En 1964 il y avait un tsunami destructif dans Crescent City et une grande partie de la zone du centre de bord de mer a été détruite. La zone la plus endommagée est maintenant un parc de bord de mer. Les scientifiques savent que la question n'est pas SI ces vagues viendront encore, mais QUAND.

Tres chers clients, pour votre prochain voyage à la plage, n'oublient pas de prendre votre lotion du soleil, de l'eau, un chapeau, et soyez attentif. Et rappelez-vous aussi, des tsunamis ne s'arrêtent pas à la plage. Ils peuvent voyager loin a l'intérieur des ligne de rivage, soyez en alertes toutes les fois que vous êtes près du rivage.

Nos personnels suivent des formation annuelle sur les différents aspects de la salubrité et de la sûreté, y compris des évacuations de tsunami, la sûreté de feu, des premiers soins et d'autres, pour vous assurer la visite la plus agréable et la plus détendant possible. Nous espérons répondre avec cette brochure a la plupart de vos questions au sujet des tsunamis. Veuillez interroger notre personnel au sujet des tsunamis si vous voulez plus d'information. Si nous ne savons pas les réponses à vos questions, nous pouvons essayer de trouver quelqu'un qui peut vous aider.

The California Seismic Safety Commission is preparing a set of recommendations for better safeguarding the people of California from future tsunamis. As part of this effort, Coastal Commission staff has prepared recommendations regarding land use planning for tsunamis. The draft set of recommendations is as follows:

Recommendation: Consider tsunamis when making land use planning decisions in potential tsunami inundation zones. These recommendations should be applied in coordination with existing requirements for flood zone mapping, wave run-up for storm events, design standards for flood and seismic loadings and special design requirements for select facilities; the most restrictive and conservative condition should be used for final planning and design purposes.

Recommendation 1 (Identification of potential hazard areas): In addition to current mapping efforts for tsunami evacuation and response, identify and map potential tsunami inundation zones for land use planning. Maps should identify generalized tsunami inundation zones on a probabilistic basis (e.g., 100-year event).

Recommendation 2 (Mitigation of hazard by avoidance): If new development is proposed within a potential tsunami inundation zone as identified by recommendation (1), require a site-specific hazard analysis for a 100-year tsunami event. Where feasible, site development outside of the area identified as a tsunami inundation zone in the site specific wave runup analysis.

Recommendation 3 (Mitigation by design standards):
a) The State should continue to fund study for development of tsunami design standards to minimize impacts to residential and commercial development, and to critical facilities, such as fire and police stations, hospitals, and schools .
b) If it is not feasible to site development outside of the tsunami inundation zone identified by a site-specific analysis (recommendation 2), locate and configure new development that occurs in tsunami inundation zones to minimize future tsunami losses by designing and constructing new buildings to minimize tsunami damage.

Recommendation 4 (Critical facilities): Avoid where feasible siting new critical facilities, including fire and police stations and hospitals in tsunami inundation zones as identified in recommendation (2). If it is necessary to site such facilities in tsunami inundation zones to provide adequate population protection, locate and configure critical facilities that occurs in tsunami inundation zones to be functional immediately after a 100-year tsunami event by meeting building standards identified in recommendation (3a).

Useful Internet Sites for Additional Information on Tsunamis

All-Hazards NOAA Weather Radio - http://www.nws.noaa.gov/nwr/

All-Hazard Alert Broadcast (AHAB) - A self-sufficient wind or solar powered warning system located in remote locations. It activates a brilliant blue US Coast Guard light and siren heard for at least a mile upon receipt of an emergency message, such as a tsunami watch or warning. It also records and repeats the verbal emergency message for those near the AHAB. http://access.wa.gov/news/2004/Dec/n20041129_7907.aspx

Cascadia Subduction Zone - http://www.pnsn.org/HAZARDS/CASCADIA/cascadia_zone.html

Emergency Alert System - http://www.fcc.gov/eb/eas/

Governor's Office of Emergency Services: Printer Friendly Versions of Tsunami: NOAA-Designing for Tsunamis and Local Planning Guidance on Tsunami Response: http://www.oes.ca.gov/Operational/OESHome.nsf/LevelTwoWithNav?OpenForm&Key=Plans+and+Publications

International Tsunami Warning Center - http://www.prh.noaa.gov/itic/ (responsible for the other 25 member nations in the Pacific Ocean Basin)

NOAA - National Oceanic and Atmospheric Administration - http://www.noaa.gov

NOAA/National Weather Service - http://weather.gov

NOAA/National Weather Service Seattle - http://weather.gov/seattle

NOAA/National Weather Service Portland - http://weather.gov/portland

Pacific Marine Environmental Laboratory - http://www.pmel.noaa.gov/ (includes tsunami and tsunami monitoring links)

Pacific Tsunami Warning Center - http://www.prh.noaa.gov/ptwc/ (responsible for all American interests in the Pacific, including Hawaii)

TsunamiReady - http://wcatwc.arh.noaa.gov/tsunamiready/tready.htm

Tsunami Detection Buoys - http://www.ndbc.noaa.gov/dart.shtml (located in the north Pacific Ocean)

USC Tsunami Research Center: http://www.usc.edu/dept/tsunamis/2005/index.php

USGS Western Coastal and Marine Geology - http://walrus.wr.usgs.gov/tsunami/

West Coast/Alaska Tsunami Warning Center - http://wcatwc.arh.noaa.gov/ (responsible for coastal waters from Alaska to California, including Washington)