

# Tsunami Warning and Mitigation – Pacific Experience – using Samoa as a Case Study

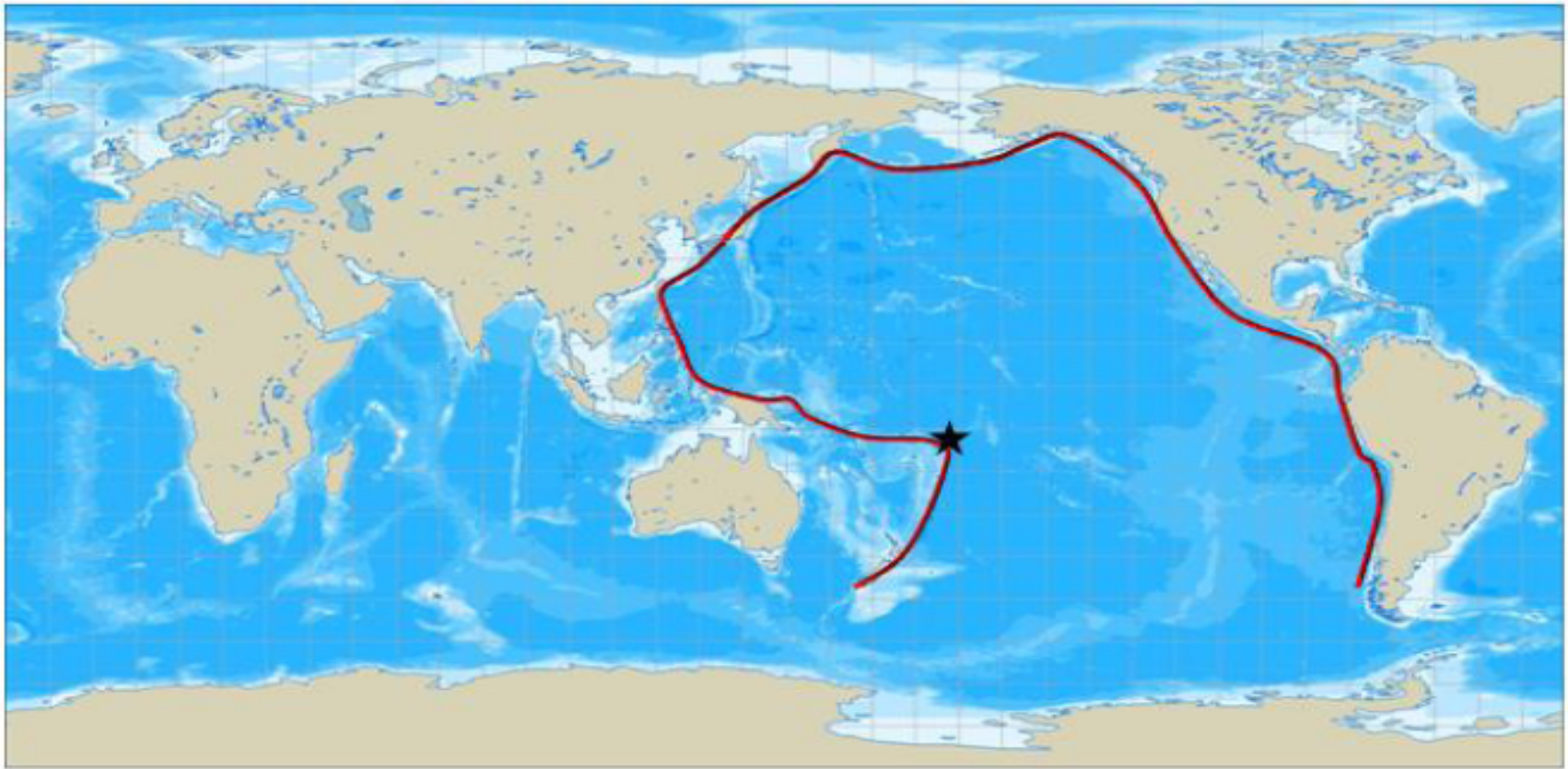
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# Outline

