

Caribbean Tsunami Warning System

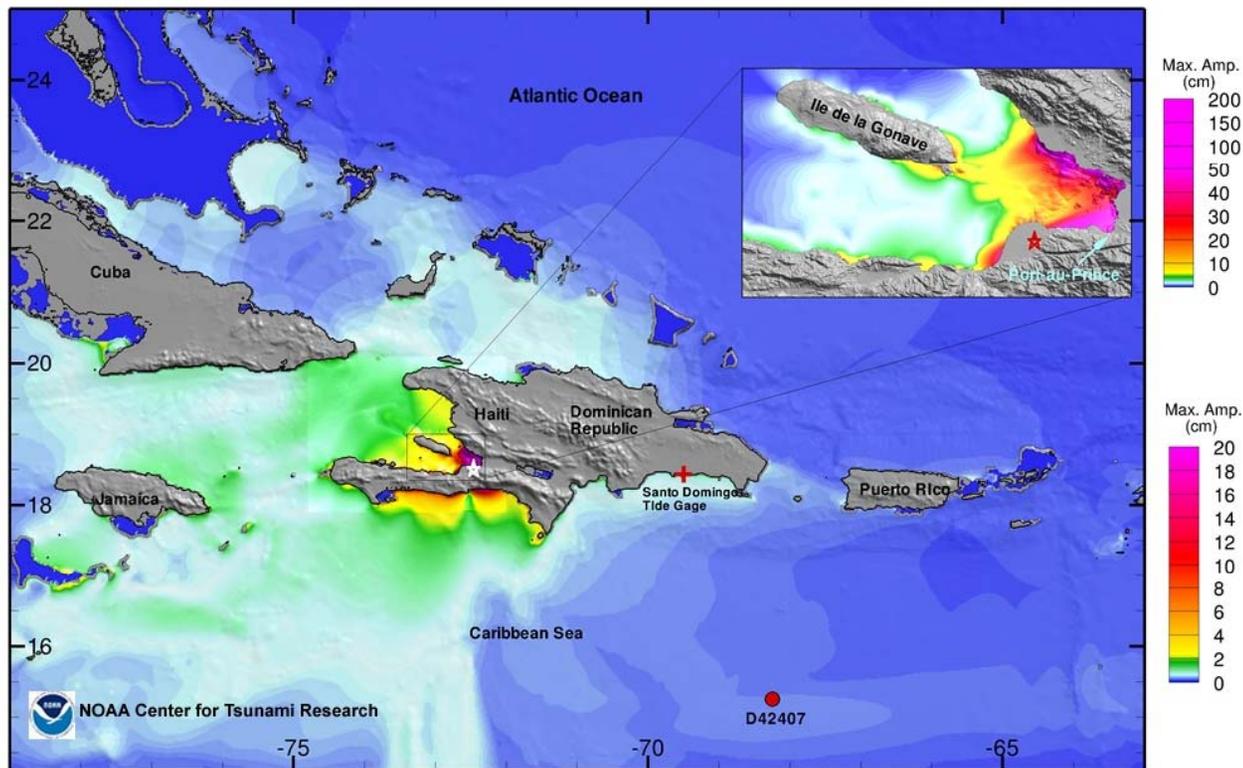
USVI Tsunami Workshop
St. Croix (July 21, 2010)
St. Thomas (July 23, 2010)



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NOAA Caribbean Tsunami Warning Program
c/o Puerto Rico Seismic Network
Dept. of Geology, UPR-Mayagüez

Haiti Earthquake and Tsunami

January 12, 2010, Mw 7.0, > 200,000 victims (EQ)



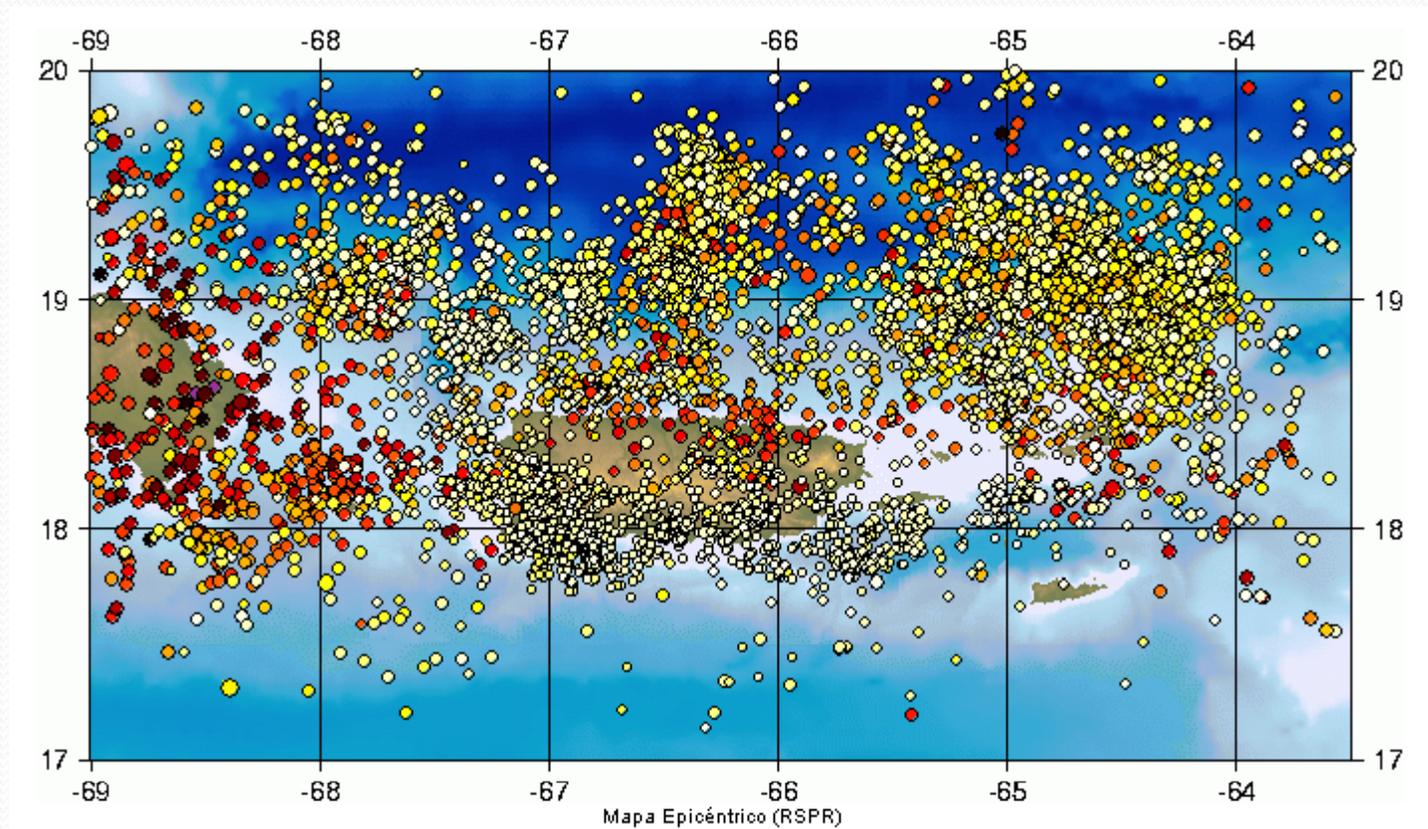
The tsunami took the lives of at least seven villagers in the town of Petit Paradis, on Haiti's western coast.

