



Understanding and lessons learned from the tsunami generated by the Hunga Tonga-Hunga Ha'apai volcano eruption on 15 January 2022 for development of Tsunami Warning and Mitigation System for tsunamis generated by volcanoes and other non-seismic sources  
8th Joint ICG/PTWS– IUGG/JTC Technical Workshop in assoc with ICG/PTWS sessions  
11 September 2023, Nuku'alofa, Tonga

## Session 4: Panel Discussion

# How can we predict and mitigate for tsunami generated by volcanoes?

Dr. Laura Kong  
Director, ITIC



UNESCO/IOC-NOAA SHOA  
International Tsunami Information Center



# Stories and Lessons from the Tonga Volcano - Tsunami

## Unexpected Events - Importance of Community Awareness and Preparedness



5:47 pm TOT, Nuku'alofa, Tonga

Dr. Laura Kong  
Director  
International Tsunami Information Center



Tanaki'anga o e nau nau 'a e kolo ki  
he Tokelau Hihake o Ano Ieka

Ha'apai, Tonga  
(TGS)



# The Event: Hunga-Tonga Hunga-Ha'apai (HTHH) Volcanic Eruption and Tsunami

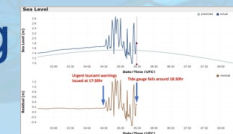
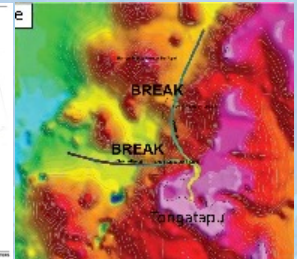
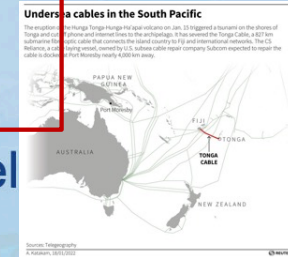
## Observations, Early Warning System

- 0412-0421 UTC – Natural warnings... Ash Cloud, Loud blasts, Lightning, Shock wave / ground shaking, Sea birds
  - 0430 UTC – Urgent Tsunami Warning / Evacuation – Radio Tonga Phone lines choked, No time for normal SOP (Coord calls, messages ...)
  - 0530 UTC – Undersea telecom cable cut – no sea level data, no outside comms, except by satellite phone
  - 1248 UTC 16 January – Downgraded to Marine Warning
  - 2100 UTC 17 Jan (North) / 0100 UTC 18 Jan (South) – Cancelled
- Because of well-functioning EWS and successful PREPAREDNESS (National Tsunami Drill, school outreach, World Tsunami Awareness Day, Nov 5), only 4 died.**

**Tsunami Warning for Tonga**  
 No: 01  
 Issued at 5:45pm on 15 January 2022  
 A volcanic eruption has occurred with these

Origin time: -  
 Coordinates: Lat: 20.54 Lon: 175.38W  
 Depth: 0km  
 Magnitude: NIL

The above magnitude is provisional and may be increased or decreased.  
**Tsunami Warning**  
 (Only Warnings issued by the Tonga Meteorological Service represent a Tsunami Warning)  
 THIS IS THE NATIONAL TSUNAMI WARNING



