



Asia-Pacific  
Economic Cooperation

# Comprehensive Advances in Tsunami Threats, Chile

*10th Emergency Preparedness Working Group Meeting  
Tsunami Workshop*

Ministry of the Interior's National Emergency Office, ONEMI  
Hydrographic and Oceanographic Service of the Chilean Navy (SHOA)

16th August 2016



# Amanecer en el epicentro

- Recorrido por Illapel, Tongoy y Coquimbo después del terremoto 8.4.
- Analistas responden: ¿Cómo impacta a Bachelet esta nueva emergencia?
- El sismo superó a Caval y Penta en Twitter.

P. 4 a 11



mañana, esta mañana.

# Terremoto provocó daños acotados, los que se concentran en la zona de Coquimbo

- Subsecretario de Obras Públicas, Sergio Gallilea, estimó en \$7 mil millones costo de reposición de infraestructura pública en este puerto.
- Hasta el momento hay doce fallecidos. Las historias de algunas de las víctimas, desde un agricultor a una bailarina.



- ▶ Nuevo modelo predictivo alertó del maremoto en menos de cinco minutos A 12
- ▶ Caso 27-F: el 15 de diciembre próximo se inicia la preparación del juicio oral C 5
- ▶ Multitudinario uso de los mensajes por WhatsApp permitió fluida comunicación A 12
- ▶ Sismo liberó cuatro veces menos energía que el del 27 de febrero de 2010 A 12



# COQUIMBO – SEPTEMBER 16 2015



# National Tsunami Warning System



Pacific Tsunami Warning Center  
Hawaii



National Earthquake Information Center  
(NEIC) US Geological Survey. (USGS)



Seismic Network of the National  
Seismological Centre of  
Universidad de Chile



German Research Centre  
for Geosciences



National Tsunami Warning  
Center

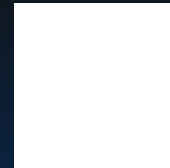


NATIONAL TSUNAMI WARNING  
SYSTEM (SHOA)  
EMWIN DART BUOY



Full 24-hours attention  
via telephone  
and radiotelephony

National Tide  
Station Network



ONEMI

Full 24-hours attention via telephone and radiotelephony .

S.D. No 156 OF MINISTRY OF INTERIOR, DATED 12TH MARCH OF 2002, COORDINATOR OF NATIONAL SYSTEM OF CIVIL PROTECTION

- GOVERNMENTAL AUTHORITIES
- GOVERNORS' OFFICES
- PROVINCIAL GOVERNMENTS
- MUNICIPALITIES
- DIRECTORS OF EMERGENCY COMMITTEES
- LOCAL SYSTEMS OF CIVIL PROTECTION
- POPULATION



MARITIME  
AREA

DIRECTORATE GENERAL OF MARITIME  
TERRITORY AND MERCHANT MARINE

MECHANT SHIPS  
MARITIME AUTHORITIES



NAVAL  
AREA

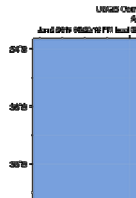
NAVAL UNITS  
NAVAL ZONES

# Responsibilities and Emergency Actions

National Emergency Office  
ONEMI

< 5 min

00:03



National Seismological  
Centre (CSN)

< 10 min

Hydrographic and Oceanographic Service of  
the Chilean Navy (SHOA)

< 5 minutes  
once  
information has  
been received  
from CSN /  
PTWC USGS  
and NTWC.



INFORMATION



CAUTION



WATCH



WARNING

# Post Earthquake and Tsunami Challenge SNAM



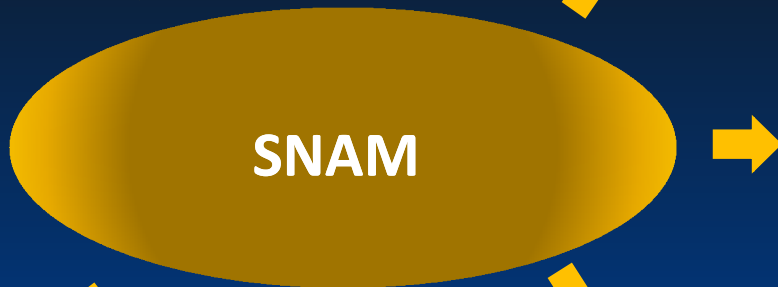
Latest events



Supporting Infrastructure



Sea Level Station Network



Monitoring @ open ocean



# EL MERCURIO

EDICIÓN DE 82 PÁGINAS  
REVISTA 28 PÁGINAS

[www.elmercurio.com](http://www.elmercurio.com)

REGIÓN METROPOLITANA: \$500  
Regiones I, II, XI, XII y XV: \$900  
Regiones de la III a la X y XIV: \$500

FUNDADO EN VALPARAÍSO EL 12 DE SEPTIEMBRE DE 1827 / AÑO CLXXXVII N° 64.344 / MCR

SANTIAGO DE CHILE, LUNES 17 DE MARZO DE 2014

FUNDADO EN SANTIAGO EL 1 DE JUNIO DE 1900 / AÑO CXIV N° 41.147 (ES PROPIEDAD)



Las novedosas aplicaciones móviles que ayudan a los alumnos a estudiar. **A 12**



“Los 33” terminó su rodaje grabando las últimas escenas al interior de La Moneda. **C 14**

El drama de Montenegro, el pueblo que se convirtió en la nueva Freirina. **C 9**



TWITTER

**RAPIDEZ.**— Iquiqueños asustados corren hacia los cerros tras escuchar las sirenas de alarma.

Tembor de magnitud 6,7 Richter se registró a las 18:16 horas:  
**Mayor evacuación desde 2011 moviliza a 100 mil personas en tres regiones del norte por alerta de *tsunami***

• Epicentro fue a 75 kilómetros de Pisagua y afectó a Arica, Tarapacá y Antofagasta. Evacuación incluyó al archipiélago de Juan Fernández.