Indication of tsunami runup in Jacmel, southern coast of Haiti

Chile Earthquake (M 8.8) and Tsunami, Feb. 27, 2010

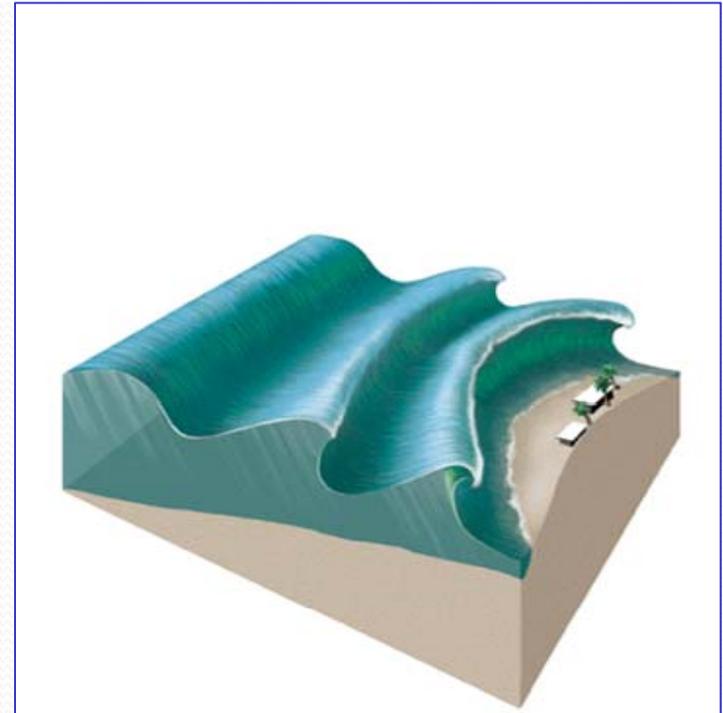
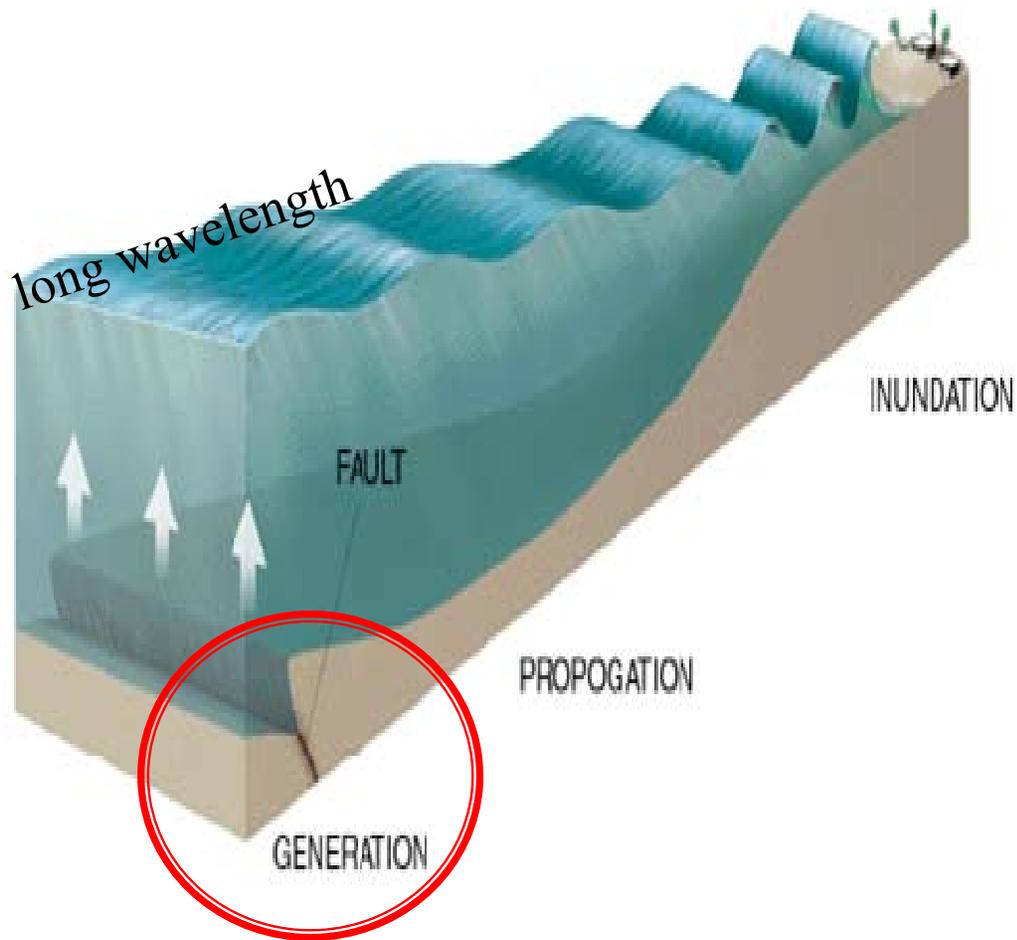


Seismicity 2006-2009



7513 earthquakes

Tsunami (soo-nah-mee)



Usually caused by an earthquake, but can also be generated by a submarine or subareal landslide or volcanic eruption or impact from space,

Why a Tsunami is a Hazard

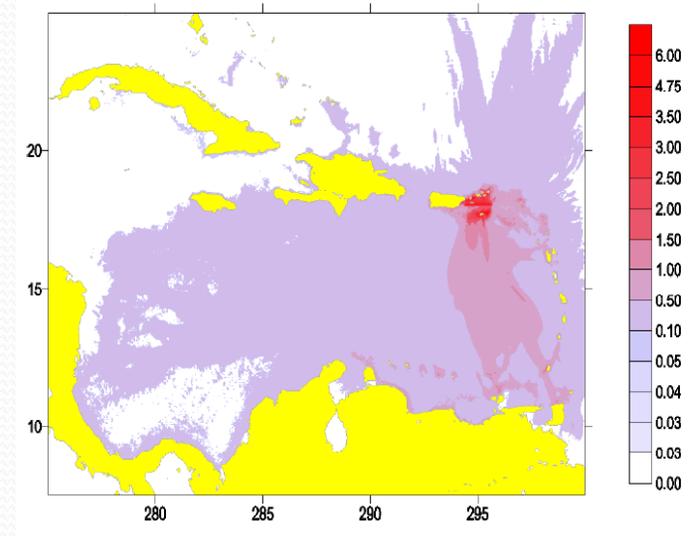
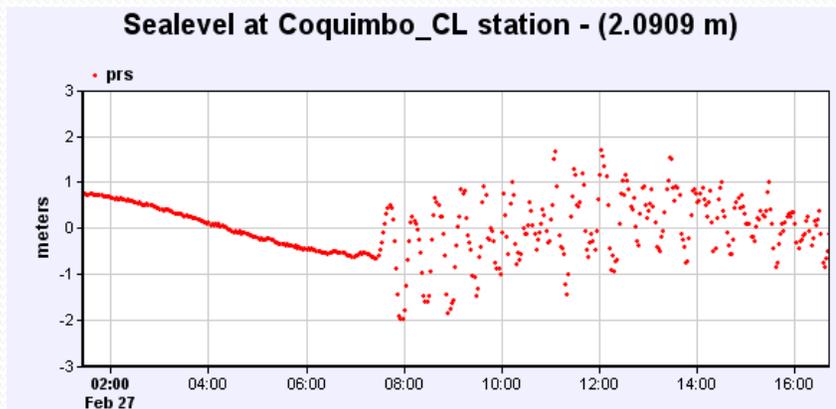
- **WAVE HEIGHTS GROW IN SHALLOW WATER**
 - **Best Case: Quickly Rising Tide**
 - **Worst Case: Wall of water with rocks and debris**
 - **High fatality hazard**
 - **Runups > 30 m , USVI more likely up to 10 m**
 - **Wrap around islands**

*April 1, 1946
Aleutian Islands
earthquake Hilo, Hawaii*



Why a Tsunami is a Hazard?

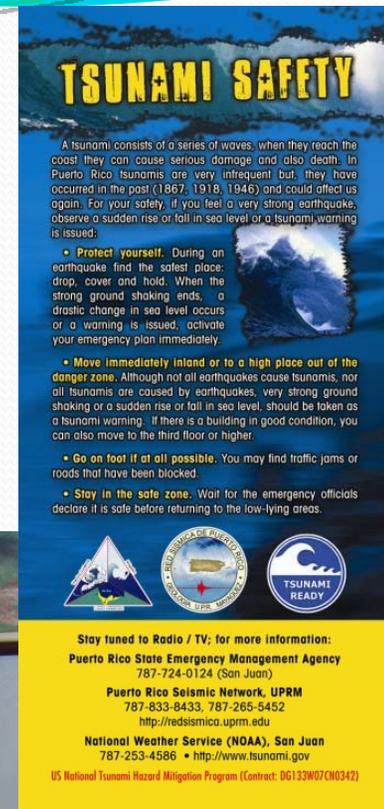
- **DANGER CONTINUES FOR MANY HOURS**
- **NOT NECESSARILY WILL THE WATER FIRST RECEDE**
- **GLOBAL IMPACT blind to political boundaries**



1867 Tsunami Amplitudes Zahibo, et. al, 2003.

An **EFFECTIVE** system means:

All persons (residents and visitors) in vulnerable coastal communities are prepared to respond appropriately, and in a timely manner upon recognition or notification that a potentially destructive tsunami may be approaching.



TSUNAMI SAFETY

A tsunami consists of a series of waves, when they reach the coast they can cause serious damage and also death. In Puerto Rico tsunamis are very infrequent but they have occurred in the past (1867, 1918, 1946) and could affect us again. For your safety, if you feel a very strong earthquake, observe a sudden rise or fall in sea level or a tsunami warning is issued:

- **Protect yourself.** During an earthquake find the safest place: drop, cover and hold. When the strong ground shaking ends, a drastic change in sea level occurs or a warning is issued, activate your emergency plan immediately.
- **Move immediately inland or to a high place out of the danger zone.** Although not all earthquakes cause tsunamis, nor all tsunamis are caused by earthquakes, very strong ground shaking or a sudden rise or fall in sea level, should be taken as a tsunami warning. If there is a building in good condition, you can also move to the third floor or higher.
- **Go on foot if at all possible.** You may find traffic jams or roads that have been blocked.
- **Stay in the safe zone.** Wait for the emergency officials declare it is safe before returning to the low-lying areas.

Stay tuned to Radio / TV; for more information:
Puerto Rico State Emergency Management Agency
787-724-0124 (San Juan)

Puerto Rico Seismic Network, UPRM
787-833-8433, 787-265-5452
<http://redsisimica.uprm.edu>

National Weather Service (NOAA), San Juan
787-253-4586 • <http://www.tsunami.gov>

US National Tsunami Hazard Mitigation Program (Contract: DG133W07CN0342)



Intergovernmental Coordinating Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG-C)

