Solid Waste Pollution
Some Marine Debris Remains in the Environment for a Very Long Time
Solid Waste - Plastics
What Happens to Plastics in the Environment?
The Great Pacific Garbage Patch
Solutions to the Marine Debris Problem
Marine and Aquatic Pollution - Summary

Tsunami

What is a Tsunami?

Why are Tsunami so Destructive?

Review for Exam 3

Readings Ch 18: 18.2-18.9

Graphics: (top) Tsunami warning sign, commonly seen on the west coast of the US. (bottom) Fishing boat beached near a damaged fire truck. Photo by D.J. Sigrist International Tsunami Info. Center, Honolulu. Courtesy of NOAA.

What is a Tsunami?

Tsu = harbor

Nami = wave

- not confined to harbors

- not created by tides

Created by direct displacements of the water's surface via undersea earthquakes, landslides or volcanic activity

Energy travels outward (like ripples that spread when a rock is thrown into a pond)

Graphic: Valdez, Alaska following a tsunami generated by the March 27, 1964 earthquake. Photo courtesy of U.S. Dept. of Interior.

Tsunami – A Global Wave

Aleutian Trench Tsunami - April 1946

- Caused by an earthquake that displaced the sea floor

- Significant damage in the Aleutians and Hawaii

Graphic: See Garrison, Fig. 10.28.

The Indian Ocean Tsunami – The Earthquake

Graphics: (top) Location of the Sumatra earthquake, courtesy of USGS, (bottom) Seismogram of the Sumatra earthquake measured at Middletown, PA, courtesy of Pennsylvania Geological Survey.

Location of the Sumatra Earthquake

Graphic: Map of the Indian Ocean, showing the location of the earthquake.

How can an Earthquake Trigger a Tsunami?

At subduction zones, plates don't usually move gradually- they can "lock"

Infrequent large earthquakes can suddenly release the accumulated strain

When sudden plate motion deforms an area of the seafloor, a large volume of ocean water is displaced… this is the beginning of a tsunami

Graphic: Courtesy of the Pacific Tsunami Warning Center.

How did the Indian Ocean Tsunami Move?

Tsunami are a series of waves that radiate away from where they are generated

As they travel, they can bend and their speed can change due to the shape of the basin (they are shallow water waves)

Animation courtesy of the National Institute of Advanced Industrial Science and Technology, Japan.

What Happens as a Tsunami Moves Ashore?

In deep water – tsunami have small wave height and long wavelength

As a tsunami moves toward shore, its wavelength decreases and it grows much higher and steeper

Graphic courtesy of the Pacific Tsunami Warning Center.

Banda Aceh – Before and After

Coastline geometry and distance from the triggering event determine the height of a tsunami; many factors, such as population density, land use and building

techniques, determine the level of destruction caused by a tsunami

Graphic: Aceh Province, Sumatra, Indonesia, IKONOS images, provided courtesy of Space Imaging/CRISP-Singapore.

Tsunami Ashore

Tsunami wash ashore as a <u>series of waves</u>

- Crests and troughs are usually separated by ~15 minute intervals

- The trough can arrive before the crest

Onshore, tsunami often appear as a very rapidly moving, very high tide

Wave heights at the shore can be 30 meters (or larger)

Graphic: See Garrison, Fig. 10.31.

The Tsunami Warning System

Objective = predict the intensity and time of arrival of tsunami generated by earthquakes

Anchored instruments measure sea level changes as tsunami pass over

These data are combined with earthquake information from the global network of seismographs

Warnings and watches are issued based on predicted arrival times

Graphic: Deep Ocean Assessment and Reporting on Tsunami (DART) buoy. Courtesy of NOAA, See Garrison, Fig. 10.37.

The Challenge of Responding to a Tsunami Warning

Graphics: (top) People searching for fish on a exposed reef as a tsunami approaches Oahu, 1957, courtesy of the Pacific Tsunami Warning Center and Honolulu Star Bulletin, (bottom) onlookers observe exceptionally low sea levels in a Honolulu Harbor as a tsunami arrives, 1952, courtesy of the Pacific Tsunami Warning Center and Camera Hawaii

Tsunami and the Pacific

Common in the Pacific due to seismic activity at subduction zones

Travel times calculated based on the time of the triggering event

Tsunami can reflect off land masses - the reflection can result in an area being affected by the same tsunami twice!

Graphic: Map of travel times for tsunami generated by earthquakes in Alaska and Chile, courtesy of USGS.

A Closer Look at the Earthquake Zone…

- Indian Plate is subducting under the more dense Burma Plate

- Plate motion ~6 cm/yr, but the subduction zone has been "locked" for ~500 years

The accumulated strain was released in a brittle deformation

Graphic: Map courtesy of USGS.

Predicting a Tsunami's Path

Computerize simulations of ocean flow can predict the motion of a tsunami within minutes of a large earthquake

These simulations are then compared with observed data

Graphics: (top) computer-based simulation of the Indian Ocean tsunami 7:10 hours after the earthquake, (bottom) comparison of the predicted and observed sea level.

Tsunami and the Atlantic

Atlantic = rimmed by passive margins

- Large earthquakes and tsunami have affected the Atlantic (e.g., Grand Banks in 1929, Lisbon in 1700)

- Today, the most likely trigger for a large tsunami in the Atlantic is a massive landslide in a coastal area

Graphic: Artists rendition of the aftermath of the Lisbon earthquake and tsunami in 1700, (bottom) Newpaper headline following a tsunami in the Atlantic in 1929,

Exam 3, then Challenges of the Marine Environment

Evolution via Natural Selection

Physical Factors in the Marine Environment – Light and Floatation

Readings

Ch 10: 10.1, 10.24-10.29

Graphic: Tuna. Courtesy of United Nations Food and Agricultural Organization.