• Subsecretario del Interior destacó el comportamiento ejemplar que tuvo la población al abandonar las zonas costeras. No hubo daños.

CÓMO SE VIVIÓ LA EMERGENCIA Y QUÉ ES UN *TSUNAMI* MENOR | **C 1**

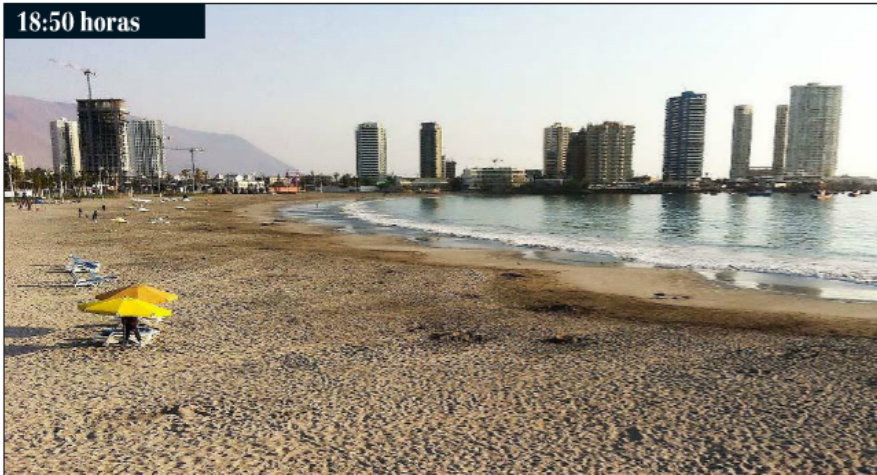


Miles de opositores marcharon ayer en Caracas para protestar por la “injerencia” de Cuba.

**Líder opositor venezolano dice que entablar un diálogo con el gobierno solo beneficia a Maduro | **A 6****



18:50 horas



**VACÍA.**— En apenas unos pocos minutos la playa Cavancho de Iquique quedó absolutamente desocupada. Según la Onemi, solo se registraron variaciones menores en el oleaje, que no superaron los 30 centímetros.

19:20 horas



**TELÉFONOS.**— Si bien la Subsecretaría de Telecomunicaciones informó que después del sismo se produjo una "congestión leve" en las redes de celular, los afectados aseguraron que estuvieron incomunicados por varios minutos.

Temblor de magnitud 6,7 Richter, con epicentro a 75 kilómetros de Pisagua, afectó a Arica, Tarapacá y Antofagasta:

# Mayor evacuación desde 2011 mueve a más de 100 mil personas en tres regiones del norte





# Integrated System of Forecast and Tsunami Warnings (SIPAT)

, tsunami waves amplitude forecast for almost 1000 km  
st. The national territory is divided according its threat



## How does SIPAT works?

Pre emergency

Emergency



## Tsunamigenic scenarios numbers: Combinations

- **Magnitudes Mw ( 6 ) :**
  - 7.0, 7.5, 8.0 @ 0,5° Latitud
  - 8.5 @ 1,0° Latitud
  - 9.0 y 9.5 @ 1,5° Latitud
- **Dip : 26**
  - 5° - 30° @ 1°.
- **Rake: 5**
  - 70° - 110° @ 10 °.
- **Depth: 9**
  - 0 km - 40 km @ 5 km.
- **Shear modulus : 3**
  - 10, 30, 50 GPa
- **5 L:W relationship**

Mw	Scenarios
7.0	397,800
7.5	397,800
5	
8.0	391,950
8.5	327,600
9.0	251,550
9.5	99,450
Total	1,866,150

- **Sample space reduction:**
  - **1) Gray magnitudes: 7.5, 8.0 y 8.5**
  - **2) Dip: Mean value that approximates to subduction geometry.**
    - **20°**
  - **3) Rake: Fixed in 90° , considered as the worst condition.**
  - **4) 8 of the initial depths.**
  - **5) Constant shear modulus**
    - **Mean value = 30 GPa**
  - **6) One L<sub>0</sub>W (2:5) relationship**