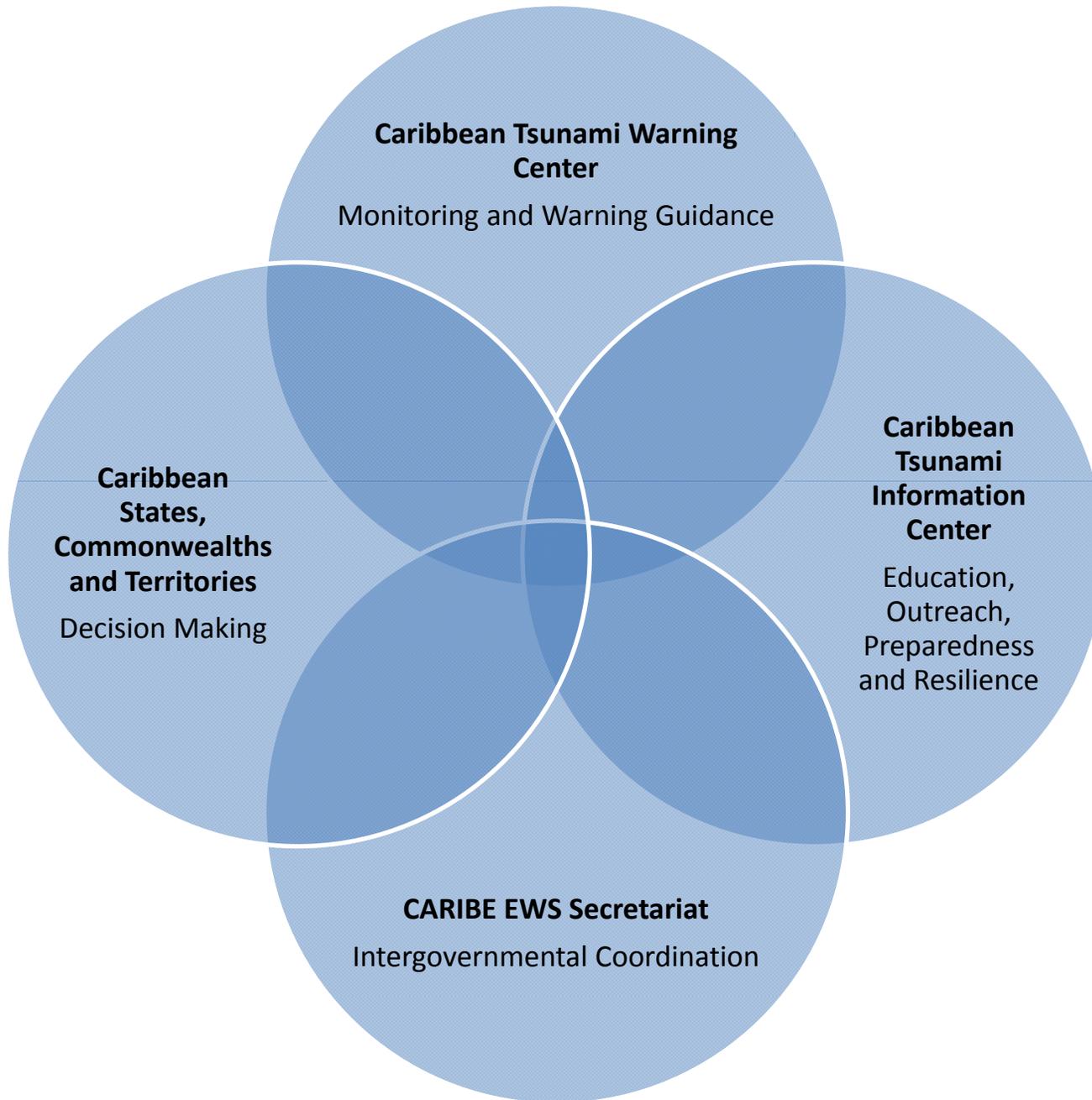
- UNESCO/IOC body
- 28 member states, commonwealths, territories-USVI and PR are part of the US Delegation
- Established in 2005
- Sessions held in 2006, 2007, 2008, 2009 and 2010



Main Components of CARIBE EWS

Per recommendation of the Member States

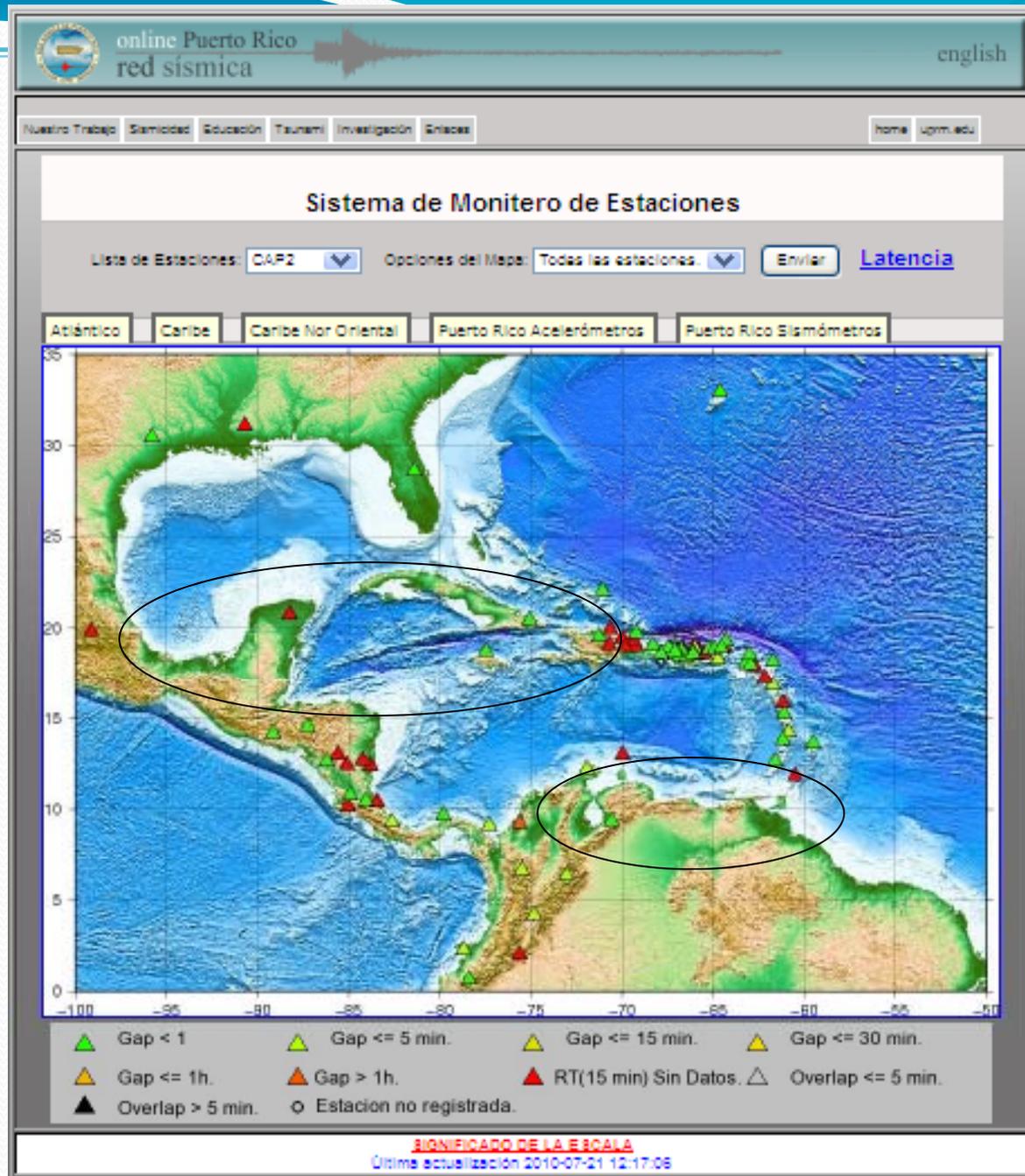
- Working Groups:
 - Monitoring and Tsunami Warning Guidance
 - Tsunami Hazard, Risk and Vulnerability Assessments
 - Communications
 - Preparedness, Readiness and Resilience
- Permanent Bodies
 - Caribbean Tsunami Warning Center-CTWP potential first step
 - Caribbean Tsunami Information Center – to be established in Barbados with funding by the Govt. of Italy
 - Secretariat-Interim location in Paris, France at UNESCO HQ



Monitoring and Warning Guidance

CARIBE EWS

Seismic Data Availability in the Caribbean



Sea Level Data Availability in the Caribbean



SEA LEVEL STATION MONITORING FACILITY

- Intro
- Map
- Stations
- Database
- Metadata

Sealevel stations

Status at 2010-07-21 12:07 GMT



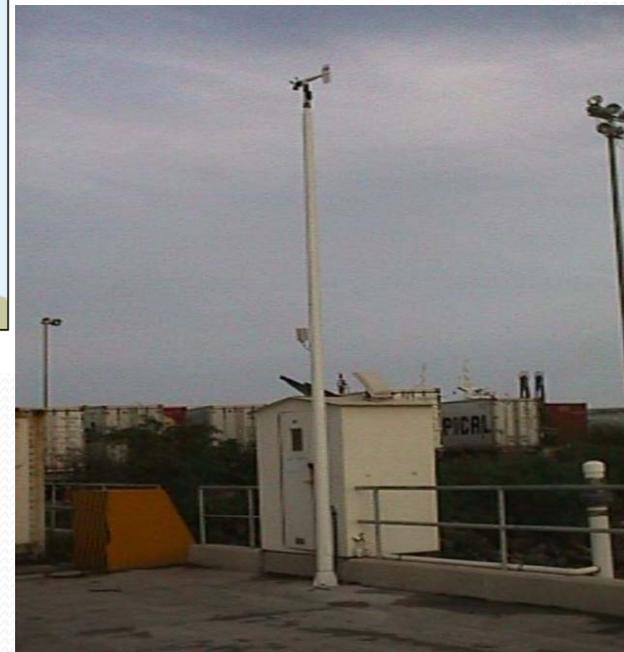
Lat: 19.8 Lon: -84.07



Type

Legend:

