

Destructive Waves

What causes storm surges?

What causes seiches?

What causes tsunamis?

Why are tsunamis always shallow-water waves?

Why don't tsunamis destroy ships in the open sea?

On the open sea, even very large waves can seem harmless. A ship rides up and over them. When they reach shallow water and unleash their energy, however, their power becomes visible. Waves driven by storm winds can be dangerous to coastal areas. There are three distinct types of wave noted for their destructive power: storm surge, seiche, and tsunami.

Storm surge is a destructive wave that forms when high winds push water against the shore, where it piles up. The shallower the water offshore, and the further it extends offshore, the greater the surge. This is why the US Gulf Coast has the biggest storm surges, which can exceed 9 meters (30 feet) for a Category 5 hurricane.

When the storm moves ashore, the storm surge builds on top of the tide. The damage to low-lying coastal areas can be tremendous when storm surge and an extremely high tide coincide. Although hurricane winds cause the most structural damage, about 90% of deaths in a hurricane result from the storm surge. Storm surge is not a progressive wave and exists only in a cyclonic storm.

Seiche (pronounced "SAYsh") is a form of standing wave that can be destructive. Seiches, which form in large bays and lakes as a wave that rocks back and forth, can result from a strong wind that pushes the water level up on one side of a lake or basin. When the wind abates, the water rocks back and forth in the basin at a frequency determined by the basin size and depth.

Lake Geneva, Switzerland, is known for seiches and is, in fact, where scientists first described the phenomenon. All the Great Lakes have seiches regularly. When combined with storm waves, seiches sometimes cause waterfront property damage.

A tsunami results from sudden water displacement caused by a landslide, an iceberg falling into the sea from a glacier, a volcanic eruption, or, most commonly, an earthquake. Tsunamis get their name from the Japanese word for *harbor wave*, thanks to their particular destructiveness in harbors and bays. You may have also heard them called tidal waves, though this is a misnomer because they're not caused by the tides or directly related to the tides in any way.

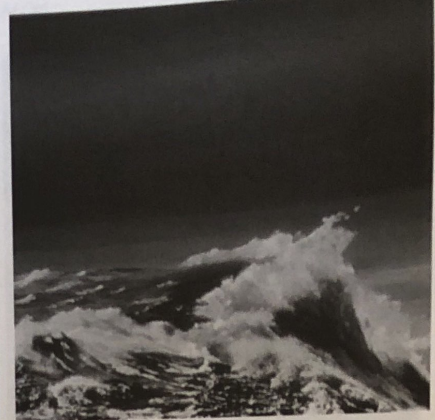


Figure 10-15

Storm surge.

Sixteen feet of storm surge struck the Florida Panhandle in September 1975 during Hurricane Eloise.

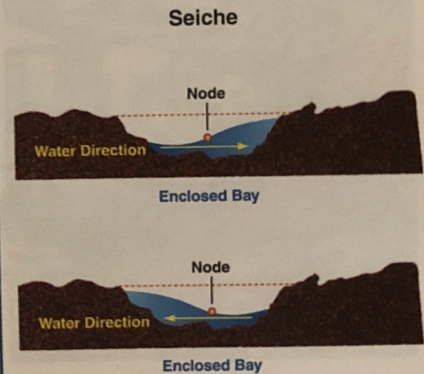


Figure 10-16

Seiche.

A seiche is the sloshing of a closed body of water, as in an ocean harbor or bay. The back-and-forth water movement can be caused by a local earthquake or when a strong wind blowing in one direction suddenly stops.

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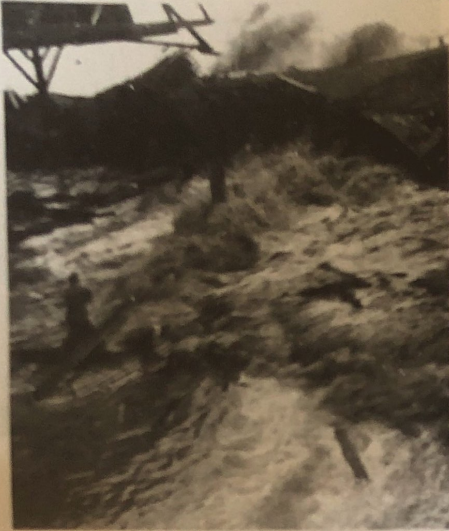


Figure 10-17a

Tsunami.

This tsunami inundated Hilo, Hawaii.

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Figure 10-17b

Tsunami damage.

This 1963 tsunami swept fishing boats into the town of Kodiak, Alaska.

LEARNING MARINE SCIENCE CAN SAVE LIVES

The undersea 2004 Indian Ocean earthquake that occurred on December 26, 2004 produced tsunamis that rank among the deadliest natural disasters in modern history. Tsunami waves reaching 15 meters (50 feet) high devastated the shores of Indonesia, Sri Lanka, India, Thailand, and other countries. The tsunami even reached as far as Somalia on the east coast of Africa, 4,500 kilometers (2,800 miles) west of the epicenter.