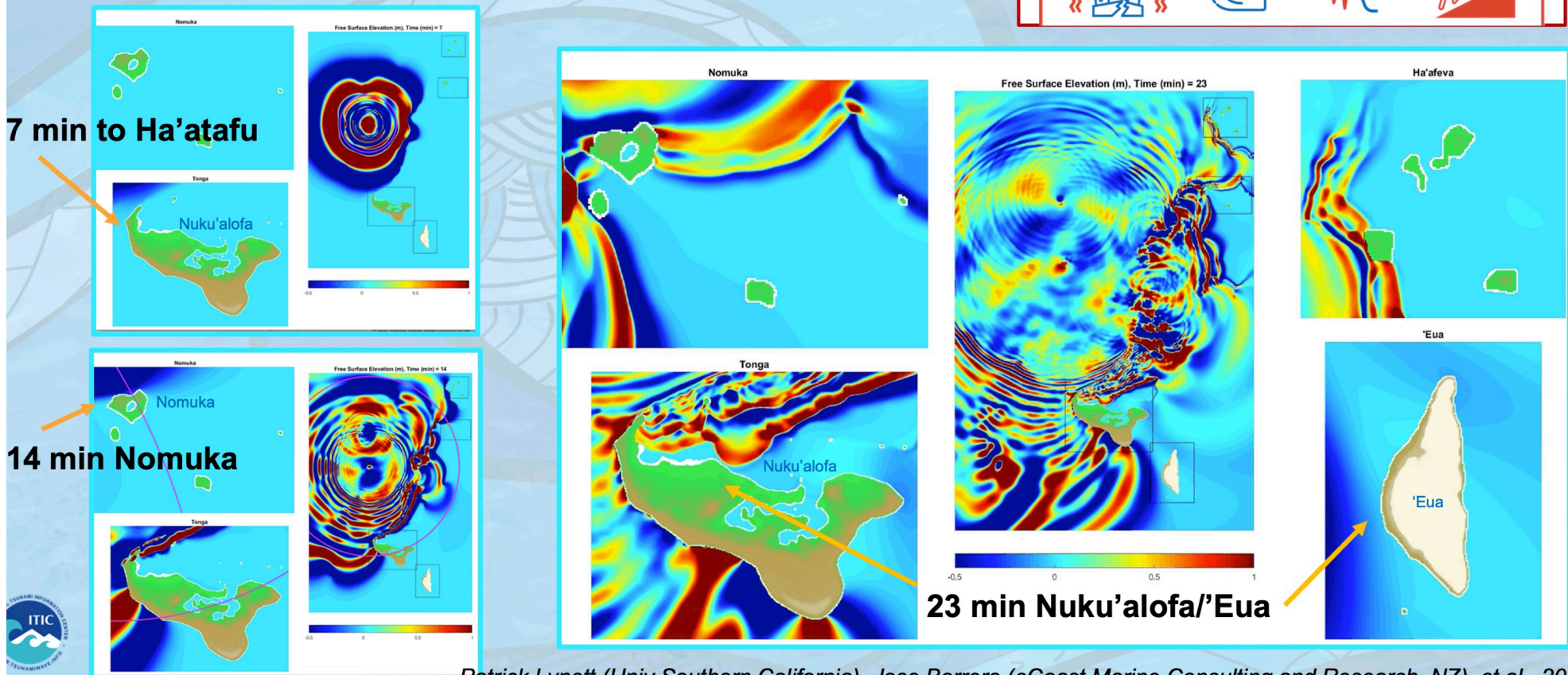
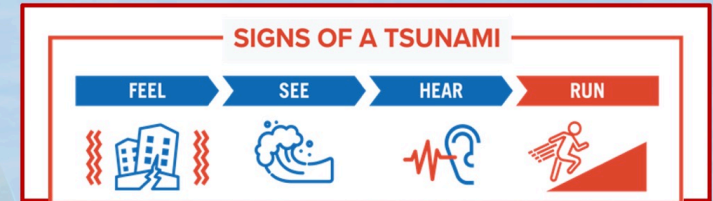
**EVACUATION MAP**

NOAAHI FAKA'ONGA FAKA NATULA 'OE PEAU KULA  
 AAKE FAKAFOKIFA TAHI  
 FAKA'ONGA FAKA NATULA 'OE PEAU KULA



# HTHH - LOCAL TSUNAMI => Act on Natural Warnings

- SEE ash cloud. HEAR loud Explosions. FEEL ground shaking.
- SEE unusual ocean (swirling eddies, fast draining), Birds flying



Patrick Lynett (Univ Southern California), Jose Borrero (eCoast Marine Consulting and Research, NZ), et al., 2022



# Public must be Educated Before They need to know – for warnings:

## □ How will the warnings be issued

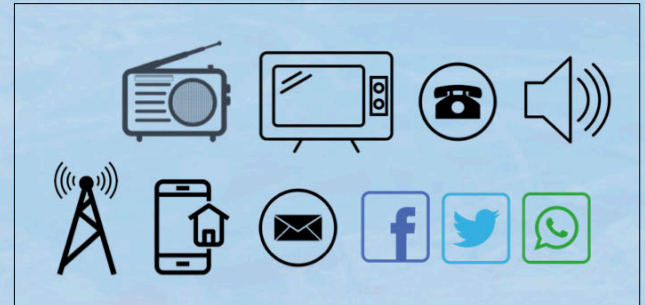
What communication systems/media used to issue warnings