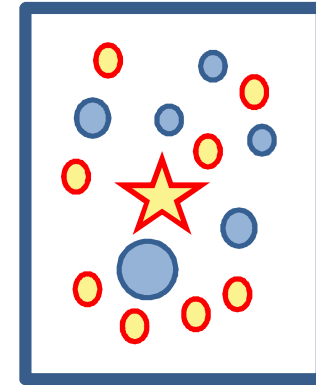
1528  
scenarios

Actually >  
3000

# SIPAT PROCESS

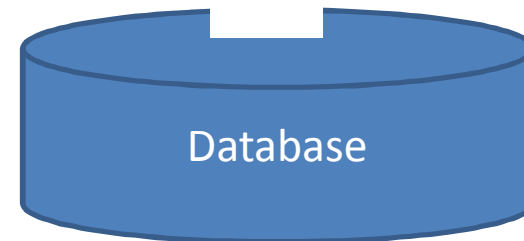


Seismic info:  
CSN  
PTWC  
NTWC  
USGS/NEIC  
GEOFON

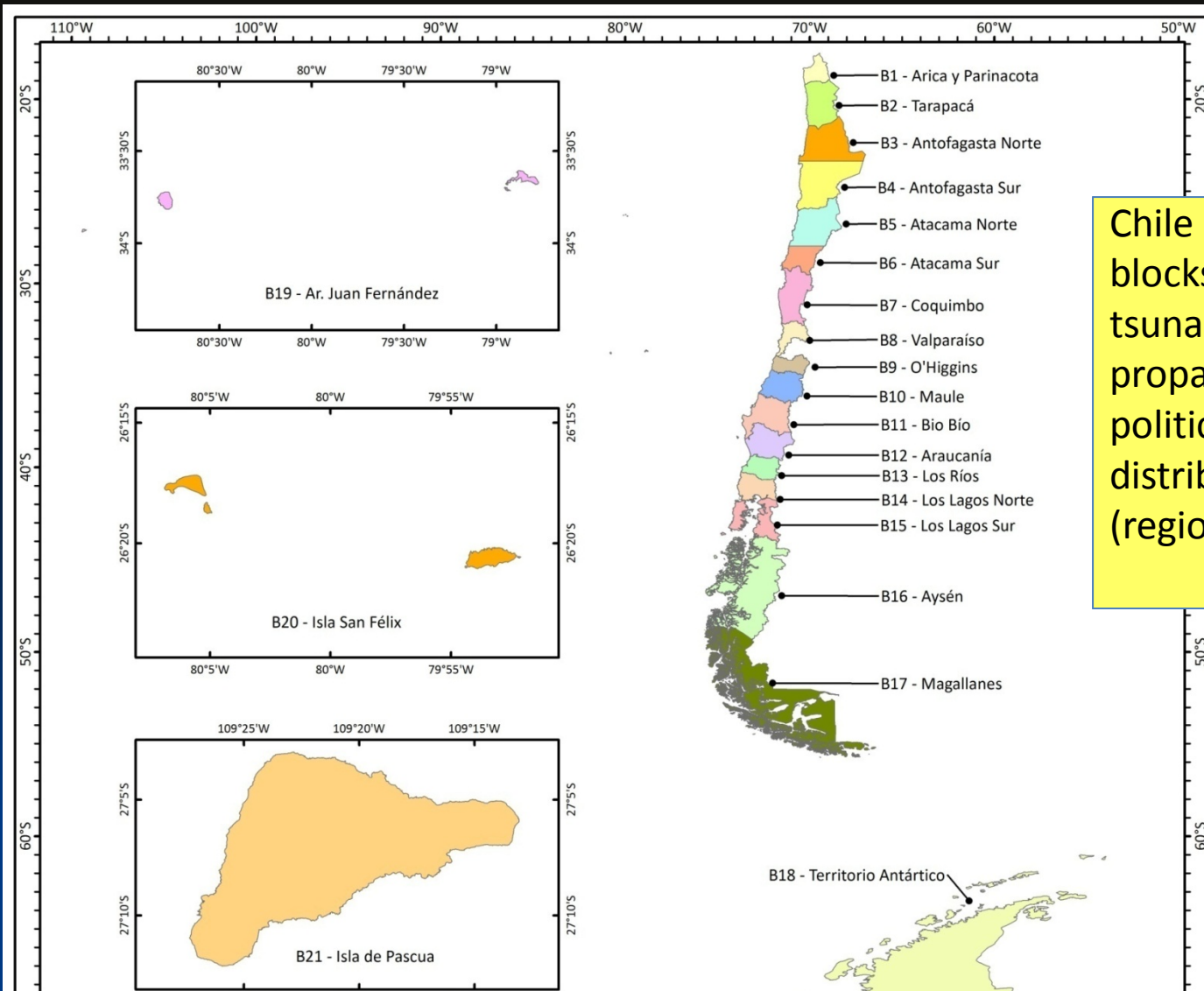


★ Real earthquake

● Scenarios



# Integrated System of Forecast and Tsunami Warnings (SIPAT)



Chile divided in 21 blocks according tsunami propagation and political distribution (regions).

## BEFORE AND AFTER SIPAT

Before SIPAT

After SIPAT

Magnitude	8,4 (Mw)
Date – Time	16 September 2015 19:54 local time (22:54 UTC)
Epicenter	31.553°S; 71.864° W
Depth	11,1 km
Reference	42 km W of Canela Baja
Region	Coquimbo
Source	Chilean National Seismic Center (CSN)