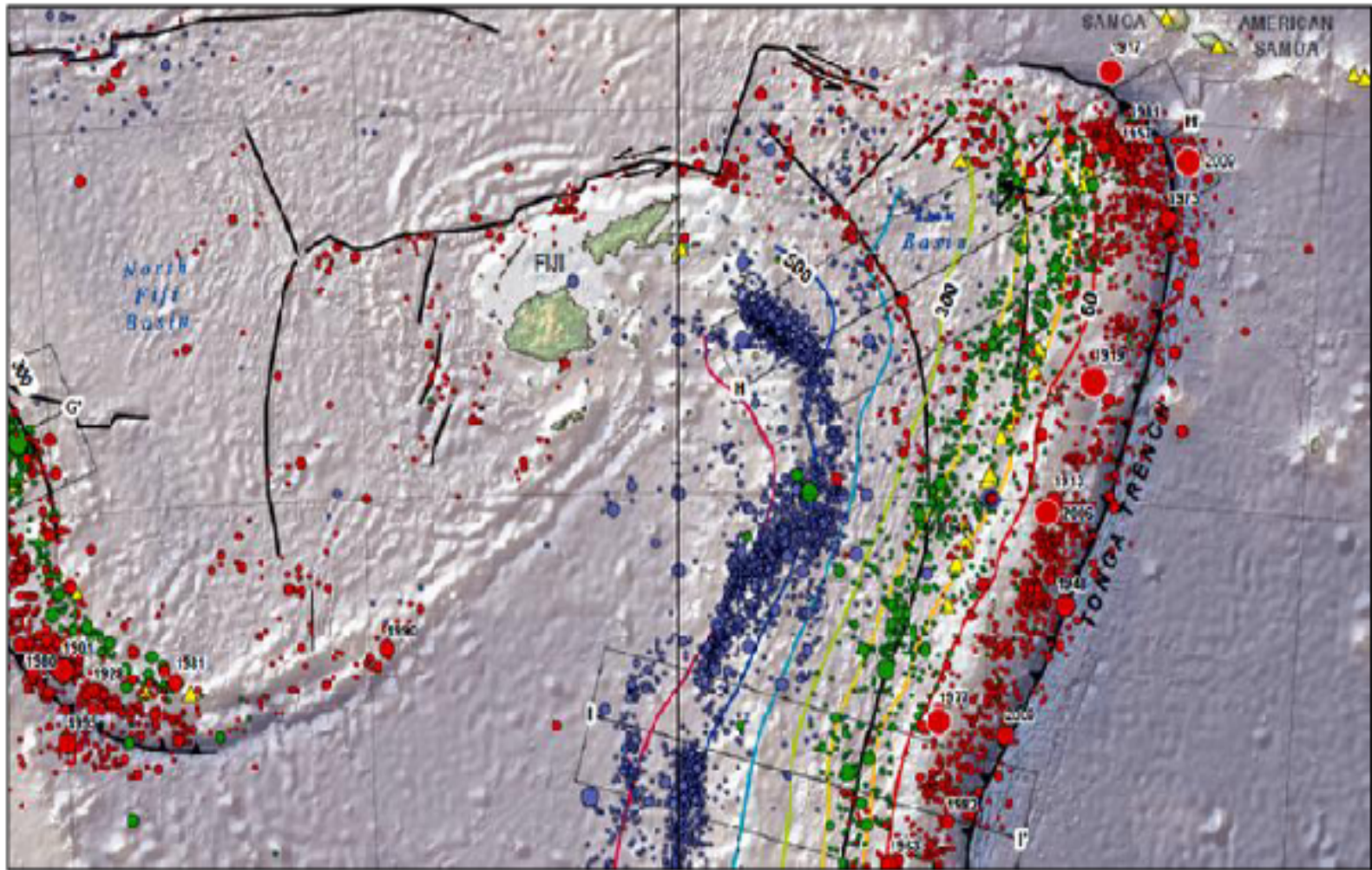
- Tsunamis that have occurred and affected Samoa
- Lessons learned
- Way forward

