Tsunami Warning and Mitigation: Chilean Experience

International Tsunami Symposium Commemorating 50th Anniversary of the Pacific Tsunami Warning and Mitigation System
April 2015
Approximately at 15:10 of May 22, 1960 there took place a big earthquake, which caused serious damages between Concepción and Chiloé provinces.

There originated a tsunami of such proportions that destroyed all the ports of this zone. Several ships sank in the Corral bay and numerous boats in almost all the coves of the zone were destroyed. The tsunami propagated by the Pacific Ocean causing damages and casualties in several countries.
Official National Tsunami Warning System (SNAM) began in 1966 as a response to the 1960 tsunami generated in the South of Chile. SNAM’s organization, direction and control were given to the SHOA, who was designated representative Oficial of Chile before the PTWS, (D.S. N° 26 of 11-Ene-1966).

**Mission**

- To inform the authorities about the tsunami generation probability and the waves arrival times at the Chilean coasts.
- To report to the International Pacific Tsunami Warning System about the tsunami generation at the Chilean coasts.
- Exchange tsunami information with Peru, Ecuador and Colombia.

- Creation of NTWC.
- Implementation of a tide gauge network
- First Standart Operational Procedures(SOP).
- Incorporation of TIDE TOOLS and CISN DISPLAY.
- 2007 Creation of a Regional Group (Chile, Perú, Ecuador y Colombia), with IOC and CPPS support.
- Update of tide gauges.
- Satellite comunicación implementation.
- TREMORS implementation.
- EMWIN implementation.
- Improval of SOPs.
- 2008 Technology improvial of Tide Gauges: MAWS 110.
- Improval and implementation of satellite (BGAN), HF and more VHF comnications with NDMO and Coast Guard.
- Replacement and increase from 20 to 40 tide gauges. Redundancy in messure and trasmition.
- Implementation of a second DART II.
- Implementation of a NTW back-up (SHELTER SNAM).
- 2009 Implematation of a 5 years budjet for SHOA and its TWC: better plans and projections.
National Warning System

Pacific-Hawaii Tsunami Warning Center
Alaska Tsunami Warning Center

United States Geological Survey (N.E.I.C.-U.S.G.S.)

National Seismological Network of University of Chile Seismology Center

ONEMI
24 Hours Phone and Radio Service

SNAM Chile

National Tide Gauge Network

NATIONAL TSUNAMI WARNING SYSTEM (S.H.O.A.)
EMWIN DART BUOY

24 Hours Phone and Radio Service

MARITIME DOMAIN

DIRECTORATE GENERAL OF MARITIME TERRITORY

MERCHAND VESSELS

NAVAL UNITS
NAVAL ZONES

S.D.156 INTERIOR DATED MARCH 12 OF 2002

NATIONAL PLAN FOR CIVIL PROTECTION 2002
• Governmental Authorities
• Regional Government
• Provincial Government
• Municipalities
• Comm. Dir. of Emergency
• Local Systems for Civil protection and emergency
• Population

NAVAL DOMAIN

TREMORS Seismology System

NAVAL UNITS
NAVAL ZONES
April 1st 2014, Tsunami in Iquique, Chile

The effects of the tsunami generated by the earthquake M 8.3, were evident in Arica and Iquique cities. In the last one, the most affected areas were Muelle Prat and Caleta Riquelme. Also destructive effects were observed in Caleta Colorada to 80 km northward Pisagua. In that place 4 wood houses were destroyed and two fishermen were dragged by the tsunami, but they managed to steady of rocks and to survive.
Establishment of state of threat Tsunami

5 mins from the information
CSN / PTWC
USGS received

INFORMATION
BULLETIN

ADVISORY

WATCH

WARNING

Preventive Evacuation

Intensity equal or superior to VII

Intensity = Mercalli = Subjective

Magnitude = Richter = Objective

Preliminary characterization of the earthquake:
epicenter
depth
magnitude

Responsibilities and actions in emergency
Second DART buoy

Technology, equipment, satellite communications radio system, telephone and fax.

Support infrastructure

Installing new multibeam system PSH Cabrales

Recovery National Cartography

Operation and monitoring

New SNAM

Procedures, exercises, specialization, establishment of Expert Committee

Decision Support System

Renovation and Increase Water Level Stations

Update Tsunami inundation charts

Post Earthquake and Tsunami Challenge SNAM

TSUNAMI CART (2011-2015)
Technology, equipment, Satellite communications system, radio, telephone and fax
Technology, equipment, Satellite communications system, radio, telephone and fax

- Fixed line phones and satellite line
- Messaging System
- VHF ONEMI / CSN
- DATAMAR2 TSUNAMI System
- Datamar2 y GOES Antennas
- DATAMAR Station
- Video conference ONEMI - SHOA
- Suitcase DATAMAR
- VTS port display cameras
Support infrastructure and support systems

Network activation Datamar 2 - Sirens

Network tide monitoring stations

Google Earth Application

Aplication TTT

Seismic data from official sources

Internal control cameras
Result System National Tsunami Warning (SNAM)

