LECTURE #8: Tsunami Monitoring & Mitigation

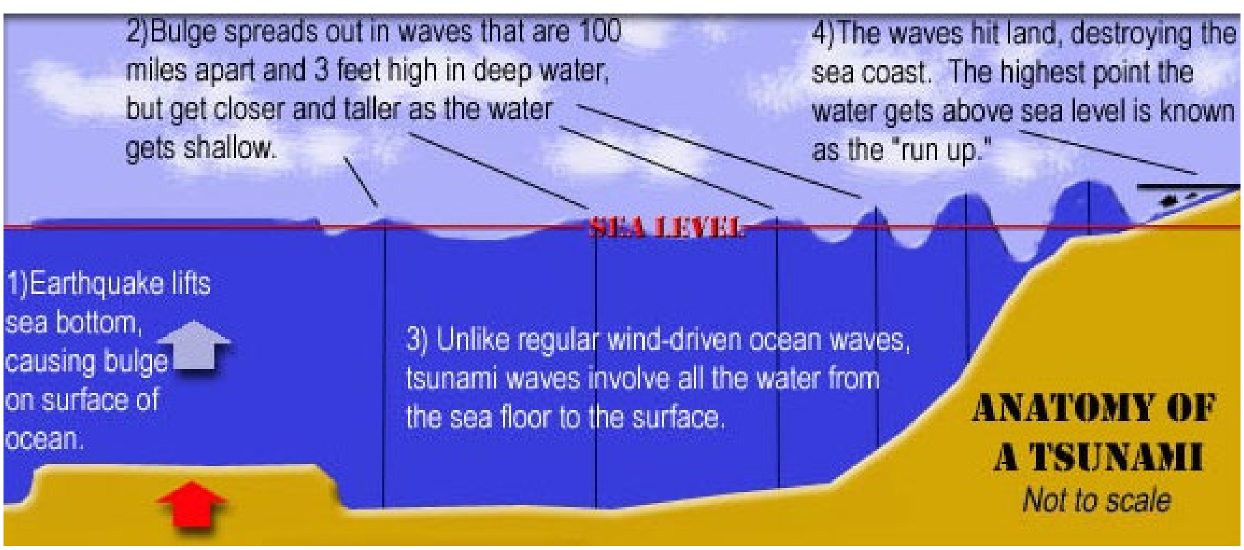
Date: 15 February 2021

I. Exam 1

- next class period!
- see important information at the top of last class's notes
- today's material will **not** be on Exam 1
- I will send out an email on Tuesday with the exam location information
  - importantly, the exam is synchronous only!
  - it will start at 2:20pm on Wed. and end at 50 minutes later
  - please be on time and focus on the questions not trying to look up the answers – if you do, you will run out of time

II. Tsunami Characteristics *(continued)*:

- shoaling:
  - process of wave height increase and "breaking" as the water depth decreases (near shore)
  - energy transfer (from speed to height, KE → PE)
  - shoaling occurs further from land than wind-driven waves
    - because of the longer wavelength and larger amount of energy
  - results in a large withdraw of water near coast prior to wave break
    - water being drawn out to form the wave
    - heights can reach 10's of meters
  - period of 15 - 60 minutes
    - dangerously long *(allows people time to return to the devastated area)*