For local tsunami, self-evacuate

## □ Who will issue warnings (official sources)

## □ When will the warnings be issued

## □ What will the warning messages say



Tsunami Advisories/ Warning - Tonga Meteorological Services 1/22/22, 10:38 AM

**Tonga Meteorological Service**  
Ministry of MEIDECC, Government of Tonga  
"Providing meteorological and maritime radio services in support of economic development, safety and security"

Kaniselili 'o e Fakatokanga Peau Kula ki he ngaahi matāfanga 'o e 'otu Mu'omu'a 'i Ha'apai (Nomuka, Mango, Fonoifua), 'Atataa, 'Eueiki, Tongatapu mo 'Eua.  
Fika: 02  
Taimi tuku atu: 10:00am 'aho 15 Sanuali 2022  
Ne mapuna ha mo'unga afi pea ko hono fua eni:  
Taimi ne hoko ai: -

Latitude: 20.54 faka-Tonga, Longitude: 175.00

Feitu'u: Hunga-Tonga Hunga-Ha'apai

**Kaniselili 'o e Fakatokanga Peau Kula ki Ha'apai (Nomuka, Mango, Fonoifua), 'Atataa, 'Eueiki, Tongatapu mo 'Eua.**

(Ko e Fakatokanga kotoa pe 'oku tuku totonu ia 'o e Fakatokanga ki Tonga)

Oku kaniselili atu heni 'a e fakatokanga Mu'omu'a 'i Ha'apai (Nomuka, Mango, Fonoifua), 'Atataa, 'Eueiki, Tongatapu mo 'Eua.

Fakatatau ki he ngaahi lipooti kuo ma' mahino mai 'a e holo e ma'olunga 'o e ma'olunga 'o e Fakatokanga ki Tonga.

Koia he ngaahi lipooti kuo ma' mahino mai 'a e holo e ma'olunga 'o e ma'olunga 'o e Fakatokanga ki Tonga.

Atataa, 'Eueiki, Tongatapu mo 'Eua.

**14 January eruption**  
**1000 TOT: Marine Warning cancelled**

(Only Warnings issued by the Tonga Meteorological Service represent warning status for Tonga)

The tsunami marine warning previously enforced for the 'otu Mu'omu'a (Nomuka, Mango, Fonoifua), 'Atataa, 'Eueiki, Tongatapu mo 'Eua coasts and waters are now CANCELLED.

Based on the observation data recorded from the tide gauge at Nuku indicated that the state of the sea level is back to normal. The fluctuation in sea level recorded in the tide gauge at Nuku'alofa was below 10cm in 24 hours.

Therefore, the tsunami marine warning previously enforced for the 'otu Mu'omu'a (Nomuka, Mango, Fonoifua), 'Atataa, 'Eueiki, Tongatapu mo 'Eua coasts and waters are now CANCELLED.

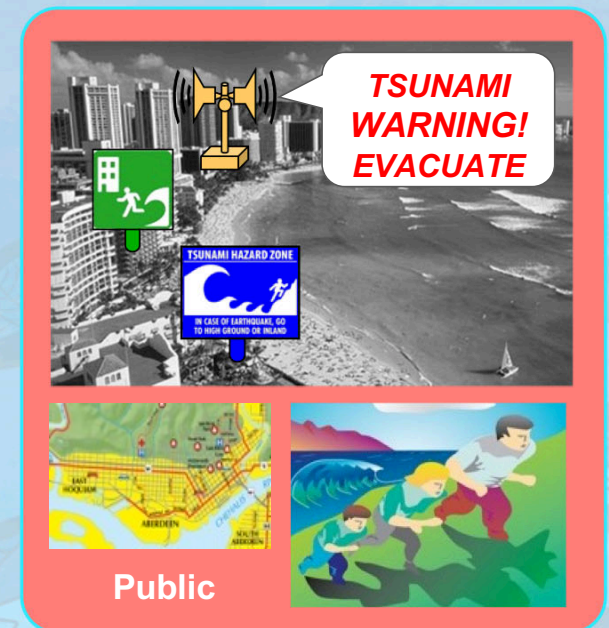
<http://met.gov.tu/tsunami-advisories-warning/>



