What is a tsunami?

- Japanese for “harbor wave”
- No connection with tides.
- Not tidal wave.

- Series of waves for hours.
  1\textsuperscript{st} wave may not be largest.

- Generated by any sudden displacement of the water column

F. Gonzalez, NOAA, Tsunami! In Scientific American, 1999
Terms: Wave Height & Amplitude

Tsunami wave periods typically range from 5-60 minutes.

In this case the leading wave of the tsunami is a depression or a drop in water level however, the leading wave can also be an elevation or rise in water level.

To correct the maximum double tsunami amplitude the effect of the tide signal must be removed.

Combined Tsunami and tide signal
Tide signal
Wavelength and Runup

As it enters shallow water, tsunami wave speed slows and its height increases, creating destructive, life-threatening waves.
Terms: Runup & Inundation

**DATUM** is mean sea level or mean low water at time tsunami attack.

**Maximum Water Level** may be located at shoreline or the inundation line or anywhere in between.
Terms: Runup & Inundation

- **Runup**: height above sea level reached by water
- **Inundation**: how far inland the water reaches
Causes of Tsunamis: not just earthquakes

- Earthquakes: 72%
- Landslides: 5%
- Volcanoes: 10%
- Meteorological: 2%
- Other/Unknown: 2%
How an earthquake makes a tsunami
Depth of rupture

- Deeper rupture produces a broad, low amplitude deformation of the sea floor.
- Shallow rupture produces a large amplitude, shorter wavelength deformation.
- The Tohoku tsunami had both: rupture started at about 50 km depth and grew up the interface to the sea floor. This took about two minutes.
How to Make a Tsunami (2): Landslide

- Rotational slumps (Papua New Guinea, 1998): local hazard only
- Debris avalanches (Lituya Bay, Alaska; Hawaii, 110 ka): extreme local hazard
- Common on volcanoes: Oshima Oshima 1742; Matuyama (Unzen) 1792; St. Augustine 1883; Ritter 1888.
- No distant hazard from oceanic island slides
- Highly dispersive tsunamis (i.e., no ocean-wide hazard) except from slides down gentle continental margins (e.g. Mauritania, Western Sahara)
- Shallow retrogressive failure (Grand Banks, 1929; Molokai, 1903): probably very common; very difficult to identify in bathymetry.
Aliko Slide (McMurtry, et al., 2004)
How to Make a Tsunami (3): Volcanic eruption

- Tsunamis generated by individual pyroclastic flows (e.g., Soufriere Hills)
- Massive tsunamis from eruption column collapse (e.g., Krakatau, 1883)
How to Make a Tsunami (4): Bolide impact

- K-T boundary Chicxulub impact
- Thick tsunami deposits in Mexico, rapidly thinning with distance.
Tsunamis travel at the speed limit, so we know when they will arrive.
Appearance

- Drawdown (Ocean Recedes)
- Bore (asymmetric steep sided wave)
- Like a Rapidly Rising Tide
Bores

- When incoming wave reaches a significant fraction of the water depth.
- Crest (deeper water) travels faster than trough.
- In extreme case, will form an undular bore (Sumatra, Thailand, Sri Lanka, India),

![Bore Formation Diagram]
Rapidly Rising Tide

Japan, March 11, 2011
Tsunami Focusing

PNG 1998

Intense Local Tsunami
Steel roofing material wrapped easily around a tree. Sissano Village.
Mahalo

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