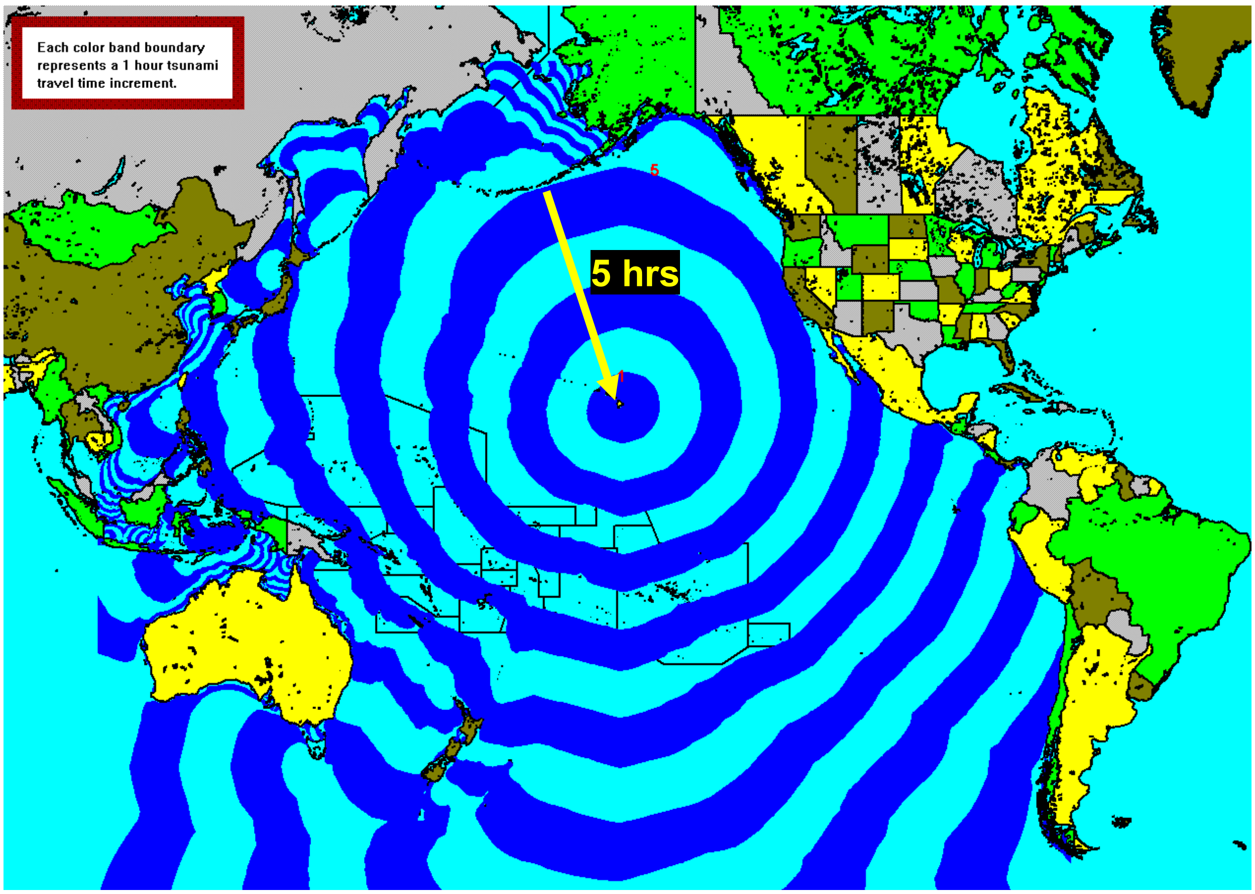
- physics of wave growth
  - v_{wave} is proportional to d_{water}
    - *wave speed goes up as the depth does*

  - h_{wave} is inversely proportional to d_{water}
    - *wave height goes up as the depth goes down*

  - E_{loss} is proportional to wavelength
    - *energy loss is greater with longer wavelengths*

  - height of a tsunami determined by the local topography of the ocean bottom

- tsunami travel time map:

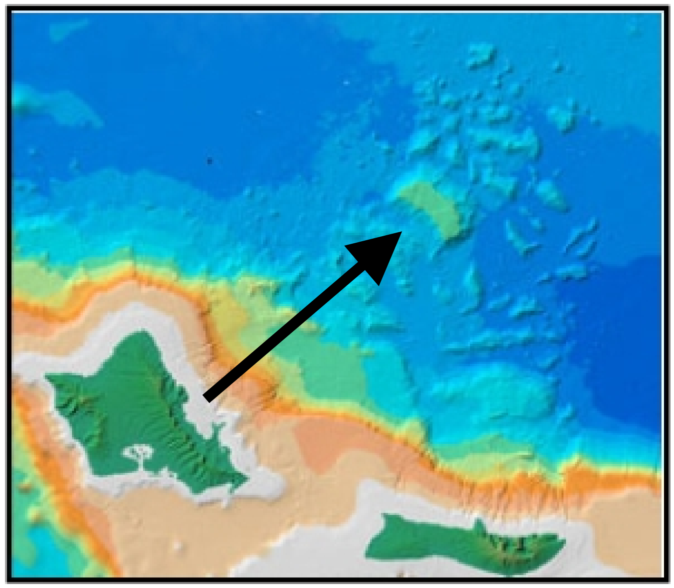


tsunami travel time *(1 color band = 1 hour)*

  - details/notes *(discussed in lecture)*:

III. Avalanche-generated tsunamis

- great deal of attention recently
    - 2018 avalanche-generated tsunami from Krakatau volcano in Indonesia
- attention in the past few decades
    - after sonar mapping of the Hawaii undersea deposits
    - HUGE debris avalanches
    - blocks larger than the island of Manhattan
    - the potential to form ~1000 foot waves!