# Samoa's location relative to the Pacific Ring of Fire



**Figure 1: General location of the Samoan Islands (black star) relative to the Pacific Rim of Fire (red line).**

Source: Williams, S.P. (2014)



# Far-field tsunamis that have affected Samoa (Source: Williams, S.P., 2014)

- Far-field sources
  - 11 March 2011 – Great East Japan earthquake and tsunami – affected south east villages on the island of Upolu
  - 1960 – 9.5 earthquake in South Chile – affected east coast of Upolu Island
  - 1957 – 8.5 earthquake in Aleutian Island affected north coast of the Savaii and Upolu
  - 1952 (Nov) – Kamchatka tsunami – destroyed a school and some Samoan houses
  - 1946 – Aleutian Island tsunami – recession of water in the Apia harbor followed by 6 waves around 1.7m high inundated the area for about two hours
  - 1868 – Peru tsunami destroyed settlements in Apia (Pararas-Carayannis and Dong, 1980)



# Near-field tsunamis that have affected Samoa (Source: Williams, S.P, 2014)

- Sept 2009 – 8.0 earthquake generated a tsunami affected a number of Pacific Island countries including Samoa, American Samoa, Tonga, impacts were also seen in French Polynesia
- 1981 – Solov'ev et al. (1986) reported 1m wave associated with an earthquake at the Tongan Trench affected a village in the southern part of Savaii island
- 1917 – 8.5 earthquake in the Tongan Trench generated a tsunami, approximately 3m waves impacted 10minutes from time origin, affected villages in the east and south of Upolu and south of Savaii
- Mt. Matavanu eruption 1905-1911 – caused 7 local tsunamis – first one in Nov 1906, rest between June – Oct 1907, affected North of Savaii
- March 1883 – storm accompanied by an earthquake and tsunami – houses within a 1/4mile of the beach on the east end of Savaii were swept away over a distance of 24m along the shore suggesting a local tsunami influence, although source is unknown (Pararas-Carayannis and Dong, 1980)

# Prior to September 2009 tsunami

- Priority hazard – Tsunamis (based on preliminary risk assessment using AS/NZ Risk Standard)
- Focus:
  - developing a tsunami warning system
  - Evacuation
  - Public awareness around tsunami science and safety and evacuation procedures
  - National tsunami drills to test the warning system and procedures, and evacuation – 2 pilot tests, 1 x national drill in Nov 2007 and Nov 2008
- Seismic activities monitoring capability – 1 seismic station, 1 tide station

# Evacuation plan for greater Apia urban area – developed based on elevation above sea level





# 8.0 Earthquake and Tsunami, 29<sup>th</sup> September 2009 (29092009)

- Timeline of the event:
  - 6:48am – earthquake occurred
  - 6:55am - warning system activated
  - 7:02am – received warning from PTWC
  - 7:15am – received a call from Vavau village reporting the first wave
  - 7:30am – first wave observed at the location of Meteorology Division/National Tsunami Warning Centre office location
  - Between 8:30am – 9:00am – emergency services arrived in the affected areas to start identification of casualties, conduct search and rescue, and initial assessment of the impact

# The impact

- Affected population
  - about 18% of total population
  - Affected areas – southern and eastern coastal parts of the island
  - Number of deaths – 143
  - Number of injuries - >600
  - Villages/families affected 824 families in 51 villages
  - Psychological effect

# The impact

- Socio -economic:
  - Total cost of damage – SAT\$262.11 million (104.44USD\$) = 20% of Samoa's GDP
  - Roads in the affected severely damaged, cut off in some areas
  - Seawalls
  - Electricity and infrastructure severely damaged
  - Water supply and infrastructure severely damaged
  - Communication towers (mobile service) damaged but serviceable
  - Tourism – severely affected and

