



Tsunami Warning and Mitigation: Chilean Experience

**International Tsunami Symposium Commemorating
50th Anniversary of the Pacific Tsunami Warning and Mitigation System
April 2015**

INTRODUCTION

Aproximately at **15:10 of May 22, 1960** there a took place a big earthquake, witch 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.

SNAM: Legal issues

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 Official of Chile before the PTWS, (D.S. N ° 26 of 11-Ene-1966).



Mission

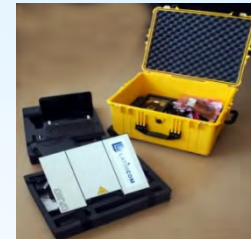
- To inform the authorities about the tsunami generation probability and the waves arrival times at the Chilean coasts.
- To report to the International Pacific Tsunami Warning System about the tsunami generation at the Chilean coasts.
- Exchange tsunami information with Peru, Ecuador and Colombia.

EVOLUTION OF THE CHILEAN NATIONAL TSUNAMI WARNING CENTER (1966 – 2015)

• Creation of NTWC.

- Implementation of a tide gauge network
- First Standard Operational Procedures(SOP).

- Incorporation of TIDE TOOLS and CISON DISPLAY.
- 2007 Creation of a Regional Group (Chile, Perú, Ecuador y Colombia), with IOC and CPPS support.



- Improval and implementation of satellite (BGAN), HF and more VHF comunications with NDMO and Coast Guard.
- Replacement and increase from 20 to 40 tide gauges. Redundancy in messure and trasmission.
- Implementation of a second DART II.
- Implementation of a NTW back-up (SHELTER SNAM).

- Update of tide gauges.
- Satelite comunicaci3n implementation.
- TREMORS implementation.
- EMWIN implementation.
- Improval of SOPs.

- 2008 Technology improval of Tide Gauges: MAWS 110.