- even smaller avalanches can cause large tsunamis
    - example: Mt. Unzen in 1792 (Japan)
        - volume ~ 1.3 km^3
        - tsunami hit 77 km of coast
            - killed 9528 people
            - moved to the other side of the bay and killed another ~5000

IV. Example: 1946 Alaska EQ (M 7.4) and Tsunami

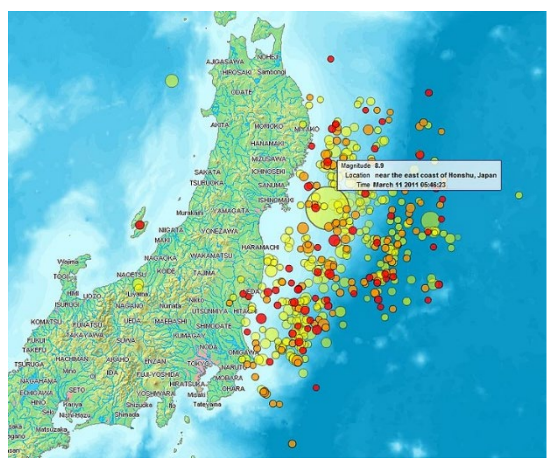
- April 1, 1946, at 3:29 local time
- Pacific-wide tsunami was triggered by the EQ
- focal depth of 25 km
- tsunami took the lives of more than 165 people
- caused over $26 million (1946 dollars) in damage
- newly built Scotch Cap Lighthouse on Unimak Island
    - 120 miles away *(~ 15 min until the tsunami reached it)*
    - 5 men lost their lives and the run-up reached 115 ft.

- Hilo, Hawaii received the most damage
    - tsunami arrived at Hilo 4.9 hours
    - produced a 10 meter high tsunami on the north coast of the Big Island
        - Hilo and other smaller villages were devastated
        - 96 people died
        - led to the formation of the Pacific Tsunami Warning Center (PTWC)
            - more on this in the monitoring section below

V. Example: Sumatra (12/26/2004)

- caused by a subduction zone M9.1 EQ
    - killing over 230,000 people in 14 countries
    - longest duration of faulting ever observed
        - between 8.3 and 10 minutes
    - inundating coastal communities with waves up to 100 feet
    - worldwide community donated more than $7 billion *(2004 U.S. dollars)*

VI. Example: Japan (3/1/2011)



- subduction zone M9.0 EQ
    - hypocenter depth of ~ 32 km
    - waves heights of up to 40.5 meters
    - travelled up to 10 km inland
- level 7 meltdowns in the Fukushima I Nuclear Power Plant
- >20,000 deaths
- over 125,000 buildings damaged or destroyed
- *other details you found?*
    -
    -
    -

VII. Tsunami Damage (depends on):

- size of the event
- offshore bathymetry *(depth of ocean floor)*
  - shoaling can occur in different locations or sooner/later

- distance of coast from the triggering event
  - <u>example:</u> Nicaragua in 1992
    - M7.0 EQ only 35 miles offshore
    - produced a 10 meter tsunami
    - reached 1/2 mile inland
    - killed ~200 people

- coastal geomorphology
  - irregular coastline can concentrate wave energy

- coastal orientation
  - tsunami perpendicular to coast will be more damaging

- state of the tides at the time of the tsunami

VIII. Monitoring

- process is very technology-intensive
  - high costs for many poorer countries

- no technology available to monitor local tsunamis
  - example: Papua New Guinea tsunami in 1998 was not detected

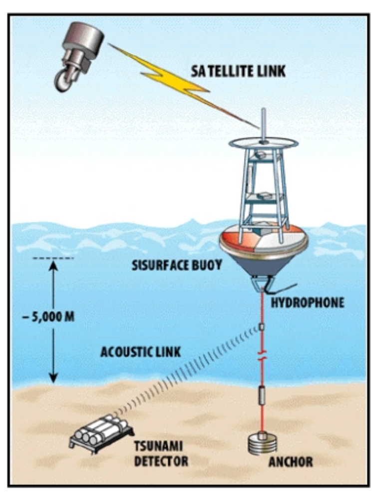
- Pacific Tsunami Warning Center (PTWC):
  - **http://ptwc.weather.gov/**
  - NOAA and the NWS
  - monitors data from all over the Pacific Rim
    - seismic, wave heights, weather …

  - estimates the likelihood of tsunami hazard and the travel time
  - issues warnings based on available data
    - via sirens and communication to local officials

- NOAA's DART system
  - *Deep-Ocean Assessment and Reporting of Tsunamis*

  - bottom pressure recorders detect crest of tsunami

  - Information transmitted to surface buoys that relay to stations via satellite



IX. Mitigation

- Hawaii is one of the most at-risk areas in the Pacific for tsunami hazards
  - center of the Pacific (less warning time)
  - vulnerable to tsunami from almost every direction

- building restrictions in hazard prone areas
  - Hilo harbor/downtown was destroyed by the tsunamis of 1946 and 1960
  - town is now rebuilt on higher ground and the devastated area is a park

- seawall construction
  - cause early wave breaking in Hilo harbor
  - prevent wave run up into urban areas

- education
  - audible and media warning systems
  - location and structure of dwellings
  - evacuation routes
    - including vertical evacuation!