The tsunamis resulted from a rare megathrust earthquake, which is a large earthquake produced by one tectonic plate suddenly slipping beneath another. The quake took place at 7:58:53 local time in the Indian Ocean off the western coast of northern Sumatra, Indonesia. At a magnitude of 9.0, it was the largest since the 9.2-magnitude Good Friday Earthquake off Alaska in 1964. The 2004 Indian Ocean earthquake tied for fourth largest since 1900, when accurate global seismographic record-keeping began.

As reported by Reuters news service, on the morning of the quake a 10-year-old British girl saved 100 other tourists from the Asian tsunami. She warned them that a giant mass of water was on its way after learning about the phenomenon weeks earlier at school. "I was on the beach and the water started to go funny," Tilly Smith told the news service in Phuket, Thailand. "There were bubbles and the tide went out all of a sudden. I recognized what was happening and had a feeling there was going to be a tsunami. I told Mummy."

While other holidaymakers stood and stared as the disappearing waters left boats and fish stranded on the sands, Tilly recognized the danger signs because she had recently completed a school project on tsunamis. Quick action by Tilly's mother and Thai hotel staff cleared Maikhao beach, just minutes before a huge wave crashed ashore. The beach was one of the few on the island of Phuket where no was killed.



Figure 10-18

Initially it may seem strange, but all tsunamis are shallow-water waves in the same way that the tidal bulge is a shallow-water wave. The typical tsunami has a wavelength of about 200 kilometers (120 miles), yet the deepest point in the oceans (Marianas Trench) is about 11 kilometers (6.8 miles) deep. There's no ocean deep enough to make a tsunami behave as a deepwater wave.

Tsunamis are fast-moving waves that can travel thousands of kilometers. They're not much of an issue in the open sea. They have very long wavelengths and are nearly imperceptible as they travel. Vessels may rise and fall about 1 meter when a tsunami passes, but they do so very gradually. Japanese folklore relates an incident in which fishermen at sea all day sailed home to find their

village wiped out by a tsunami. The fishermen were unaware it had passed under them.

When a tsunami reaches shore, it becomes much higher. The wave surges ashore, breaking (as you learned), hurling a tremendous water mass and energy onto land. If the trough precedes the crest to shore, the wave water recedes as if a massive low tide were in progress. The building period can take several minutes and has accounted for some fatalities. Curious beachgoers, unaware of the danger, have wandered out onto the drained seabed, only to be drowned by the wave a few minutes later. History records a tsunami surging up a hillside 530 meters (1,740 feet) high in Lituya Bay, Alaska, in 1958.

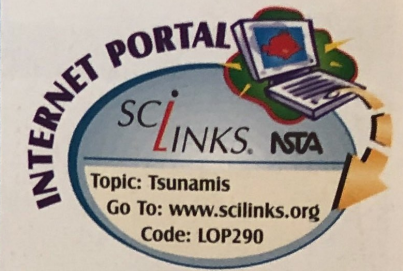
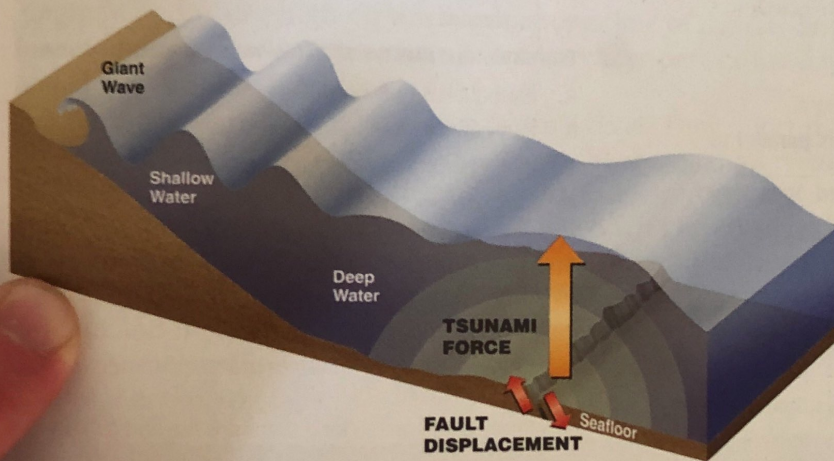


Figure 10-19

Tsunami formation.

A tsunami results from sudden water displacement caused by a landslide, iceberg, volcanic eruption, or, most commonly, an earthquake. The long period and wavelength make them nearly unnoticeable at sea. When the wave reaches shore it can unleash a tremendous water mass and energy onto land.

CLOCKING A TSUNAMI

How fast can you swim a tsunami? Just how fast are tsunamis, anyway? If you know the depth, you can figure it out for yourself. The velocity of a shallow-water wave is determined by this equation:

$$v = \sqrt{gd}$$

where:

v = velocity

g = the acceleration of gravity (9.8 meters per second squared) and

d = the water depth.

That is, velocity = square root of gravity times depth.

Suppose a tsunami originates in water that is 4,000 meters deep.

$$v = \sqrt{(9.8 \text{ m/s}^2)(4,000 \text{ m})}$$

$$v = \sqrt{39,200 \text{ m}^2/\text{sec}^2}$$

$$v = 198 \text{ m/sec}$$

Therefore, the velocity of the tsunami would be 198 meters per second. That works out to 712.8 kilometers (442.9 miles) per hour.