Mapa de Decisión

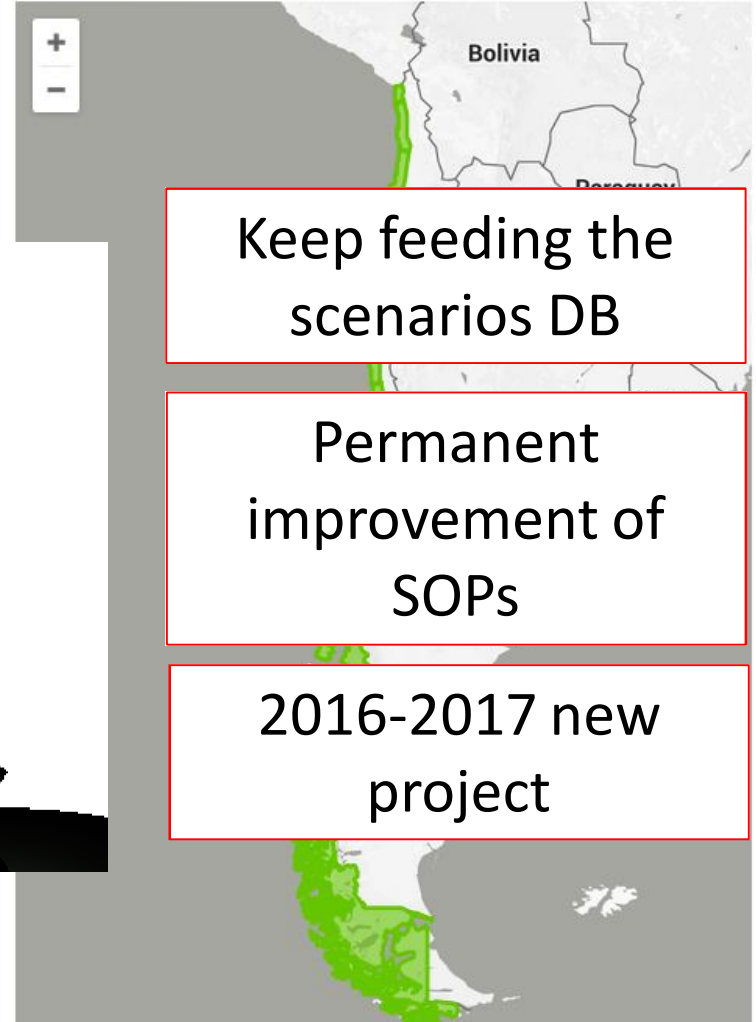
Isla San Félix



Archipiélago Juan Fernández



Chile Continental



Keep feeding the scenarios DB

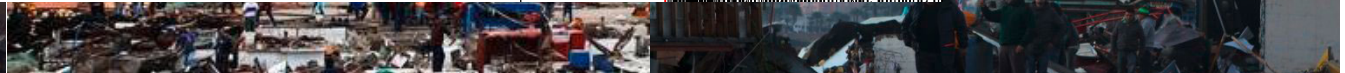
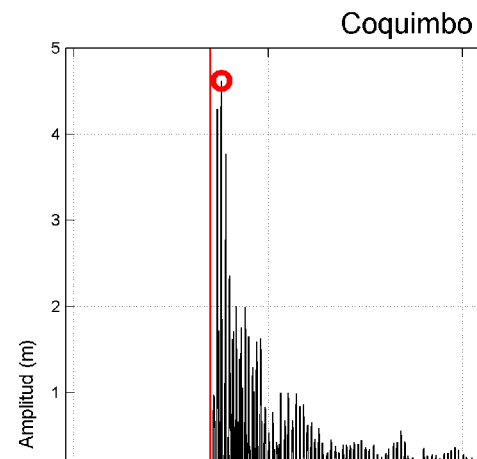
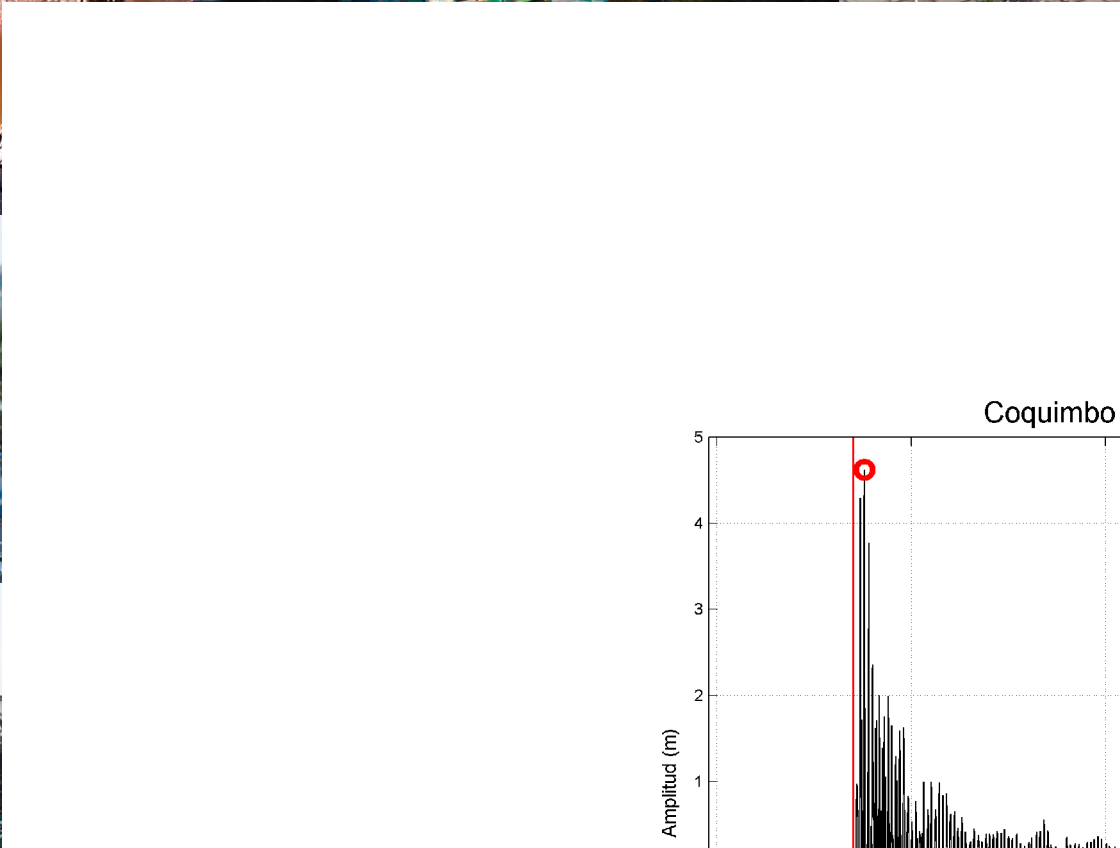
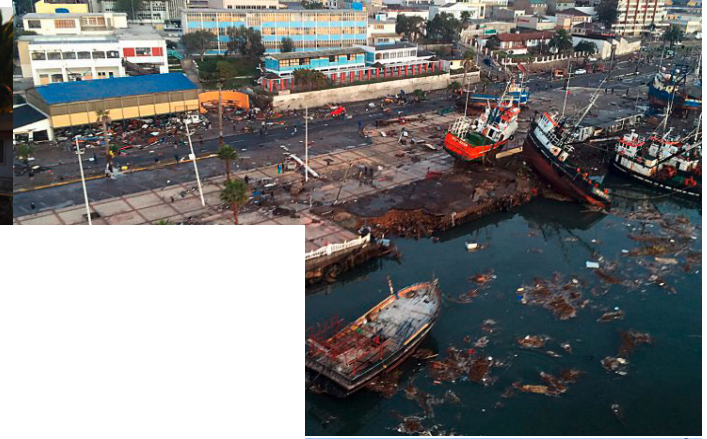
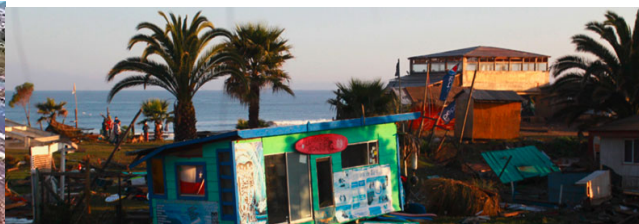
Permanent improvement of SOPs