1966

1999

2005

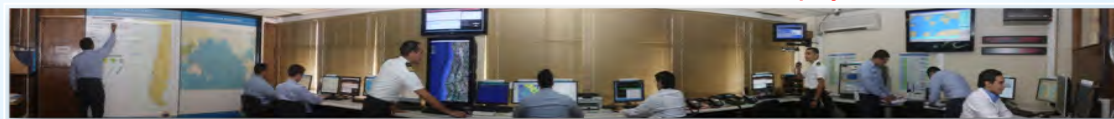
2006

2008

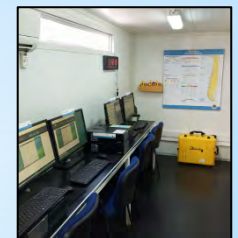
2009

2010

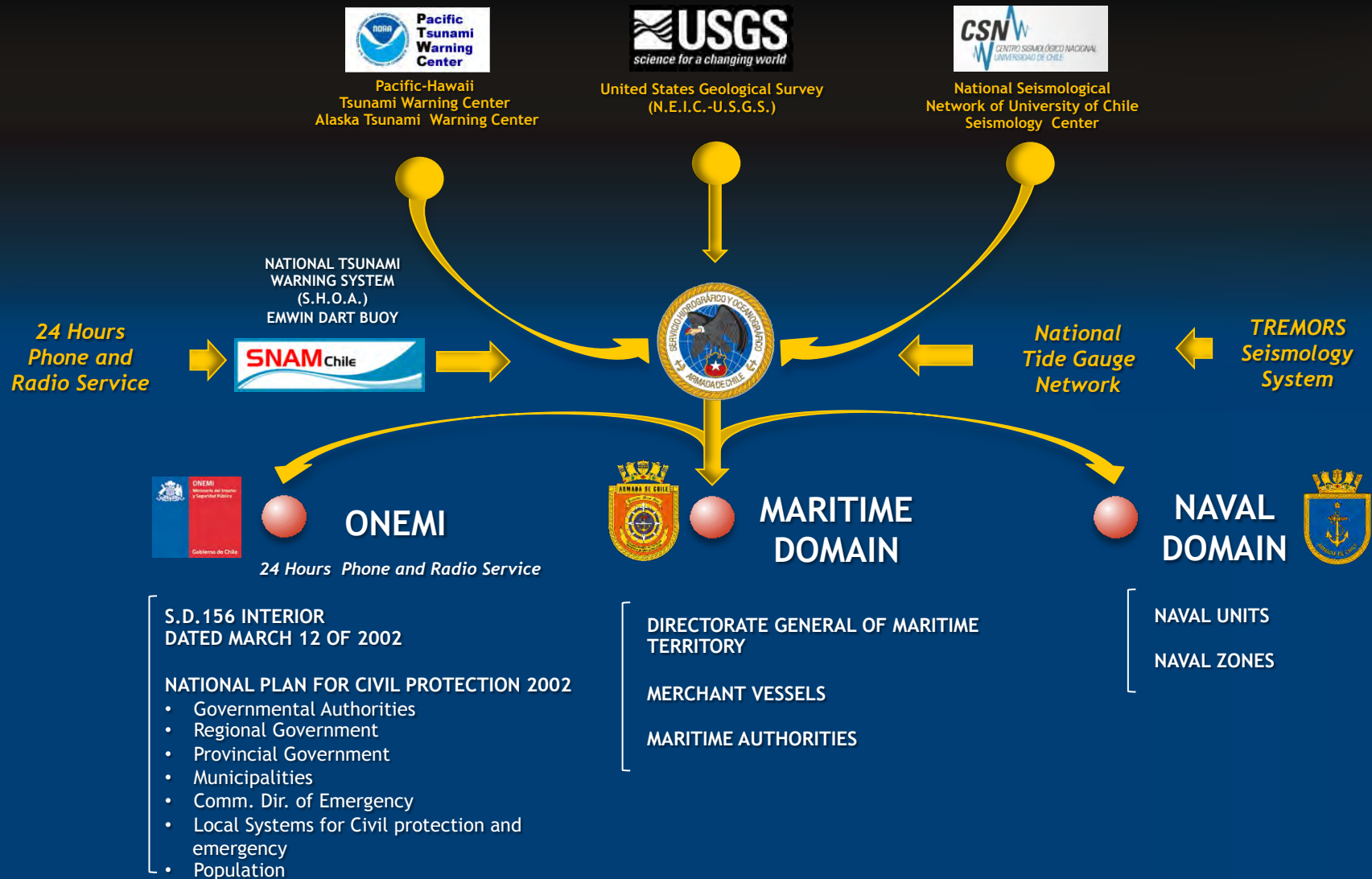
2014



- 2009 Implematation of a 5 years budget for SHOA and its TWC: better plans and projections.