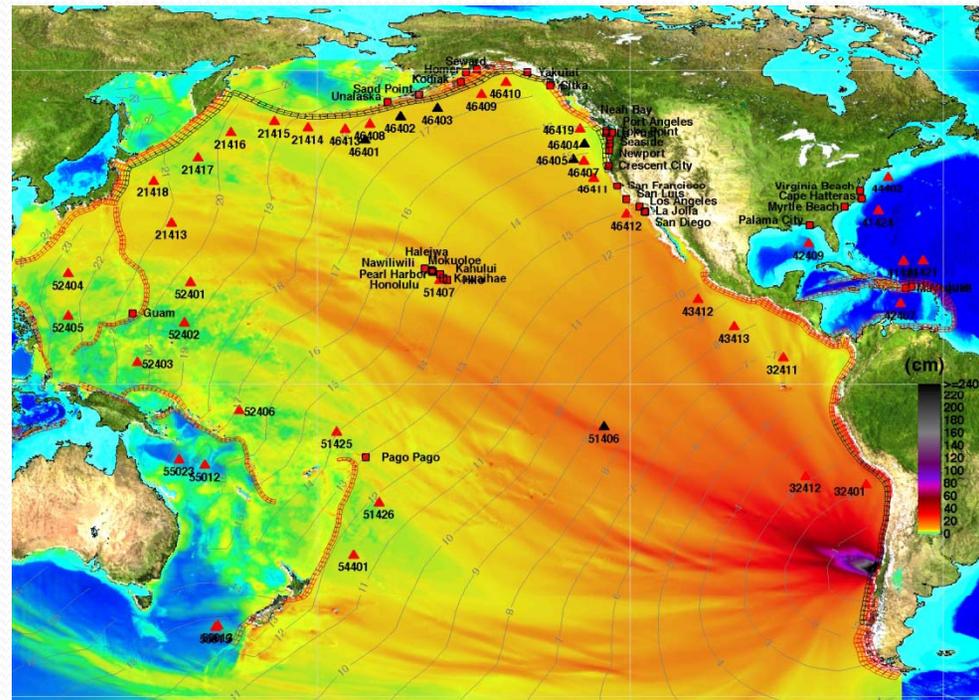
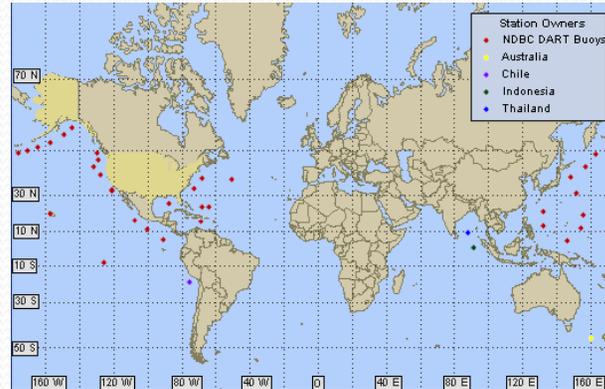
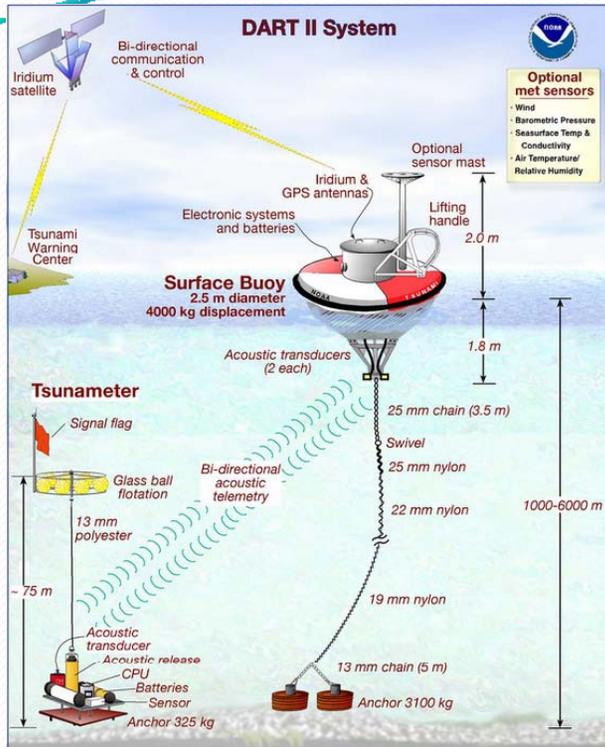
- Station is offline, or data is outdated
- Station is online
- Station is not available at this site



Lime Tree Sea Level Station, St. Croix

DART

Buoys- Tsunami Detection and Forecasting



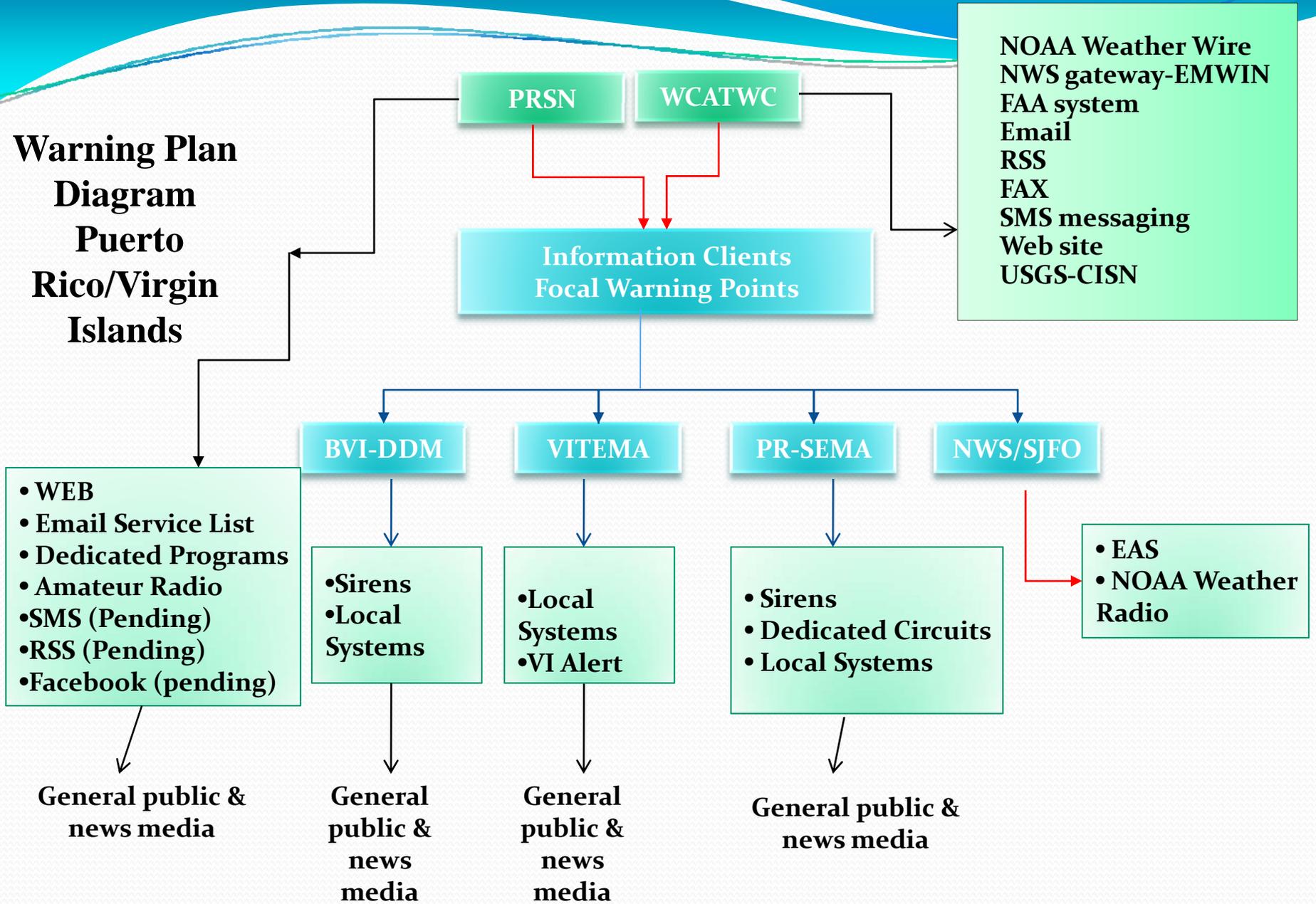
NOAA PMEL Tsunami Forecast Model for Chile 2010 Tsunami



Current Tsunami Warning Service Providers

- West Coast and Alaska Tsunami Warning Center
 - Provides Interim Warning Service to Puerto Rico and the USVI
 - Backup to the PTWC
- Puerto Rico Seismic Network
 - Provides 24 x 7 earthquake and tsunami warning service to Puerto Rico and the USVI and BVI
- Pacific Tsunami Warning Center
 - Provides Interim Tsunami Warning Guidance Service to the non US Caribbean and adjacent regions
- Caribbean Tsunami Warning Center (in proposed phase)

**Warning Plan
Diagram
Puerto
Rico/Virgin
Islands**





- Danger!
- Run for High Ground!
- Follow Emergency Instructions.

W A R N I N G

A D V I S O R Y

- Possible Strong and Dangerous local Currents.
- Stay tuned for local Emergency guidance.



- Potential Danger.
- Stayed tuned for more information.



W A T C H



- Relax.
- No Danger.
- A distant ocean basin may be in danger.

**I N F O R M A T I O N
S T A T E M E N T**

WEST COAST & ALASKA TSUNAMI WARNING CENTER



Red Sísmica de Puerto Rico

<http://redsismica.uprm.edu> Teléfono: 787-833-8433

Centro de Alerta de Tsunami de la Costa Oeste & Alaska

<http://wcatwc.arh.noaa.gov>

4 Niveles de Mensajería de Tsunami



- ¡Peligro!
- ¡Corra a tierras altas!
- Siga las instrucciones de emergencia.

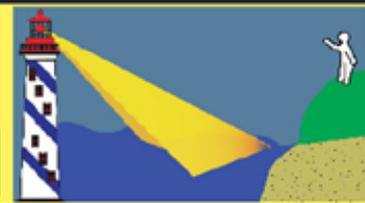
Aviso

Advertencia

- Posibles corrientes locales fuertes y peligrosas.
- Manténgase escuchando las instrucciones locales de emergencia.



