EARTHQUAKE CASE HISTORIES II (08)

I Main Topics for next two lectures
   A Recognition of earthquake hazards from case histories
   B Key Lessons
   C Key questions regarding characterization of earthquakes and faulting

II Case Histories

A Kau, HI, 1868
B Alaska, 1946
C Chile, 1960
D Kalapana, HI, 1975
E Kiholo Bay, HI, 2006
F Tohoku, Japan, 2011
A Kau Earthquake  
4/2/1868, M ≈ 7.9

The April 2, 1868, earthquake...

- destroyed houses, toppled stone walls, opened ground cracks, and threw people off their feet.
- killed at least 77 people.

- generated a tsunami. A wave up to 18 m (60 ft) high along the Kūʻī-Puna coast resulted in 46 deaths.
- triggered multiple landslides, including one in Kīlauea’s Wood Valley, where 31 people died.
- induced short-lived eruptions on Kīlauea and Mauna Loa.

Source: USGS

If this earthquake occurred today, damages could cost as much as:

$500 million


B Alaska, 1946 (April 1)  
$M_w = 8.1$; 165 killed; 159 killed in Hawaii

https://www.youtube.com/watch?v=gcaR7tDKlq8

http://en.wikipedia.org/wiki/1946_Aleutian_Islands_earthquake

C Chile, 1960  
$M_w = 9.5$; 61 killed in Hilo by tsunami

C Kalapana, Hawaii
4:48 AM, November 29, 1975; M=7.7

1 Maximum subsidence along coast: 3.5 m
2 Earthquake caused by deep-seated failure of SE flank of Kilauea
3 Triggered eruption at Kilauea at 5:32 AM

4 Damage estimate: $4 million (~$13 million in 1999 dollars)

Spilled merchandise in Hilo supermarket
Damaged home about 7 km north of Hilo
C Kalapana, Hawaii
4:48 AM, November 29, 1975; M=7.7

5  Surface rupture along Koae fault system and Hilina fault system

Reactivated scarp along Hilina Pali


From Martel and Langley, 2006


C Kalapana, Hawaii
4:48 AM, November 29, 1975; M=7.7

6  Maximum tsunami height 12.2-14.6 m, at Keauhou Landing

House in Punalu’u demolished by tsunami

C Kalapana, Hawaii
4:48 AM, November 29, 1975; M=7.7

7. Earthquake similar to April 2, 1868 earthquake
8. Two “1906” earthquakes in 90 years on Big Island

D Kiholo Bay, Hawaii
7:08 AM, November 29, 1975; Mw=6.7

- Date: October 15, 2006
- Origin time: 17:07:49 UTC
- Magnitude: 6.7 M_w
- Depth: 29 kilometers (18 mi)
- Epicenter: Coordinates: 19.89°N 156.07°W
- Areas affected: Hawaii, United States
- Max. intensity: VIII (Severe)
- Tsunami: Yes
- Aftershocks: 6.1 M_w Oct 15 at 17:14 UTC
- Casualties: None
D Kiholo Bay, Hawaii
7:08 AM, November 29, 1975; Mw=6.7

1 Earthquake attributed flexure of oceanic crust from load of Big Island

2 >$200 million in damage

Road damage, Pololu Valley (Kahala) Kalahikiola Congregational Church (Kohala)

http://www.geotimes.org/feb07/geophen.html
D Kiholo Bay, Hawaii
7:08 AM, November 29, 1975; Mw=6.7

3  Power outages on Oahu, Big Island, and Maui

4  Honolulu Airport temporarily closed

Delays at Honolulu Airport

Power outage, Manoa Valley Safeway

http://archives.starbulletin.com/2006/10/16/news/art2bx.jpg

http://archives.starbulletin.com/2006/10/16/news/art3x.jpg

D Kiholo Bay, Hawaii
7:08 AM, November 29, 1975; Mw=6.7

4  Many rock falls on Hawaii

Rock fall between Ka‘aha and Halape

Rock fall at Waipio Valley


1/26/15  GG303
Major Earthquakes in Hawaii since 1868

So... It's not IF a destructive earthquake will strike Hawaii, but WHEN the next one will happen.


E Tohoku, Japan

- Date 11 March 2011
- Origin time 14:46:24 JST (UTC+09:00)
- Duration 6 minutes
- Magnitude 9.0 (Mw)
- Depth 30 km (19 mi)
- Epicenter Coordinates: 38.322°N 142.369°E
- Type Megathrust earthquake
- Total damage Tsunami wave, flooding, landslides, fires, building and infrastructure damage, nuclear incidents including radiation releases
- Max. intensity IX - Violent
- Peak acceleration 2.99 g
- Tsunami Up to 40.5 m (133 ft) in Miyako, Iwate, Tohoku
- Foreshocks 7
- Aftershocks 11,106 (as of 7 September 2014)
- Casualties 15,889 deaths, 6,152 injured, 2,601 people missing

http://www.newscientist.com/blogs/shortharshscience/2011/03/giant-quake-was-small-for-its.html

E Tohoku, Japan
Severe shaking for 2-3 minutes

https://www.youtube.com/watch?v=PZvjqJs_qkA&list=PLD216A99991F751D9

E Tohoku, Japan
Tsunami

https://www.youtube.com/watch?v=wjAd7jFRX0&spfreload=10
E Tohoku, Japan
Tsunami overwhelsms seawall at Miyako

https://www.youtube.com/watch?v=5-oCBoq.8I

E Tohoku, Japan
Tsunami overwhelsms seawall

https://www.youtube.com/watch?v=m35A17b2Q4Q&index=21&list=PLD216A9998F7558D99&spfreload=10
E Tohoku, Japan

1 Collateral damage in Japan
   a Tsunami
   b Nuclear power plants
      i Fukushima disaster (Level 7 event)
      ii Fire and small coolant loss at Inagawa plant
      iii Partial power loss at Tokai plant
   c Multiple power plants damaged
   d Oil refinery burned for 10 days
   e Sendai liquefied natural gas (LPG) plant in severely damaged
   f Severe disruption to transportation systems
      1 Sendai airport
      2 Tohoku expressway
      3 Various train services
   g All Japanese ports temporarily closed
   h Fujinuma irrigation dam failed
   i Telecommunications failed
   j National defense- Matsushima Air field flooded
   k Many fires
   l Debris: ~25 million tons


E Tohoku, Japan

2 Collateral damage in Hawaii

https://www.youtube.com/watch?v=lOSulxinFkQ
III Key Lessons

A Recognition
1. Major earthquakes in Hawaii not recognized until 1868
2. Hawaiian tsunami hazard not recognized until 1946
3. Japan earthquake and tsunami hazards long recognized
4. Hawaii faces major and varied seismic hazards

B Characterization failures
1. 1960 Hilo tsunami
2. 2011 tsunami
3. Adequate characterization, required to adequately evaluate seismic hazard and to assess whether the risk is acceptable

IV Some key characterization questions

A. What controls earthquake size?
B. What dictates ground response to seismic waves?
C. What controls buildings respond to seismic waves?
D. How can we predict when and where an earthquake is likely to occur?
E. What is the uncertainty associated with the predictions?