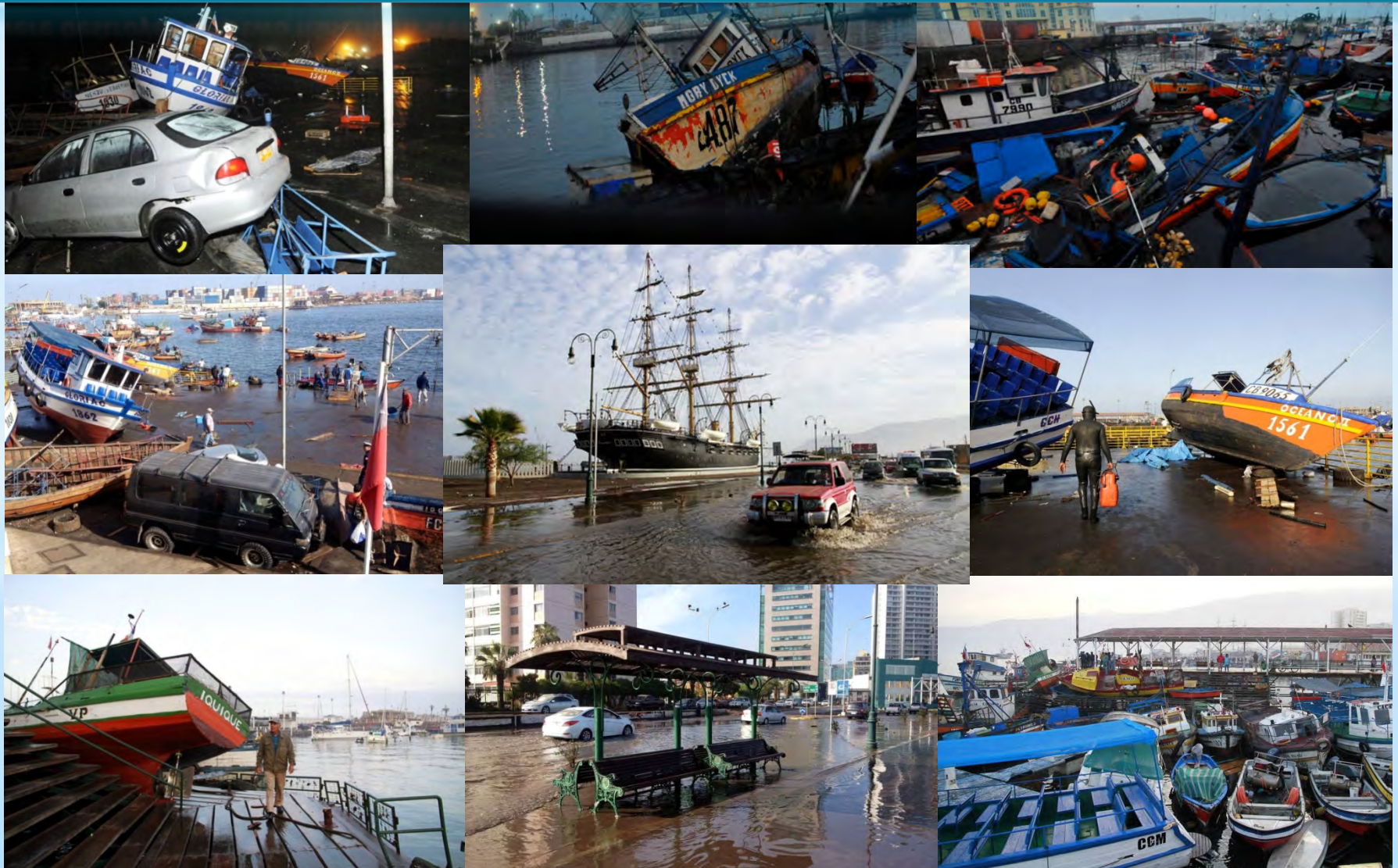
National Warning System



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.



Responsibilities and actions in emergency

National Emergency Office ONEMI

< 5 min



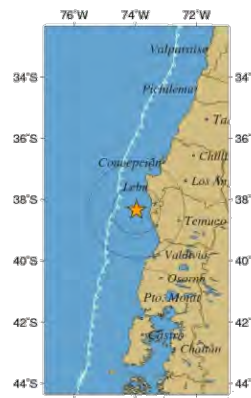
Intensity equal or superior to VII

Preventive Evacuation

Intensity = Mercalli = Subjective

Seismological Center University of Chile SS U. de C.

< 10 min



Preliminary characterization of the earthquake:

epicenter
depth
magnitude

Magnitude = Richter = Objective

Hydrographic and Oceanographic Service of the Navy SHOA

5 mins from the
information
CSN / PTWC
USGS received



Establishment
of state
of threat
Tsunami



TSUNAMI!