# Public must be Educated Before.

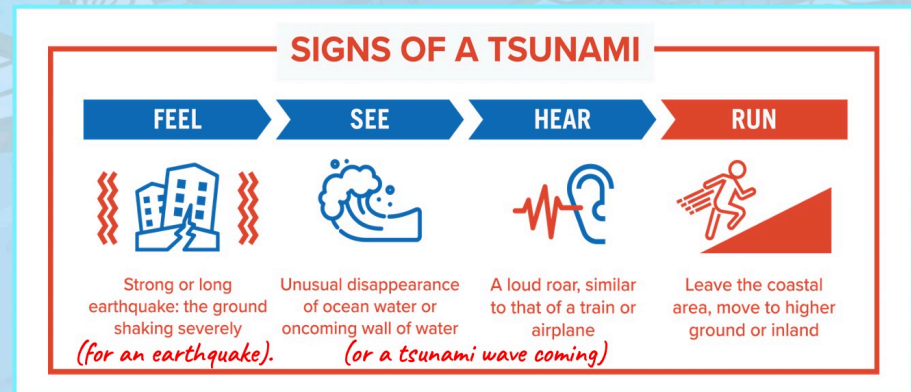
## They need to know – for evacuation:

- ❑ **Official sources** of tsunami information
- ❑ **Evacuation maps & routes**
- ❑ **Local / Distant tsu response differences**
- ❑ **Local tsunami - Natural Warning signs**
- ❑ **Warning systems** for their own community
- ❑ **What sirens sound like** (verbal msg, test)
- ❑ **How to respond** to siren sounding
- ❑ **Community support network / orgs**



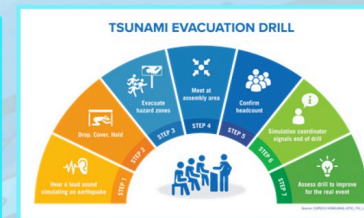
# Summary - The Issues - Tonga

- *Not an earthquake!* Warning for 'unfamiliar' event: →→ 'Detect', then Warn
- *Remember Past!* - Day before, small eruption, small waves, sulfur smell next day
- **AS IT HAPPENS - SEE, HEAR, FEEL →→ ACT**
  - **SEE** the steam/ash cloud/lightning. **HEAR** the loud Explosion.  
**FEEL** ground shaking.  
"everyone knew something going to happen since never happened before"
  - **AS IT ARRIVES, SEE**
    - *Unusual ocean -*  
*Witness fast draining*  
*Swirling water eddies*
    - *Animals disturbed*  
*Birds flying, Ash falling*



# Lessons Learnt - Communities

- Noting historically, earthquakes generate 87% of tsunami  
Prepare for earthquakes, but be aware of other 13%
- For local (close by) and distant, **GET TSUNAMI READY!**
- **Communities:** Know ETA (time to reach) fr ALL sources  
Must Plan Ahead & Practice. Natural Warnings!  
**YOU must act yourself - your personal action / responsibility**
- **Communications:** Must Reliable, Robust, Redundant, Realistic (4Rs)  
Broadcast. Simple. Reach all (low and high-tech)







# EQ Tsunami

# End-to-End Tsunami Warning

TWC - Science

Intl / Natl

### Country Alert System

### Emergency Alert System & Mass Media

DMO / EMA – Safety

Natl / Prov / Local Govt

Public

Community

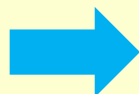
EQ  
T=0

Race against Time

WAVE  
T=20 min

## 3Rs, 1T Required for Tsunami Any Warning

- ❑ **Robust** - capable of **performing without failure under wide range of conditions**
- ❑ **Reliable** – giving the **same result on successive trials, dependable.** perform and maintain functions in routine circumstances, as well as hostile or unexpected circumstances
- ❑ **Redundant** - serving as **duplicate for preventing failure of an entire system** upon failure of single component. duplication of critical components or functions
- ❑ **Tested regularly** – so that system works during real events



**EASY TO SAY – HARD TO DO**

## Warning Communications Are:

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- ❑ **Focused** on the people at risk
- ❑ **Ubiquitous** - same message everywhere
- ❑ **Reaches all** people irrespective of what they are doing & where they are
- ❑ **Easy** to access and use
- ❑ **Do not create added risk**
- ❑ **Reliable**
- ❑ **Issued with** appropriate **lead time**
- ❑ **Authenticated**, authoritative