# The impact

- Natural Environment:
  - Coastal vegetation
  - Beach erosion
  - Coastal erosion
  - Existence of invasive species
  - Marine ecosystems
  - Debris





# Lessons learned/observations

- Detection, monitoring and warning capability
- Decision making on alert level to activate warning system – what tsunami bulletin to issue??
- Communication and coordination
  - On site coordination
  - NEOC
- Information management
  - Reporting was slow
  - Not well coordinated
- Limited staff
  - Manifested into fatigue
  - Work overload
- Limited specialized resources

# Positive feedback

- Pre-planning paid off
- Strengthened public, response agencies and community groups, international humanitarian organizations' awareness
- Provided opportunity to identify gaps and weaknesses within existing disaster management arrangements
- Provide more resources in disaster risk management sector
- Lift profile of Disaster Risk Management at all levels
- Strengthen partnerships at all levels

# Needs highlighted as a result of this tsunami

- Improve understanding tsunami risks (hazard, vulnerability and exposure)
- Improvements to earthquake detection and monitoring capability
- Improvements to warning dissemination and procedures
- Public awareness with emphasis on natural warning signs
- Simulations to test procedures and plans



# Programs implemented to address needs highlighted

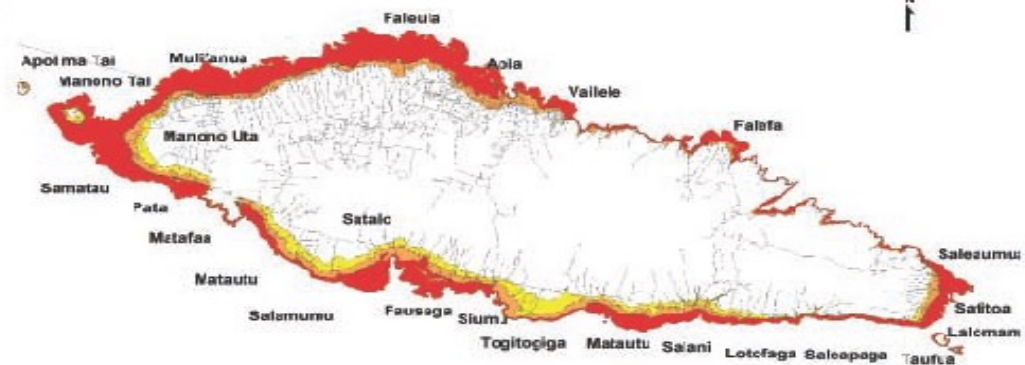
- Establishment of seismic network increasing monitoring and detection stations to six – funded and supported by the Government of China through the China Earthquakes Network Centre
- Establishment of national seismic data centre responsible for monitoring, data analysis and warning products that now operates on 24/7 basis – funded through national budget
- Tsunami inundation modeling and mapping and tsunami signage – supported and funded by the Government of New Zealand through GNS Science
- Emphasis on integration of tsunami hazard into wider community-based disaster management program – attached a number of financial support from various donors and development partners
- Improvement to warning dissemination – In-house SMS capability, and establishment of emergency siren network
- Warning Standard Operating Procedures review and revision



# Tsunami inundation modeling and mapping



SAMOA TSUNAMI HAZARD ZONES MAP



**Red** – highest level of threat, people within the red zone needs to evacuate as soon as warning is issued despite the tsunami source, that is whether it is generated from a local earthquake or distant source, like in Japan, Chile.

**Orange** - this zone is expected to be affected by either local source tsunami or tsunamis that are caused by local earthquakes i.e. Tongan Trench and also by some very big distant tsunamis similar to Japan.

**Yellow** - this is expected to be potentially affected or inundated due to a local tsunami based on modeling and mapping completed for whole coast of Samoa, establishing a yellow zone in the North part of Samoa is not necessary.

**Safe Zone** – zone outside of the Red, Orange and Yellow zones showed on the maps.

## Tsunami Hazard Zones:

- Yellow
- Orange
- Red







Thank you