**INFORMATION
BULLETIN**

ADVISORY

WATCH

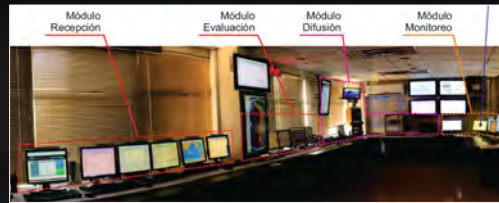
WARNING



Post Earthquake and Tsunami Challenge SNAM



Renovation and Increase
Water Level Stations



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



Support infrastructure



Installing new multibeam system
PSH Cabrales



Update Tsunami inundation
charts



Operation and monitoring



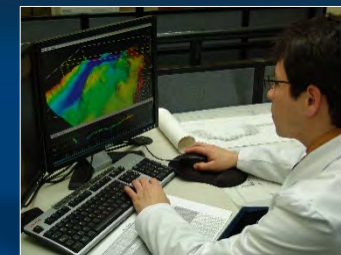
New SNAM



Procedures, exercises, specialization,
establishment of Expert Committee



Decision Support System



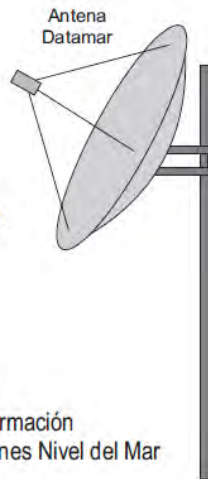
Recovery National Cartography



Second DART buoy

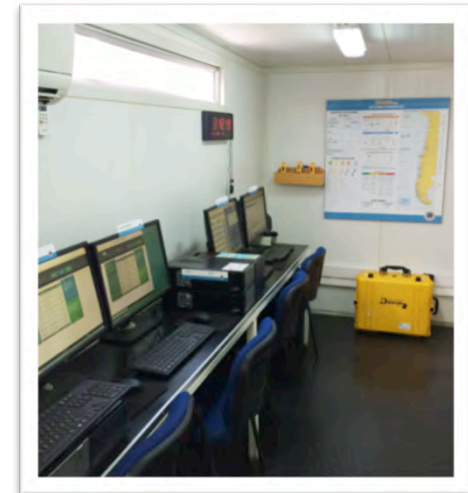
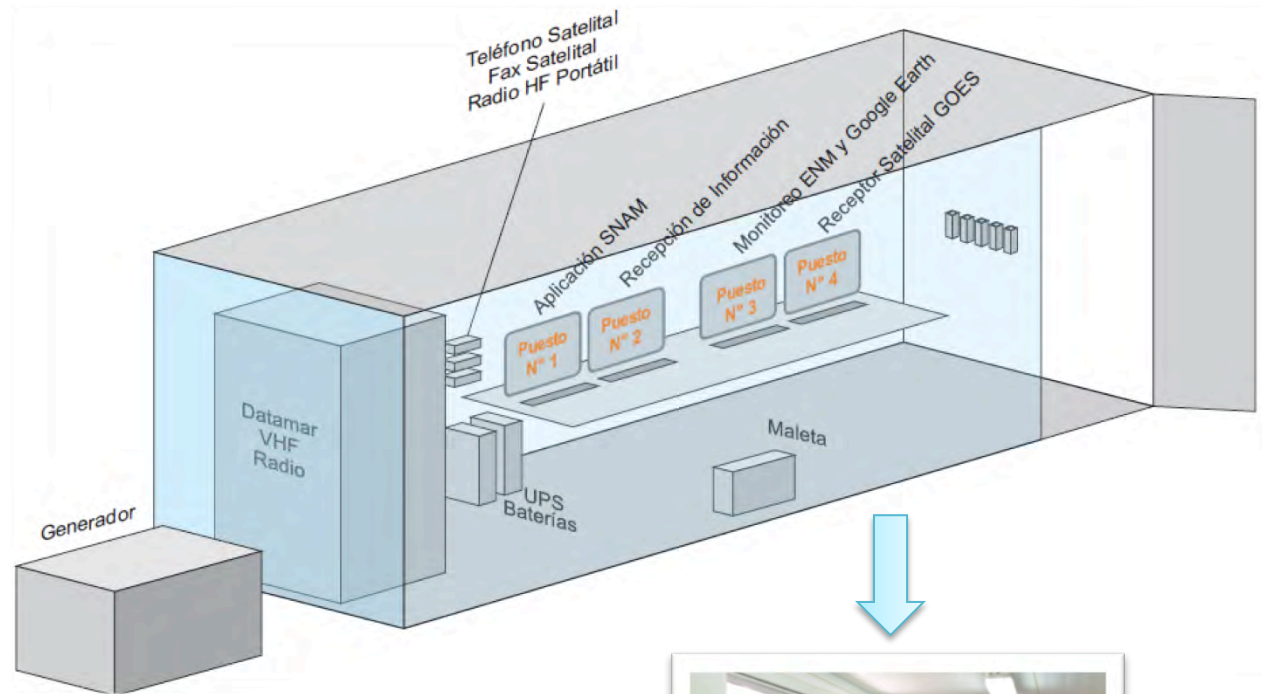