Specialization: Personal continuously trained.
• Diffusion to the community, books, flyers, web based information.
• Tsunami Exercises: National and International.
• Increased personnel: For SNAM operation and a Head of Service and Service Professional oceanographers.
• Training and agreements: JICA / UC - UCH. - PUCV - PUCs.
• Establishment of a Tsunami Expert Committee: composed of outstanding teachers from different national universities.
• ONEMI Protocol - SHOA: Defining responsibilities, actions and determination of formats to be used.
### Post Earthquake and Tsunami Challenge

**TOTAL 23 Charts**

**Areas Affected by Earthquake**

1. **Área N° 1**
   - Bahías Concepción y San Vicente
2. **Área N° 2**
   - Rada el Algarrobo
3. **Área N° 3**
   - Aproximación a Puerto San Antonio
4. **Área N° 4**
   - Between Punta Pite and Punta Topocalma
5. **Área N° 5**
   - Bahía y Puerto Valparaíso

### Table of Areas and Challenges

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<th>Area</th>
<th>Challenge Description</th>
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<td>Caleta Las Casas – Isla Quiriquina</td>
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Dart Buoy

DART® II System

Station Owners
- NDBC DART
- Australia
- Chile
- Ecuador
- Thailand
- Russia
- India
- Japan

Deep ocean Assessment and Reporting of Tsunamis

Surface Buoy
- 2.6 m diameter
- 4000 kg displacement

Bottom Pressure Recorder
- Bi-directional acoustic telemetry
- Glass ball flotation
- 19 mm nylon
- 13 mm chain (6 m)
- 25 mm nylon
- 100 m Nitspin®
- 25 mm chain (3.5 m)
- Swivel

Bi-directional communication & control
Iridium satellite
Iridium & GPS antennas
Lift handle
Surface Buoy

Anchor 310 kg
Anchor 340 kg
Acoustic transducer
Acoustic release
Batteries

West Coast Alaska Tsunami Warning Center
DGOA PVEF
Pacific Tsunami Warning Center

NOAA

SHCOA Chile
Existing Charts (38)

1. Arica
2. Iquique
3. Tocopilla
4. Mejillones
5. Antofagasta
6. Taltal
7. Chañaral
8. Caldera/Calderilla/bahía Inglesa
9. Huasco
10. La Serena
11. Coquimbo
12. Los Vilos
13. Papudo
14. Zapallar
15. Quintero/Ventana/Horcón
16. Concon/Riotoque
17. Valparaiso/Viña del Mar
18. Pascua Hanga Roa/Hanga Piko
19. Pascua Hanga Hotuiti
20. Pascua, La Perouse Anakena
21. Algarrobo
22. San Antonio
23. Constitución
24. Tomé
25. Penco/Lirquén
26. Talcahuano
27. San Vicente
28. Coronel
29. Lebu
30. Corral
31. Maullín 1:20000
32. Maullín 1:6000
33. Ancud
34. Aysén
35. Chacabuco
36. Antofagasta sur a Caleta Coloso
37. Bahía Cumberland (Is. R. Crusoe)
38. Lota/Coronel

Charts to be edited 2015 to 2016

39. Punta Arenas
40. Puerto Williams
41. Pichilemu
42. Puerto Saavedra
43. Tírúa
44. Quellón
45. Pisagua
46. Cobquecura
47. Trehuaco
48. Coelemu
OUR CHALLENGE

Decision Support System New SNAM
### DLR/SHOA Tsunami Iquique Mw 8.2

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<th>EWH &lt; 0.3m</th>
<th>EWH 0.3m - 1m</th>
<th>EWH 1m - 3m</th>
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<td>1.4</td>
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<td>San Felix</td>
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<tr>
<td>XIV Region de Los Ríos</td>
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<tr>
<td>y la Antartica chilena</td>
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<td>Archipiélago Juan Fernández</td>
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<td>0.1</td>
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DLR/SHOA Tsunami Iquique Mw 8.2

Matching #401
Created: 2015-04-01T10:13:20Z

based on Observation(s)

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Scenario
Scenario ID: r2012_mw30_mw6_50_dep30_n0131_10h

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<td>1.1 m</td>
<td>0.5 m</td>
<td>1h:04m:57s</td>
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<tr>
<td>San Félix</td>
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<td>I Region de Tarapaca</td>
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<td>0.3 m</td>
<td>1h:25m:33s</td>
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<td>XIV Region de Los Ríos</td>
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<td>X Region de los Lagos</td>
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<td>0.3 m</td>
<td>0.2 m</td>
<td>3h:05m:39s</td>
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</tbody>
</table>
• Two computers
• Fax
• Telephone
• TREMORS
• EMWIN
• More seismic information
• Satellite communications
NTWC: FIRST STEPS

- Redundancy in all systems
- More tide gauges and buoys
- Strongest communications
- Back-up SHELTER
There is no system in the world able to predict Earthquakes and therefore a Tsunami.

There are no foolproof systems, even with advanced technology and redundant systems.

The best signal to evacuate is the Earthquake by its self.

People should be always prepared to evacuate with the proper elements.
Hydrography – Much more than just nautical charts!

Contribution of hydrography in global development

Hydrography – Many users….. Many applications!
Actively contributing to the development of the country