2016-2017 new project





# COQUIMBO – SEPTEMBER 16 2015

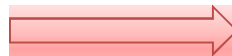


# Post Earthquake and Tsunami Challenge

SEA LEVEL STATIONS, BEFORE 27F: Total 20

ARIICA  
 IQUIQUE  
 ANTOFAGASTA  
 I. SAN FÉLIX  
 CALDERA  
 COQUIMBO  
 VALPARAÍSO  
 Archo. Juan Fernández  
 SAN ANTONIO  
 TALCAHUANO  
 CORRAL  
 PTO. MONTT  
 ANCUD  
 PTO. CHACABUCO  
 SAN PEDRO  
 PTA. ARENAS  
 PTO. WILLIAMS

Total: 20



SEA LEVEL STATIONS PRESENTLY: Total 40

BUCALEMU

BAHÍA GREGORIO

Total: 40



# Dart Buoys

## DART BUOYS

LOCATION:

### IQUIQUE

BUOY TYPE DART II  
 IDENTIFICATION NUMBER 32401  
 POSITION L:  
 20°28'22" S, G: 073°25'46" W.  
 PLACE OF FUNDING 186 MN. TO W OF IQUIQUE  
 DEPTH 4797 M.  
 DATE OF FUNDING 12/03/2014

LOCATION:

### CALDERA

BUOY TYPE DART II  
 IDENTIFICATION NUMBER 32402  
 POSITION L:  
 26°44'36" S, G: 073°58'59" W.  
 PLACE OF FUNDING 194 MN. TO W OF CALDERA  
 DEPTH 4067 M.  
 DATE OF FUNDING 08/04/2013

LOCATION:

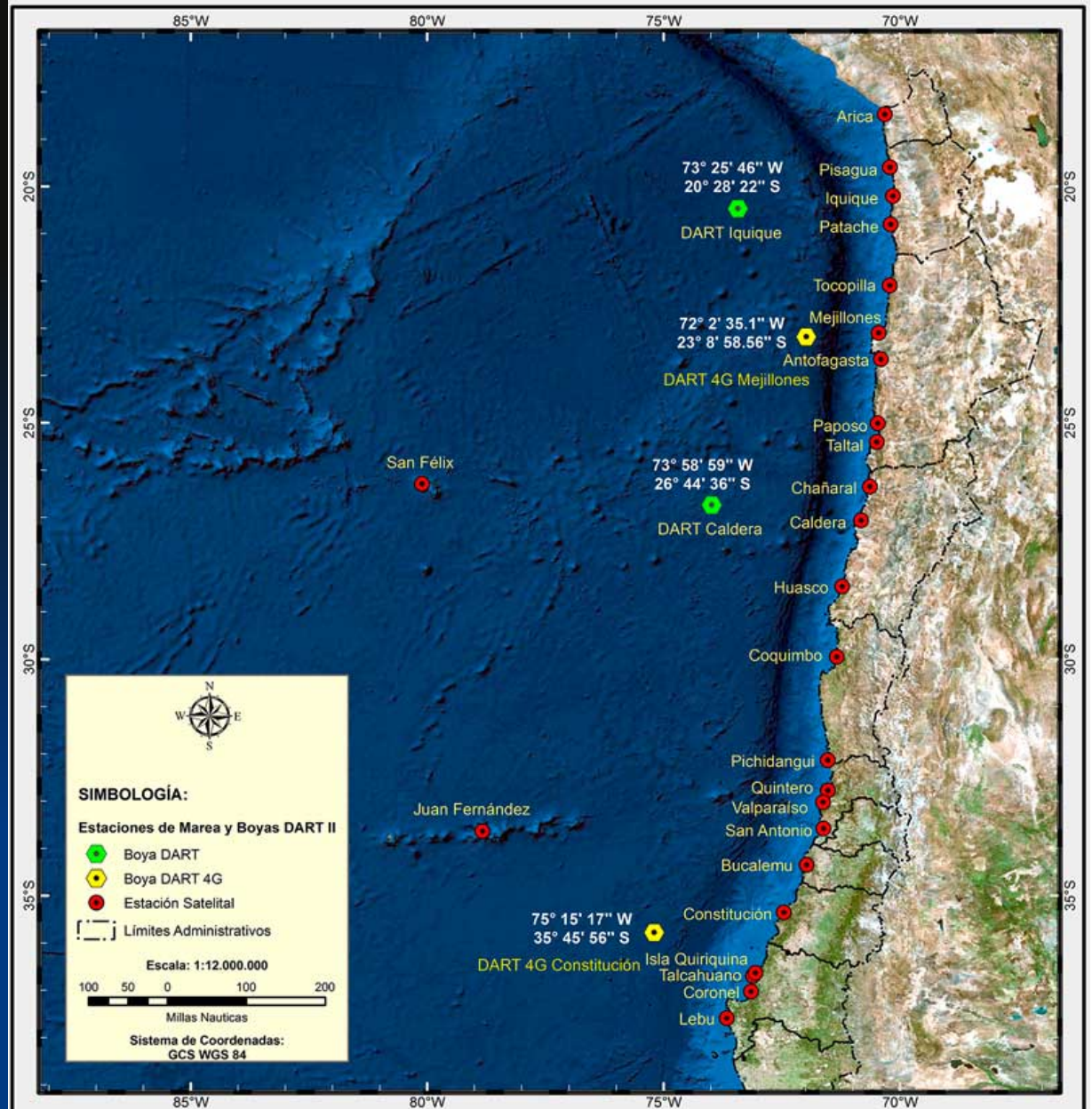
### MEJILLONES

BUOY TYPE DART  
 4G  
 IDENTIFICATION NUMBER 32403  
 POSITION L:  
 23°09,976" S, G: 072° 02,585" W  
 PLACE OF FUNDING 81 MN. TO W OF PENINSULA OF  
 MEJILLONES  
 DEPTH 4237 M.  
 DATE OF FUNDING 24/09/2015

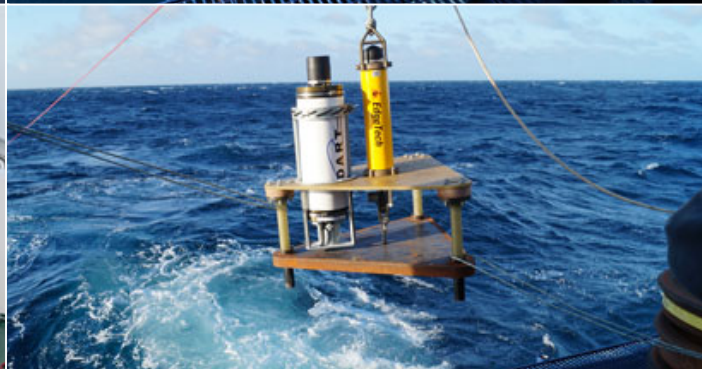
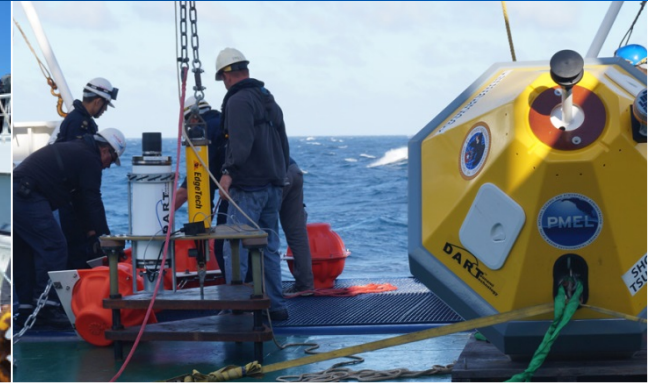
LOCATION:

### CONSTITUCION

BUOY TYPE DART  
 4G  
 IDENTIFICATION NUMBER 32404  
 POSITION L:  
 35°45'56" S, G: 075°15'17" W.  
 PLACE OF FUNDING 139 MN. TO SW OF  
 CONSTITUCION  
 DEPTH 4140 M.  
 DATE OF FUNDING 28/09/2015



# DART Deployment



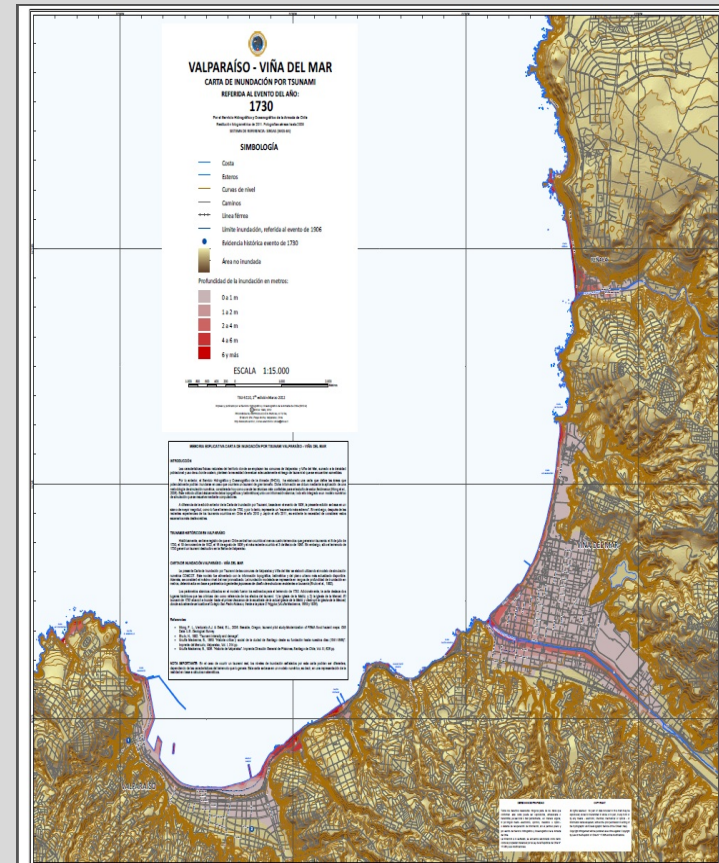
# Updating of Tsunami Inundation Charts 2010 - 2016