Technology, equipment , Satellite communications system, radio, telephone and fax



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



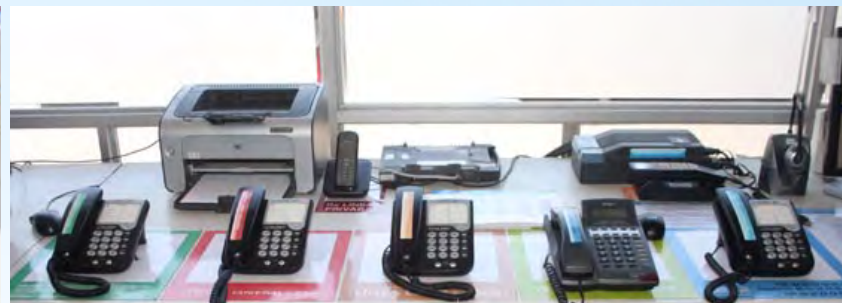
Technology, equipment , Satellite communications system, radio, telephone and fax



Information room



Messaging System



Fixed line phones and satellite line



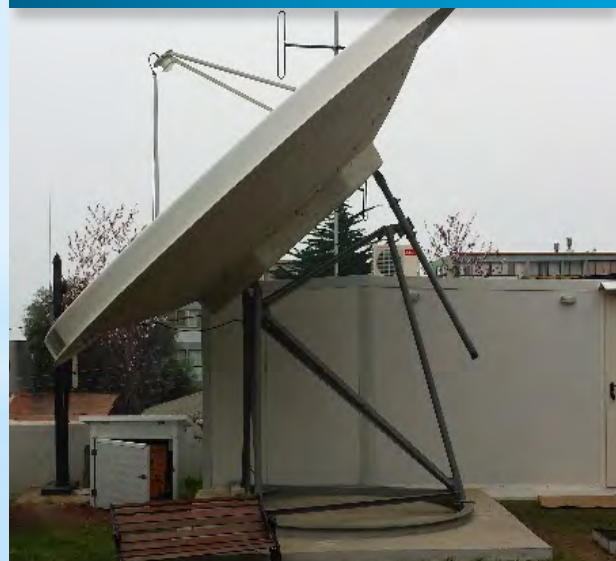
DATAMAR2 TSUNAMI System



Suitcase DATAMAR



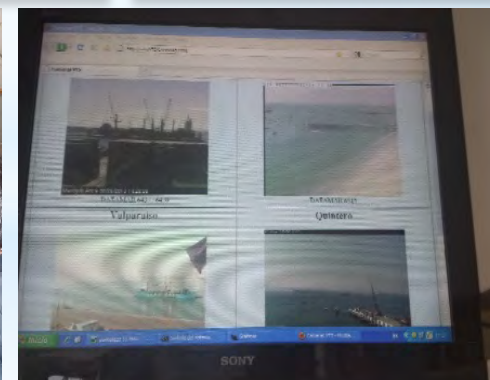
VHF ONEMI / CSN



DATAMAR Station