# Maui wildfires – high winds, dry brush => fast-spreading

- ❑ At least 2 source fires in Lahaina - 115 confirmed, ~400 missing officially
- ❑ ~\$5 billion in damage – infrastructure/lifelines (power, roads, comms), livelihoods (jobs, schools, social and mental strain and fatigue)

TOP NEWS

## Maui County raises death toll to 55

By Star-Advertiser Staff · Aug. 10, 2023

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CINDY ELLEN RUSSELL / CRUSSELL@STARADVERTISER.COM

People pick through the rubble along Honoapiilani Highway today.

## Lahaina residents had little warning before wildfires overtook town

By Claire Rush, Ty O'Neil, Jennifer Sinco Kelleher and Rebecca Boone / Associated Press · Aug. 11, 2023

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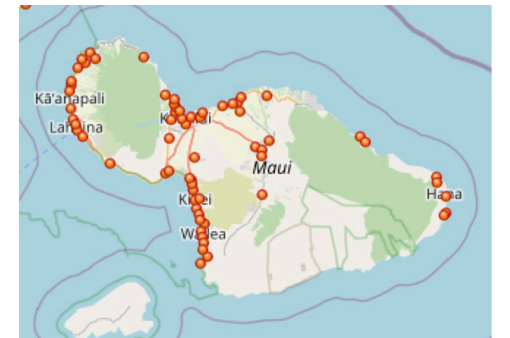
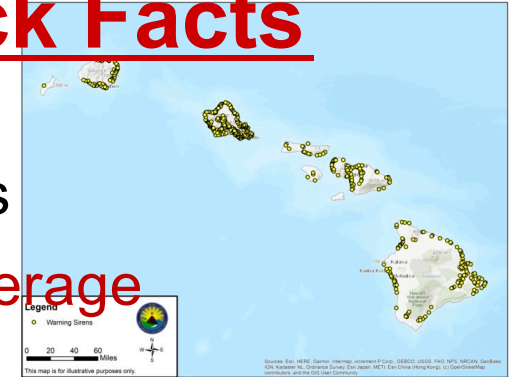


ASSOCIATED PRESS

Wildfire wreckage is shown, Thursday, in Lahaina. The search of the wildfire wreckage on Maui, Thursday, revealed a wasteland of burned-out homes and obliterated communities as firefighters battled the stubborn blaze making it the deadliest in the U.S. in recent years.

# Alerting - Maui Siren System – Quick Facts

- ❑ Statewide for decades. Tested monthly.  
All-hazard system - natural & human-caused events
- ❑ ~500 statewide, **Tone, 80-90% work, not 100% coverage**
- ❑ 121 decibels. Manufacture **radius 3400 ft (~1km)**.  
Battery w / photovoltaic charging system.
- ❑ Emergency Alert System (EAS – radio TV ) /  
Wireless Emerg Alerts (WEA – mobile text)



## Public – what to do

- ❑ **When siren tone heard, tune into local Radio/TV/Cable stations for emerg info and instructions by official authorities.**
- ❑ **If in low laying area near coast, evacuate to high ground, inland, or vertically to 4th floor / higher of concrete building.**

# Importance of Communications in Early Warning

HAWAII NEWS

## Deficiencies abound with Hawaii's disaster warning sirens

By Andrew Gomes · Sept. 5, 2023



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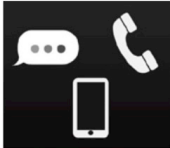
One of four emergency warning sirens in Lahaina is shown still standing amid the charred ruins of the historic seaside town on Maui at the corner of Papalaua Street and Honoapiilani Highway.

## Evacuation alert shows limits of cellphone warning system

By New York Times · Sept. 4, 2023



MAKA'ALA



NEW YORK TIMES / AUG. 11

Many people most in need of the Aug. 8 emergency alert said the message never reached their phones. Charred vehicles sit on a Lahaina road.



UNESCO/IOC-NOAA SHOA  
International Tsunami Information Center



**Thank you!**  
**Malo 'aupito!**

Dr. Laura Kong  
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