Tsunami
“Seismic Sea Wave”

soo-NAH-mee

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http://www.prh.noaa.gov/itic/
“the breaking wave off Kanagawa” wood block color print
Historical map of 731 tsunamigenic events occurring in the Pacific between 1901-2000.

the event’s surface wave magnitude, Ms.
Famous Tsunamis

• December 26, 2004: A massive earthquake off the coast of Sumatra generates tsunami waves that wreck coastlines in 10 countries, killing more than 225,000 people.
• July 17, 1998: A tsunami strikes the north coast of Papua-New Guinea, killing 2,000 people.
• August 16, 1976: A tsunami hits the Moro Gulf region of the Philippines, killing 5,000 people.
• March 28, 1964: The Good Friday earthquake in Alaska creates a tsunami that envelopes the Alaskan coastline. The same tsunami also hits Oregon and California. A total of 132 people die.
• May 22, 1960: A 35-foot-high tsunami hits Chile, Hawai‘i, the Philippines, Okinawa and Japan. More than 1,000 people die.
• April 1, 1946: An Alaskan earthquake generates a tsunami that destroys North Cape Lighthouse and hours later hits Hilo, Hawai‘i. In total, 164 people were killed.
• January 31, 1906: An offshore earthquake creates a tsunami that swallows part of Tumaco, Colombia. The death toll is estimated at between 500 and 1,500.
• December 17, 1896: A tsunami washes away the main boulevard of Santa Barbara, California. No fatalities are recorded.
• June 15, 1896: The 70-foot-high Sanriku tsunami strikes Japan, killing 26,000 people.
• August 27, 1883: The eruption of the volcano Krakatau creates a tsunami that sweeps over nearby Java and Sumatra, killing 36,000 people.
• November 1, 1755: The Great Lisbon earthquake creates a 20-foot-high tsunami that destroys coastal Portugal, Spain and Morocco.
“most powerful earthquake the planet has seen in 40 years” (CNN)

Deaths = 225,000
Tsunami

- Vertical displacement of ocean water, due to:
  - Large Earthquakes ($M > 9.0$)
  - Mass movements (landslide) – submarine landslide
  - Submarine volcanic eruption
  - Meteorite impacts
Tsunami:

- *Tsunami* is a Japanese word meaning “great wave in harbour” – *ombak besar di pelabuhan*

- Larger tsunami can cause:
  - coastal flooding
  - Erosion
  - damage to buildings and
  - loss of life in extreme cases.
Tsunami

- **Earthquake triggered tsunami**
  - 26 Dec 2004; Sumatera; M = 9.0
  - 12 countries; 250000 people dead

- **Landslide triggered tsunami**
  - 1. Lituya Gulf, Alaska (1958)
    - "Mega Tsunami"
    - Landslide 90 million tons of rock
    - Create tsunami ½ km (500m) height
  - 2. Volcanic of North Africa (Canary Island) @ La Palma – belum berlaku, tapi pasti akan berlaku!!
Earthquake triggered tsunami & Plate tectonic
M9.0 Andaman - Nicobar Islands Earthquake of 26 December 2004

1,600 km
15 m slip
Subduction zone (India vs Burma)

1st phase (400km)

2nd phase
Latest Earthquakes

Subscribe: Earthquake Notification Service
Did You Feel It? Report an Earthquake

USA (Magnitude 1+)
February 4, 2010 14:00:01 UTC

World (Magnitude 4.5+)
February 4, 2010 14:01:10 UTC

ShakeMap: Maps depicting shaking intensity
PAGER: Estimate of population exposure

Atom XML Feed  Google Earth KML
Tonnes of rock shooting upward with tremendous force

Energy transfers to water; swell above sea level

Gravity forces the energy out across the surface of the ocean (think of ripple effect)
Anatomy of a normal wave

The most important thing to know about waves is that they do not represent the movement of water, but instead show the movement of energy through water.
## Typical Tsunami Wave vs. Typical Wind-generated Wave

<table>
<thead>
<tr>
<th>Wave Feature</th>
<th>Wind-generated Wave</th>
<th>Tsunami Wave</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wave Speed</strong></td>
<td>5-60 mph (8-100 kph)</td>
<td>500-600 mph (800-1,000 kph)</td>
</tr>
<tr>
<td><strong>Wave Period</strong></td>
<td>5 to 20 seconds apart</td>
<td>10 minutes to 2 hours apart</td>
</tr>
<tr>
<td>(time required for two waves to pass a single point in space)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wave Length</strong></td>
<td>300-600 feet apart (100-200 meters apart)</td>
<td>60-300 miles apart (100-500 km apart)</td>
</tr>
</tbody>
</table>
Tsunamis are often no taller than normal wind waves, but they are much more dangerous.