- Peligro potencial.
- Permanezca alerta para mas información.



Vigilancia

- Permanezca tranquilo.
- No hay peligro.
- Una cuenca oceánica distante puede estar en riesgo.

**Declaración de
Información**



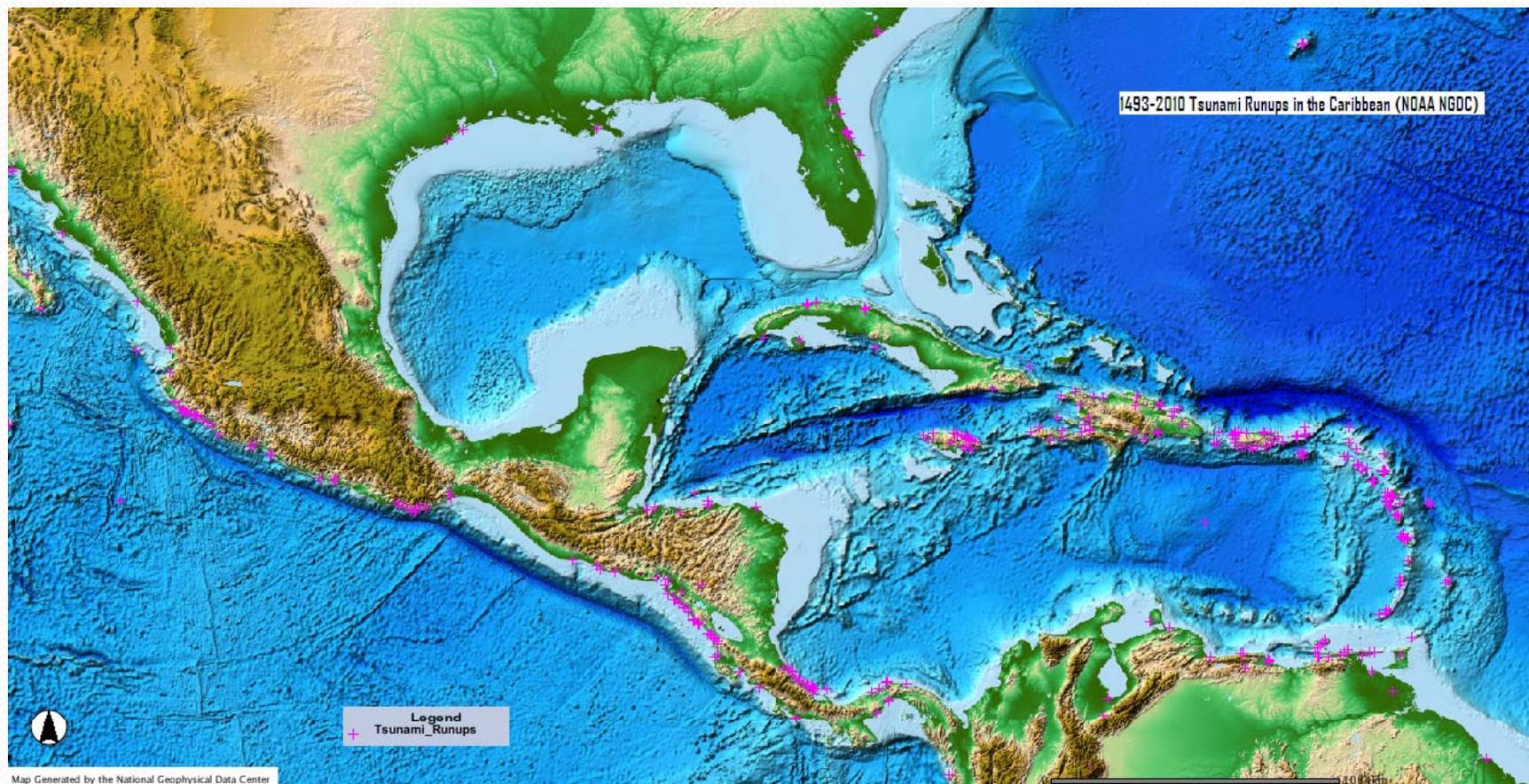
WEST COAST & ALASKA TSUNAMI WARNING CENTER



Hazard, Risk and Vulnerability Assessments

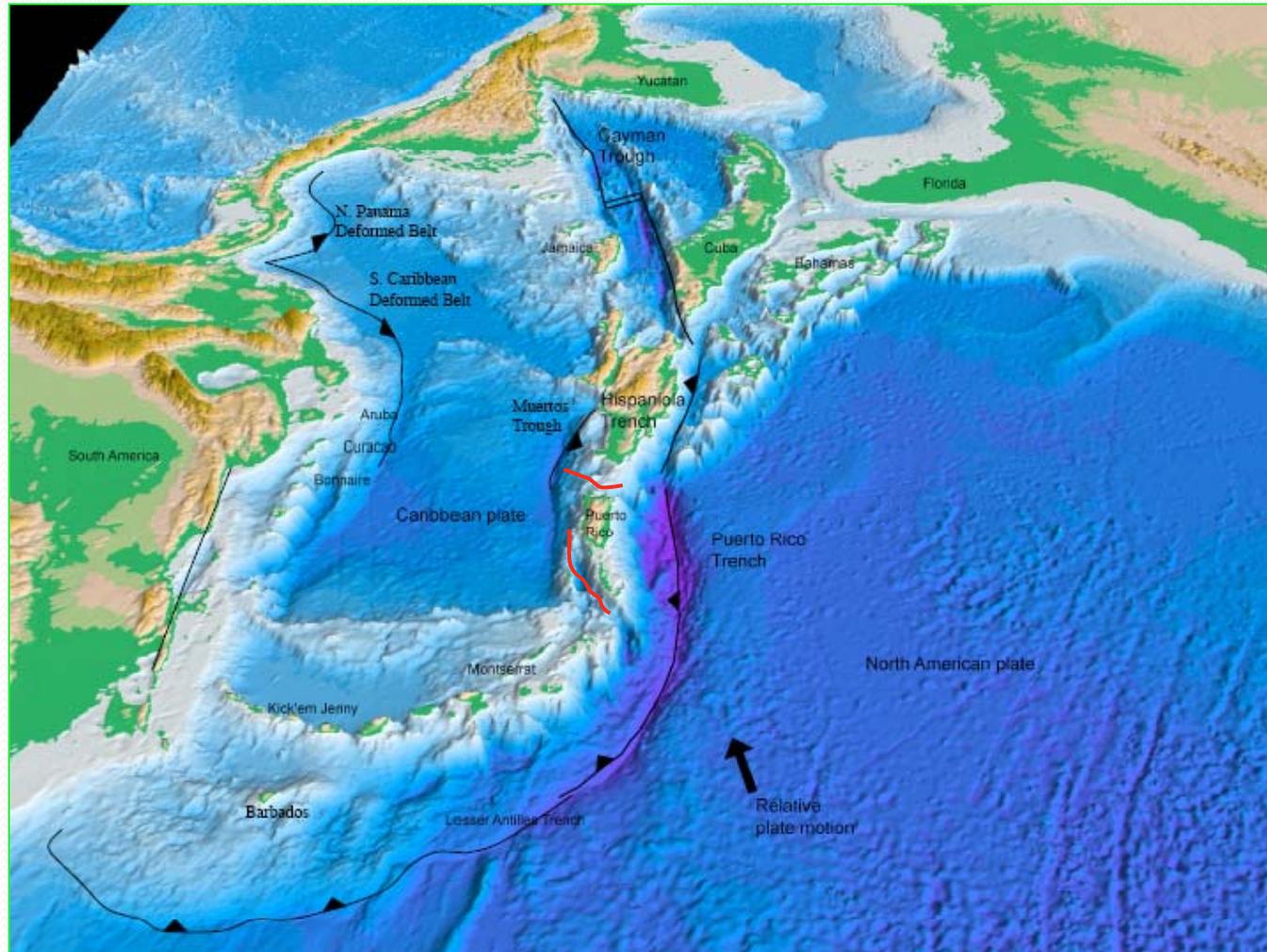
CARIBE EWS

1493-2010 Tsunami Runups in the Caribbean



Map of tsunami runups in the Caribbean 1493-2010 (National Geophysical Data Center, <http://www.ngdc.noaa.gov/hazards/tsu.shtml>)

Principal Earthquake, Landslide and Tsunami Sources

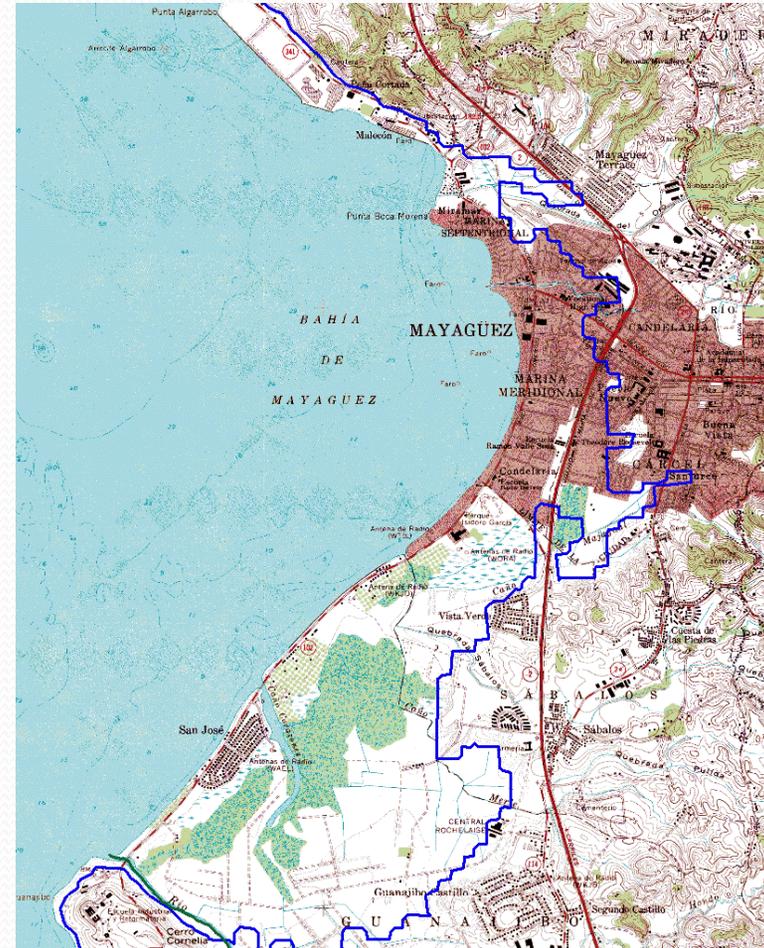


Source: U. ten Brink, USGS

Major faults and structures in the Caribbean with the potential of generating large local and regional tsunamis from earthquakes and submarine landslides.