## Cartas Vigentes

- |   |  |
|---|--|
| 1. Arica                                      | 21. I. Pascua Hanga Roa / Hanga Piko     |
| 2. Pisagua                                    | 22. I. Pascua Hanga Hotuiti              |
| 3. Iquique                                    | 23. I. Pascua La Perouse Anakena         |
| 4. Tocopilla                                  | 24. Algarrobo                            |
| 5. Mejillones                                 | 25. San Antonio                          |
| 6. Antofagasta                                | 26. Pichilemu                            |
| 7. Antofagasta sur a Caleta Coloso            | 27. Constitución (Actualización en 2016) |
| 8. Taltal                                     | 28. Bahías Concepción y San Vicente      |
| 9. Chañaral                                   | 29. Tomé / Lirquén / Penco               |
| 10. Caldera / Calderilla / Bahía Inglesa      | 30. Sector Isla de Los Reyes             |
| 11. Huasco                                    | 31. Talcahuano/ San Vicente              |
| 12. La Serena                                 | 32. Coronel                              |
| 13. Coquimbo                                  | 33. Lota                                 |
| 14. Los Vilos                                 | 34. Lebu                                 |
| 15. Papudo                                    | 35. Puerto Saavedra                      |
| 16. Zapallar /Cachagua/La Laguna/Maintencillo | 36. Corral                               |
| 17. Quintero / Ventana / Horcón               | 37. Maullín 1:20.000                     |
| 18. Concón / Ritoque                          | 38. Maullín 1:5000                       |
| 19. Valparaíso / Viña del mar                 | 39. Ancud                                |
| 20. Bahía Cumberland                          | 40. Aysén                                |
|   | 41. Chacabuco                            |
|   | 42. Quellón                              |

## Cartas por editar al 2016:

- |                                     |                                   |
|-------------------------------------|-----------------------------------|
| 43. Tirúa                           | 46. Pingueral / Dichato / Coliumo |
| 44. Cobquecura                      | 47. Puerto Williams               |
| 45. Boca Itata / Perales (Trehuaco) | 48. Punta Arenas                  |



# INAUGURACIÓN DE SALA SNAM



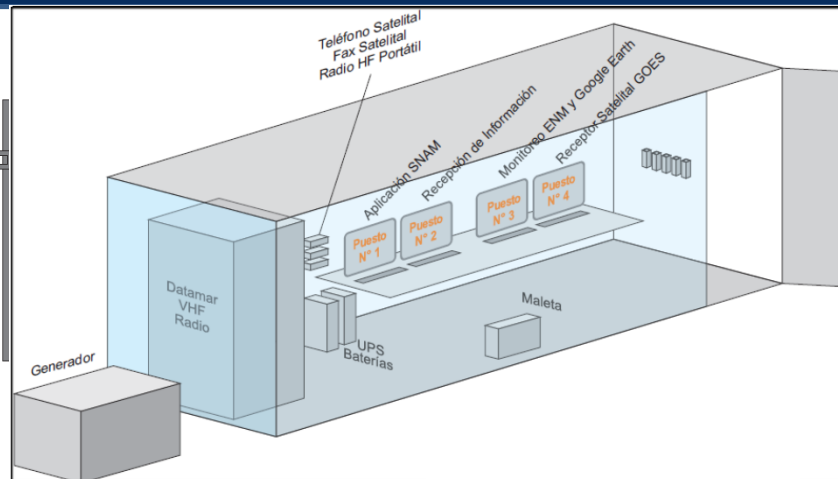
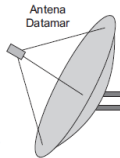


## SISTEMA NACIONAL DE ALARMA DE MAREMOTOS



### EQUIPAMIENTO SHELTER

- DATAMAR VHF Radio
- FAX Satelital
- Teléfono Satelital
- HF portátil
- Puesto N° 1: Aplicación SNAM
- Puesto N° 2: Recepción de Información
- Puesto N° 3: Monitoreo Estaciones Nivel del Mar Google Earth
- Puesto N° 4: Receptor Satelital GOES
- Linternas
- Maletas
- Baterías
- Generador (autonomía)
- Antenas