Wind waves come and go without flooding higher areas.

Water flows in a circle.

Tsunamis run quickly over the land as a wall of water.

Water flows straight.

Even a tsunami that looks small can be dangerous!

Any time you feel a large earthquake, or see a disturbance in the ocean that might be a tsunami, head to high ground or inland.
After 5 hours

Fig. 19. November 15, 1994 tide measurements at Batangas Pier. Measurements were made using dip stick at 15 minute intervals. Measured tide oscillations were related to tsunami. (Data from HANJIN Construction Corporation)
Water level measurements beneath the Wailuku River bridge during the first hours of the tsunami of 23 May 1960.
TSUNAMIS

- **Deep water**: >800 km/hr (easily keep pace with Boeing 747!!!)
- **Wavelengths**: >160kms (100 miles)
- **Wave heights**: 1-2m
- **Gentle slopes; go unnoticed**

- **Shallow water**: slower
- **Waves behind begin to overtake** (*shoaling*)
- **The energy contained in waves is condensed into smaller volume of water; waves increase in height and steepness**
- **Huge breaking wave as a “wall of white, foamy water”**
Sumatera Tsunami: Travel 600km in 75 mins; speeds of 480kph

Low velocity; height increases
Compressed energy; forces the water up
50kph; 30m a.s.l
1.6km of the shore line
A GIANT TSUNAMI

THE 1946 ALEUTIAN TSUNAMI 30m HIGH

THE LIGHT HOUSE WAS WASHED AWAY.

The light house was 18 m high.
It stood on the ground 10 m high above sea level.
What should we do against the tsunami disaster?

1. Before the tsunami generation
   * Prediction of next tsunami event (date and magnitude)
   * Establishment of tsunami warning system
   * Education for the disaster-prevention

2. During and just after the tsunami generation
   * Escape from the tsunami!
   * Rescue activities for disaster victims
   * Recovery aid

3. After the tsunami generation
   * Investigation of effect and magnitude of the tsunami
   * Check-out the tsunami warning system and education process
Tsunami warning sign
Koh Phi Phi
26th December
memorial Ceremony
Please be quiet and respectful in and around this area. Thank You.
US: 8 years tsunami event!!

How can we predict the next tsunami event?

= How can we know the recurrence interval of tsunami events?

If we can identify ancient tsunami events, we may understand the recurrence interval of tsunami events.

This idea is applied to estimate the recurrence intervals of earthquake, volcanic activity...
Common warning signs of a tsunami

- Sudden and noticeable recession in water away from the shoreline
- Earthquake is a natural tsunami warning

EG: 10-year-old British School Girl Tilly Smith – saved hundreds from death because she could recognise some tsunami warning signs (holiday in Phuket). She had just completed the chapters about earthquakes and tsunamis.
"My mum didn't realise what was happening on the beach because she wasn't taught about tsunamis when she was younger. She had never even heard the word “tsunami” and she didn't know how to react. I think it's really important for all kids to know about tsunamis and other type of natural hazards “said Tilly Smith.
Survival tips:

- If you are on a boat in a harbour, either **dock it quickly and move to higher ground**. You can also **take it out to sea** as far as possible since tsunamis only cause damage when they move from deeper to more shallow waters.
- Get away as fast as possible from the coastline and **seek higher ground**.
- Be aware that **the first wave may not be the largest** in a series of waves.
- If you are near a high-rise building, head for its **upper levels** to avoid the water.
THE TSUNAMI ARRIVED AT HAWAII.

School children saw a precedent abnormal tide and warned. No one listened to this warning. It was on April 1st.
FAILED TO EVACUATE.
159 DEATHS in Hawaii.

A waterside worker at the Hilo Harbor.
Tamat