Tsunami Inundation Maps

- Information Required:
 - Tsunami sources, eg. Faults, Landslide, Volcanoes
 - Digital elevation models of near shore topo and bathymetry
 - Inundation model-TIME, MOST



Tsunami Inland Flood Limit for Mayagüez, PR

Vulnerability

- Vulnerability Factors
 - Age
 - Sex
 - Family/Marital Status
 - Special Needs
 - Education
 - Housing
 - Economic resources



Communications

CARIBE EWS

Communications and Dissemination

- 24 hour capability to rapidly receive and disseminate emergency information messages

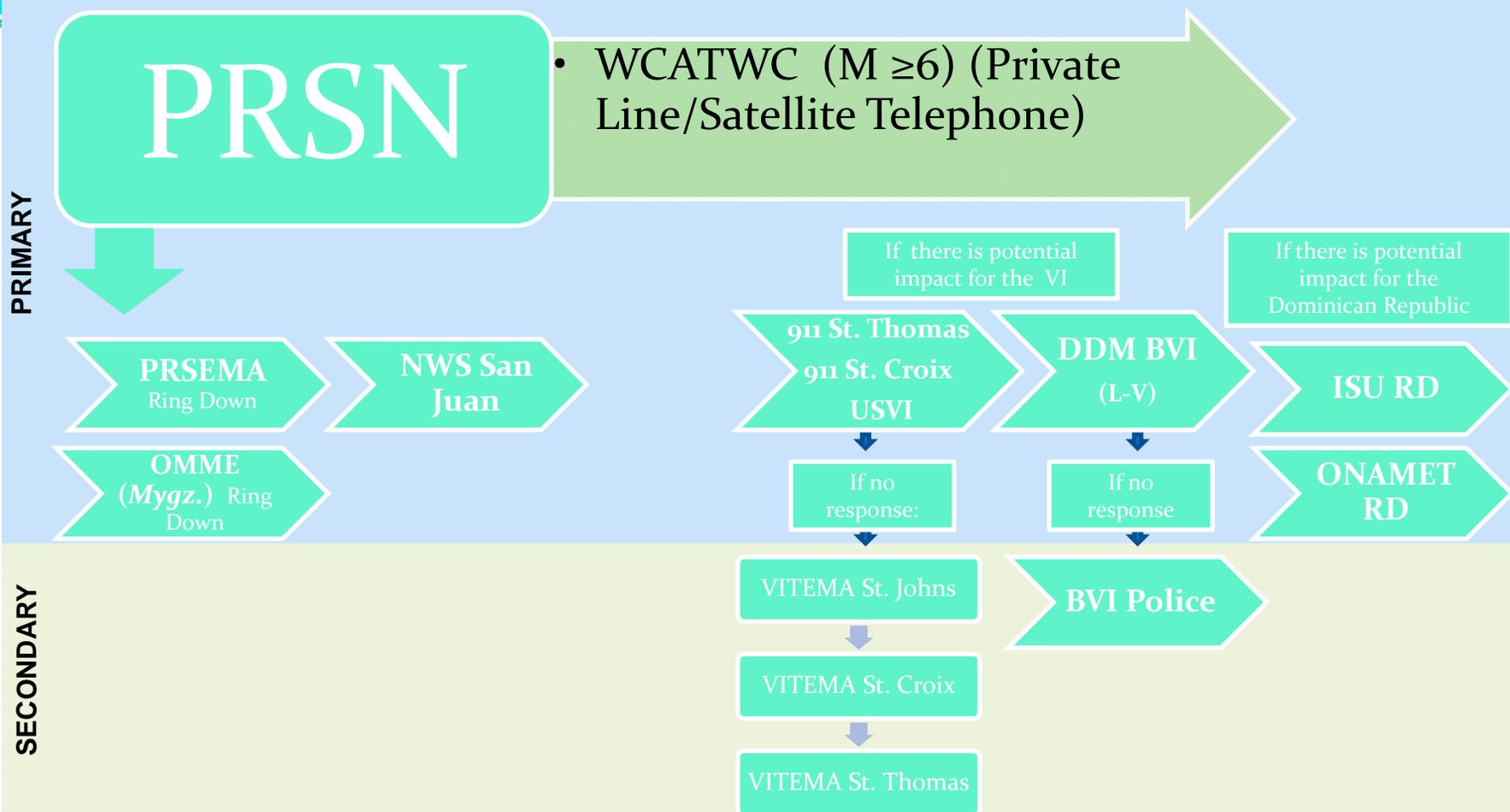


“80% of tsunami mortalities occur within the first hour after the source event” (exception: 1946 Aleutian tsunami)

EOS-AGU, v.88, n. 52



PRSN Agency Dissemination Protocol



Calls will also be made to:
 - PRSN Director
 - PRSEMA Director
 - USGS (M ≥ 6)

Preparedness, Readiness and Resilience

CARIBE EWS

Tsunami Ready

When seconds count, TsunamiReady communities are ready to respond



America Samoa Tsunami, Sept. 29, 2009

TsunamiReady™ Objectives

- Create minimum standard community guidelines for adequate tsunami readiness.
- Increase public awareness and understanding of tsunami hazard.
- Improve community pre-planning for tsunami disasters.
- Encourage consistency in educational materials and response.
- Recognize communities that have adopted TsunamiReady™ guidelines



TsunamiReady™ Benefits

- Community is better prepared for “*all hazards*.”
- Increase contacts with experts (emergency managers, researchers, academia, NWS).
- Identify community readiness needs.
- Host regularly scheduled education forums.
- Enhance “core” infrastructure to support other community hazards.
- Allow public to see how tax dollars are being spent.



How does a Community become TsunamiReady™?



- Establish Communication and Coordination Plan
 - 24 Hour Warning Point
 - Emergency Operations Center
- Receive Critical Tsunami Warning Information
 - Emergency Managers Weather Information Network (EMWIN)
 - NOAA Weather Radio
 - NOAA Weather Wire
 - News Media (Radio/TV)
 - Internet
 - Pagers, cell phones, etc.



How does a Community become TsunamiReady™?

- Disseminate Tsunami Warnings
 - Emergency Alert System
 - Cable Override
 - NOAA Weather Radio in public buildings
 - Sirens
 - Ham radio
 - Email alert notifications
 - SMS
 - Telephone calling tree



How does a Community become TsunamiReady™?



- Increase Community Preparedness
 - NWS staff and EM provide Tsunami safety presentations
 - Designate safe areas outside of inundation zone
 - Establish tsunami evacuation areas, evacuation routes, and install evacuation route signs
 - Provide written, locality specific, tsunami hazard response material to public
- Schools:
 - Encourage tsunami hazard curriculum
 - Practice evacuations if located inside inundation area
 - Provide safety material to staff and students



Preparation and Distribution of Evacuation Maps.



How does a Community become TsunamiReady™?

- Administrative
 - Develop formal tsunami hazard operations plan
 - Yearly meeting/discussion by emergency manager with NWS
 - Visits by NWS official to community at least every other year

Emergency Operations
Plan



TsunamiReady™ Recognition Process

- Community applies to local NOAA NWS Office.
- Local TsunamiReady™ Advisory Board reviews application. Rafael Mojica, WCM, NWS, San Juan is the chair.
- Local TsunamiReady™ Advisory Board performs on-site verification visit.
- If guidelines are not met, Local TsunamiReady™ Advisory Board suggests improvements and works to implement changes.
- Once guidelines are met, a recognition Ceremony and Press Conference is held for community.