# Post Earthquake and Tsunami Challenge SNAM



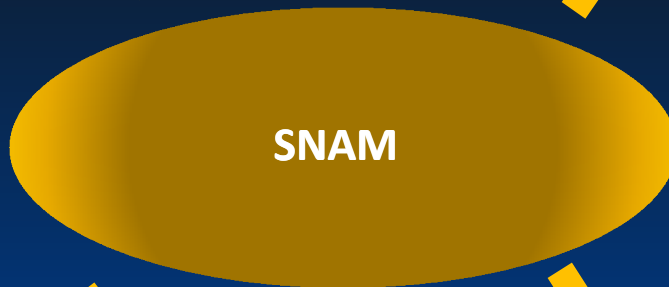
Latest events



Supporting Infrastructure



Sea Level Station Network



Monitoring @ open ocean



Building Capacity



# Summarizing the main managements of SHOA

- Permanent training and improvement of SOP in the tsunami field.
- Strong relationship with Universities, ONEMI & CSN.
- Redundancy as general concept.
- SNAM relay in PTWC-NTWC for far field events.
- Looking forward to increase cooperation opportunities with NTWC.
- Seek fund cooperation for APEC Project (jul 2017) ***Tsunami Threat Assessment for National Tsunami Warning Centers of APEC economies.***
  - in order to improve tsunami assessments and share Standard Operational Procedures,
  - to discuss ways to achieve greater levels of coordination
  - and exchange of information between them



## NATIONAL ADVANCES FOR REDUCTION RISK DISASTER

- **National Platform for Disaster Risk Reduction** since 2012. Headed and coordinated by ONEMI, multisectoral instance that aims to achieve incorporate GRD mainstreamed in policies, planning and development programs, in line with the implementation of international frameworks to which Chile subscribes.
- Chile validates the commitment to the Hyogo Framework for Action (HFA) in 2005, with the signing of Sendai Framework 2015-2030, in March 2015.
- Community Emergency Response Team Program, more tan 1000 per year.
- Drills (educational sector, and coastline population) and simulations (decision makers and authorities).
- International cooperation, example JICA (SATREPS - *Research Project on Enhancement of Technology to Develop Tsunami-resilient Community*, KIZUNA - Human Resource Development for Disaster-Resilient Communities); USAID OFDA (inclusive strategies), and others.



The main objective of the research project is to develop technologies and measures for communities and people in Chile, Japan and other tsunami-prone areas to well prepare for and be resilient to tsunamis. Activities of the project has been conducted in five research groups:

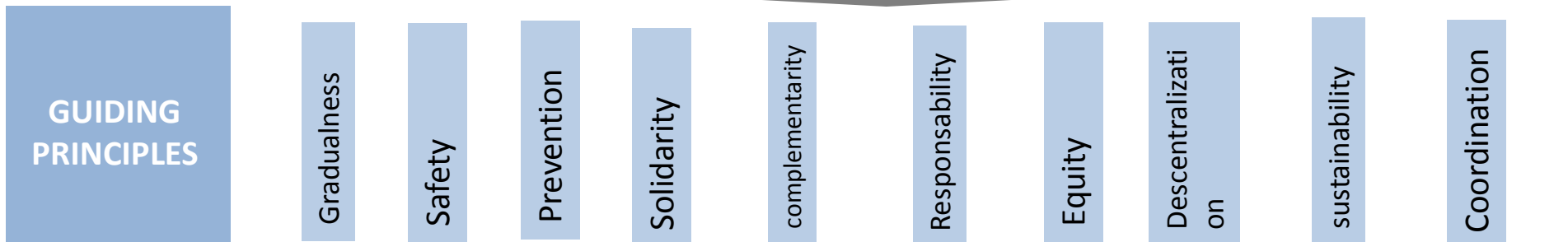
- Group 1 for development of mathematical simulation models to estimate tsunami damage,
- Group 2 for development of tsunami disaster estimation methodology and mitigation,
- Group 3 for development of precise tsunami warning system,
- Group 4a for development of methodology for people to be resilient to tsunamis, and
- Group 4b for development of business continuity management methodology in ports.



# NATIONAL POLICY FOR DISASTER RISK MANAGEMENT

**PURPOSE**  
 To give the State of Chile an instrument or guidance framework to develop an integrated risk management disaster where policy is coordinated with the cross-cutting policies and sectoral policies, and where they carry out the actions of prevention, response and recovery disaster, within the framework of sustainable development

<b>PRIORITIES FOR ACTION</b>	<b>Institutional strengthening</b> Ensure that DRR is a national, regional and local priority with a strong institutional basis for implementation.	<b>Strengthening Monitoring and Early Warning Systems</b> Make available to the SNPC timely and quality technical information that permits an evaluation of efficient and effective risk for decision-making.	<b>Promoting Culture of Prevention and Assurance</b> Promote in the country a culture of safety and resilience through the use of knowledge, innovation and education.	<b>Reducing underlying risk factors</b> Consider the underlying disaster risk factors in the country in terms of decision making in both the public and private sectors, in support of sustainable development.	<b>Strengthen disaster preparedness for effective response at all levels</b> To maintain permanent interagency coordination mechanisms to strengthen disaster preparedness in order to achieve adequate DRR, to ensure a timely, effective and efficient response
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## NATIONAL POLICY FOR DISASTER RISK MANAGEMENT

It provides a framework guides different state institutions to significantly reduce the adverse effects caused by disasters, providing a set of guidelines for developing a sustained reduction of disaster risk and respond adequately to emergencies in the country .



**ONEMI**  
Ministerio del Interior y  
Seguridad Pública



## NATIONAL STRATEGIC PLAN FOR DISASTER RISK MANAGEMENT

The purpose of Plan (2015- 2018) is promote the Disaster Risk Management in the country of a transverse and priority way, therefore it seeks to provide a base line for concrete actions and promote the development the initiatives feasible on current stage job. It has 5 Priorities Axis, 26 Strategic Objectives, 84 Strategic Actions and 115 key achievement indicators.

# Thanks for your attention

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[czuniga@shoa.cl](mailto:czuniga@shoa.cl)