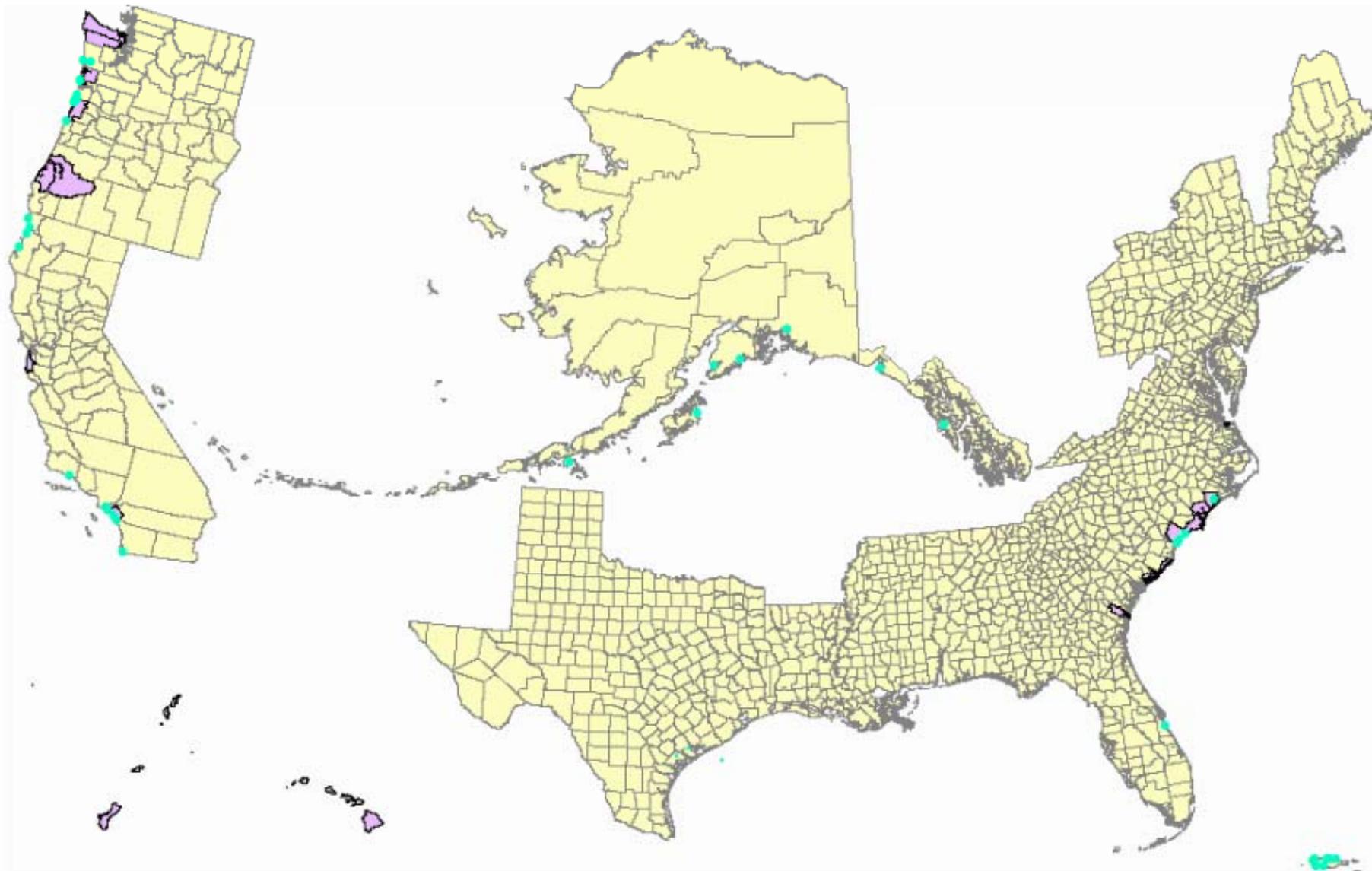
Successful Applicants Receive:

- TsunamiReady™ recognition letter valid for 3 years.
- Two official TsunamiReady™ signs.
- Authorization to use the TsunamiReady™ logo.
- Instructions for acquiring additional signs.
- Listing on TsunamiReady Web site





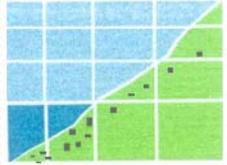
As of May 5, 2010, there were **75** TsunamiReady™ Sites in **10** states,
Puerto Rico and **Guam** and the **Northern Mariana Islands**
1 TsunamiReady Supporter



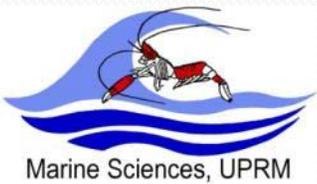
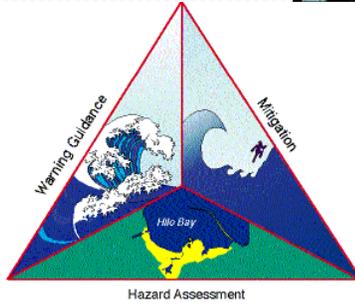


TsunamiReady™ Renewal Process

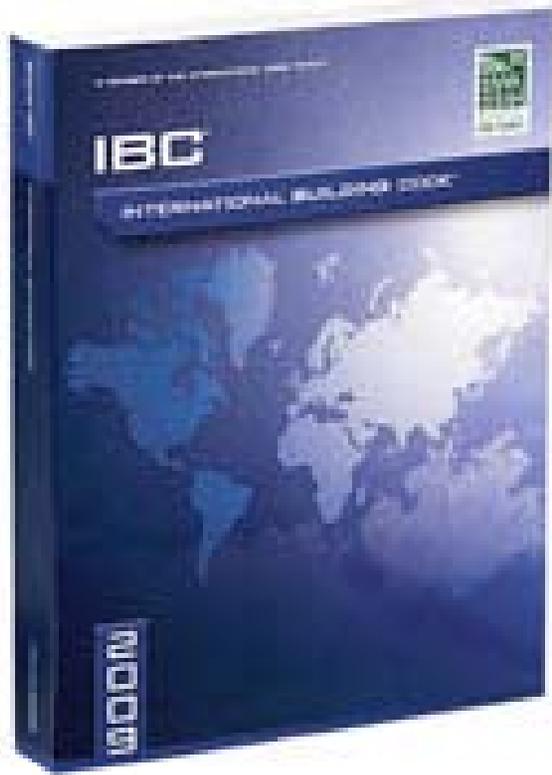
- NWS Office sends notification letter to communities that need to re-apply with 6 months advance notice.
- A copy of the original application is reviewed by community officials to certify it is still accurate.
- Community provides an updated list of any new technology or information that has been added since the initial application was signed.
- Once the community official signs and returns the application a 3-year renewal becomes effective.



CISA



Earthquake and Tsunami Building Codes and Guidelines



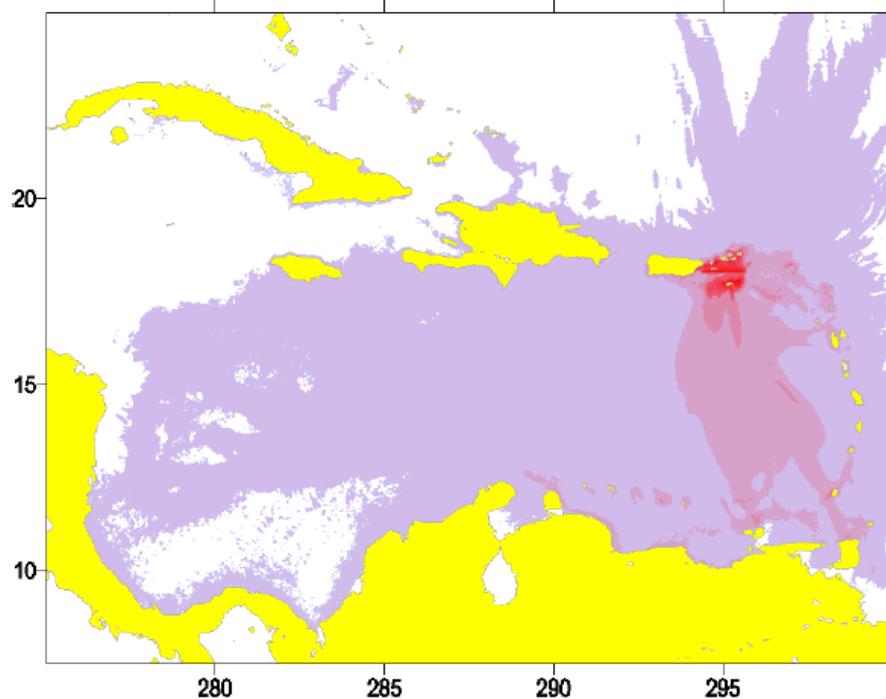
Guidelines for Design of Structures for Vertical Evacuation from Tsunamis

FEMA P646 / June 2008

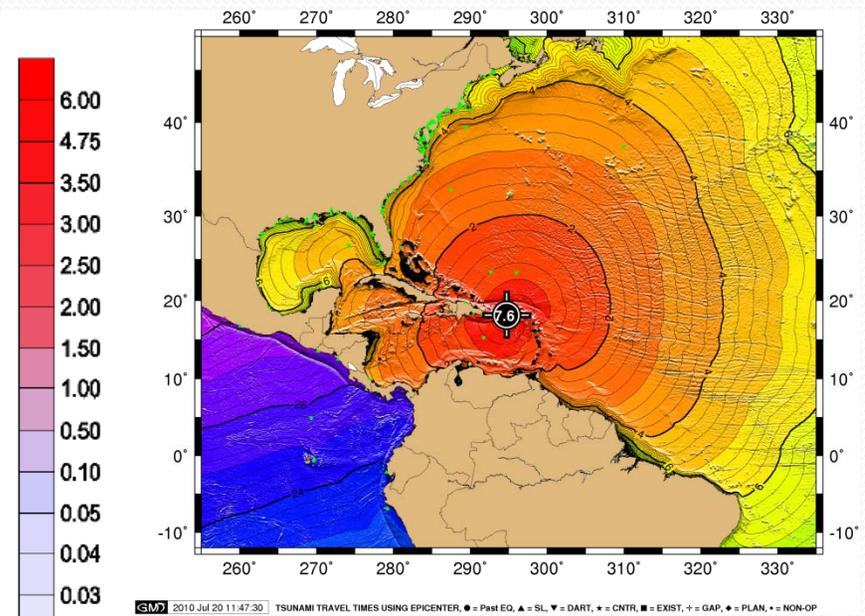


CARIBE WAVE LANTEX 2011, March 23, 2011

- Tsunami generated by a magnitude @ 7.5 earthquake in the US Virgin Island Basin (similar to the 1867 VI EQ and Tsunami)



The distribution of computed maximum positive tsunami amplitudes. The water surface elevation is in meters). Taken from Zahibo, et. al, 2003.



Estimated times of initial tsunami arrival:

Christiansted, U.S. Virgin Is	0911 AST MAR 23	1311 UTC	MAR 23
Vieques Is., Puerto Rico	0911 AST MAR 23	1311 UTC	MAR 23
Limetree Bay, U.S. Virgin Is.	0919 AST MAR 23	1319 UTC	MAR 23
Lameshur Bay, U.S. Virgin Islands	0921 AST MAR 23	1321 UTC	MAR 23
Culebra, Puerto Rico	0922 AST MAR 23	1322 UTC	MAR 23
Mona Island, Puerto Rico	0937 AST MAR 23	1337 UTC	MAR 23
Virgin Gorda, British Virgin Islands	0939 EDT MAR 23	1339 UTC	MAR 23
Magueyes Island, Puerto Rico	0941 AST MAR 23	1341 UTC	MAR 23
San Juan, Puerto Rico	0945 AST MAR 23	1345 UTC	MAR 23

Remember....

- A tsunami is a series of waves – not one wave
- The first wave may not be the largest, might not be receding
- Time between waves: 5 min to > 1 hour
- Hazard can continue for many hours
- Natural tsunami warning signs
 - Strong or long shaking from an earthquake
 - An unusual withdrawal of the sea
 - An unusual loud roar from the sea
- Tsunamis easily wrap around islands
- Can occur day or night, cloudy or sunny
- Tsunamis are usually the secondary effect of an earthquake, also have to plan to deal with the earthquake and other secondary effects, liquefaction, landslides

More information...

- NOAA NWS <http://tsunami.gov>
 - Caribbean Tsunami Warning Program, Tel. 787-833-8433, christa.vonh@noaa.gov
- Puerto Rico Seismic Network
 - <http://prsn.uprm.edu>
- PRTWMP with PR Tsunami Inundation Maps
 - <http://poseidon.uprm.edu>
- UNESCO IOC Caribe EWS <http://www.ioc-tsunami.org/>

online Puerto Rico seismic network spanish

Our Work: Seismicity Education Tsunami Research Links home uprm.edu

Welcome MICRONETWORK

"this page is under construction"

RECENT SIGNIFICANT EARTHQUAKES

Magnitude	Agency	Local Time (GMT-4)	Latitude	Longitude	Depth	Region
3.3M	PRSN	2010-07-14 09:34:06	18.022	-65.327	0	EASTERN PUERTO RICO
3.61M	PRSN	2010-07-13 19:45:22	18.409	-68.434	161	EASTERN DOMINICAN REPUBLIC
3.67M	PRSN	2010-07-12 08:10:02	19.565	-66.420	43	PUERTO RICO TRENCH
4.63M	PRSN	2010-07-07 11:05:41	19.044	-64.758	4.75	SOMBRERO SEISMIC ZONE
3.51M	PRSN	2010-07-05 01:20:39	19.316	-69.927	109.9	EASTERN DOMINICAN REPUBLIC
4.6M	PRSN	2010-07-02 09:44:47	18.645	-68.731	179.9	EASTERN DOMINICAN REPUBLIC
3.36M	PRSN	2010-07-01 18:42:30	19.079	-64.884	112	SOMBRERO SEISMIC ZONE
3.68M	PRSN	2010-06-19 09:39:49	19.560	-65.385	96.7	PUERTO RICO TRENCH
3.69M	PRSN	2010-06-17 20:44:59	18.451	-68.004	126.0	EASTERN DOMINICAN REPUBLIC
3.68M	PRSN	2010-06-15 13:29:08	19.100	-64.797	89	SOMBRERO SEISMIC ZONE
4.53M	PRSN	2010-05-15 15:05:33	19.553	-65.439	40	PUERTO RICO TRENCH

Special Reports: Earthquakes Online News and activities

Monthly Reports: Detailed information of the monthly seismicity in Puerto Rico and Virgin Islands

Annual Reports: Annual Reports of the seismic activity

Hand Earthquake: Special Report about the earthquake occurred in Haiti on January 12, 2010

CARPECO Explosion: Explosion of the Caribbean Petroleum refinery at Bayamón, October 23

Seismicity in North Area: Special Report of the seismic activity detected in the north area of Puerto Rico

Report a felt earthquake: If you have felt an earth tremor in PR, you can help us to determine the intensity of the same one by completing our electronic form.

Significant Earthquakes: List of earthquakes with a magnitude of 3.0 or greater, or reported as felt

Caribbean and adjacent regions: Earthquakes detected by the Puerto Rico Seismic Network (PRSN) in Caribbean and adjacent regions with a magnitude of 4.0 or greater

Conferences: Educational Portal of Emergency Management: Interactive courses that provide training and preparedness for natural phenomenon

Conference Request: To apply for conferences, lectures, workshops or arrange a visit to the Seismic Network

Drills, Table Tops and Related Material: [View more...](#)

Courses, Workshops and Conferences: [View more...](#)

LANTEX-2011: A tsunami warning exercise for the U.S. east coast, the Gulf of Mexico and the Caribbean [Participate.](#)

February 9, 2007

CARIBBEAN TSUNAMI HAZARD
 Proceedings of the NSF Caribbean Tsunami Workshop
 San Juan, Beach Hotel, Puerto Rico 30 - 31 March 2004

edited by Aurelio Mercado-Irizarry (University of Puerto Rico, USA) & Philip Liu (Cornell University, USA)

This book aims to present the overall existing tsunami hazard in the Caribbean Sea region, a region which is typically only associated with hurricanes. It initially presents an overview of all of the existing tsunami-causing factors found in the region: earthquakes, sub-aerial and submarine landslides, and submarine explosions. This is followed by field evidence of recent and pre-historic tsunami events, which gives credibility to all of this effort. The next section is a description of the tsunami hazard mitigation efforts being carried out locally and in collaboration with national and international programs. The final part is dedicated to the presentation of related recent research results.

August 28, 2006

TSUNAMI THE FORGOTTEN DANGER
 VIDEO DOCUMENTARY
NEW DVD VERSION AVAILABLE FOR DOWNLOAD!

The tsunami documentary produced in Puerto Rico. This video includes the history, hazards, and protective measures concerning tsunamis. The video was prepared by JAM Media (San Juan, P.R.) and it has been freely distributed to many schools, governmental and private agencies. To obtain copies of the documentary (VHS or DVD) contact the Puerto Rico Seismic Network Telephones: 787-833-8433, 787-265-5452.

Three DVD quality versions available for download. On IE right button click on image and select "Save Target As...". Warning: This are very large files! Broadband (DSL or Cable Internet) recommended. If you're on dial-up use a download manager.

West Coast and Alaska Tsunami Warning Center
 Latest Event

Tsunami Information Statement (TIS)

2010/07/23 12:57:28 (UTC)
 Depth: 10 km
 Magnitude: 4.7
 Location: 23.73N -107.47W
 Location: 25 miles/40 Km S of
 Santa Rosa
 Puerto Rico

Please click [here](#) to see the area-of-responsibility (AoR) for the WC/ATWVC and the PTWVC.

The NWS operates two Tsunami Warning Centers and the International Tsunami Information Center

West Coast/ Alaska Tsunami Warning Center (WC/ATWVC)

The WC/ATWVC provides tsunami warning guidance for all U.S. coastal states (except Hawaii), the Canadian coastal provinces, Puerto Rico, and the Virgin Islands.

Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWVC)

The PTWVC provides tsunami warning guidance for Hawaii and countries in the Pacific Ocean, Indian Ocean, and Caribbean Sea.

International Tsunami Information Center (ITIC)

Operated by the NWS on behalf of the Intergovernmental Oceanographic Commission of UNESCO, the ITIC supports the IOC's Tsunami Program which focuses on the coordination of tsunami warning and mitigation systems globally. The ITIC provides direct support to Member States in the Pacific by monitoring and recommending operational improvements to the Tsunami Warning System in the Pacific and by working with countries to increase tsunami awareness and preparedness, and promote education and research.

Is your community prepared for the next destructive tsunami?

TsunamiReady Program

A program designed for recognition for Communities that have met certain standards of tsunami preparedness.

IOC Tsunami Information

Welcome to the UNESCO/IOC global tsunami website, a one-stop resource for all tsunami-related information

The IOC of UNESCO was established in 1990 and has successfully coordinated the Pacific Tsunami Warning System (PTWS) for the Pacific Ocean since 1995. After the Sumatra tsunami on December 26, 2004, the IOC received the mandate to help all UNESCO Member States of the Indian Ocean rim to establish their own Tsunami Early Warning System (ITWES).

At the same time IOC began coordinating the establishment of similar Early Warning Systems (EWS) for tsunamis and other ocean-related hazards in the Caribbean (Caribbean EWS) and the Mediterranean and northeast Atlantic Ocean and connected seas (MEDATWES).

To provide immediate interim coverage for tsunami warnings in all other oceans, advisory systems have been established under the aegis of the IOC of UNESCO, in cooperation with the Pacific Tsunami Warning Center (PTWC) from the USA and the Japan Meteorological Agency (JMA) from Japan.

Tsunami Warning Systems (TWSs), owned and operated by Member States, collect, distribute and interpret continuously all available seismic and sea level data for the existence and propagation of a tsunami. They issue timely and clear warnings for their area of operation and exchange these data and information with other national and international centres. Complementary and sustained activities in tsunami hazard risk assessment, tsunami warning training, emergency response, and preparedness are part of the comprehensive tsunami mitigation programs that extend the TWS's as end-to-end systems.

Our Mission: Save lives, property and livelihood...



Thank you