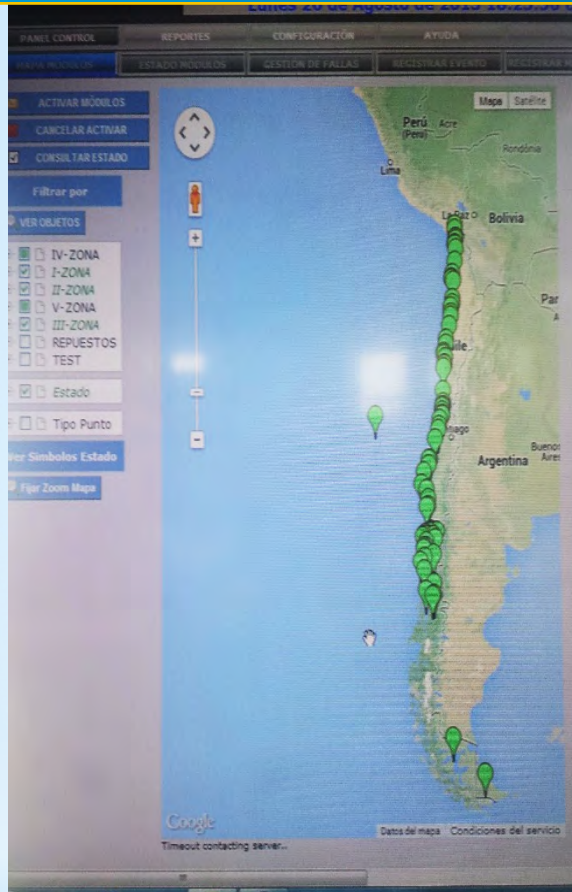
Video conference ONEMI - SHOA



VTS port display cameras



Support infrastructure and support systems



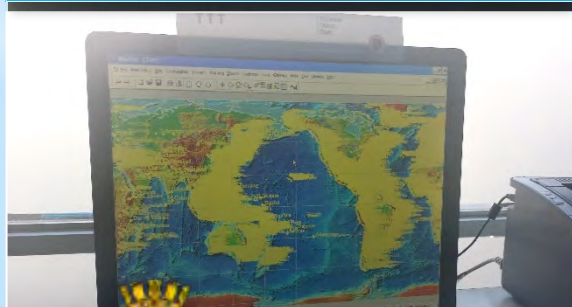
Network activation Datamar 2 - Sirens



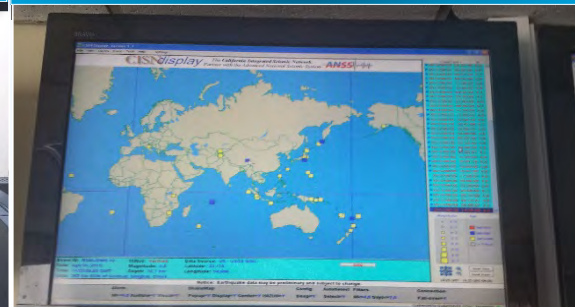
Network tide monitoring stations



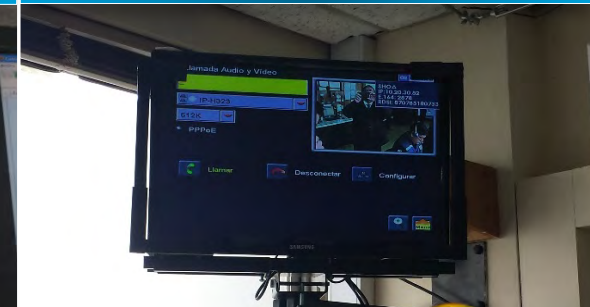
Google Earth Application



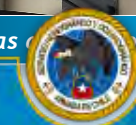
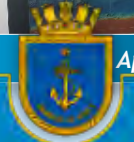
Aplication TTT



Seismic data from official sources



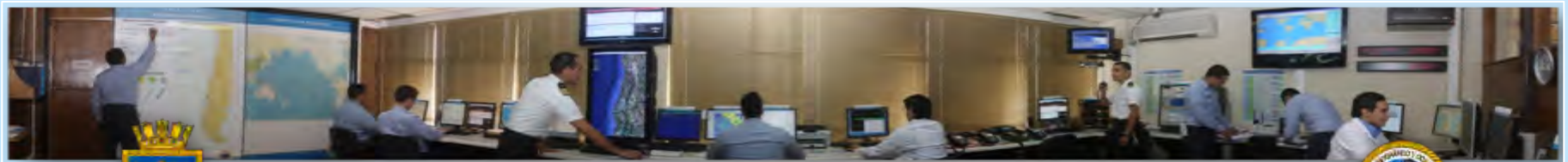
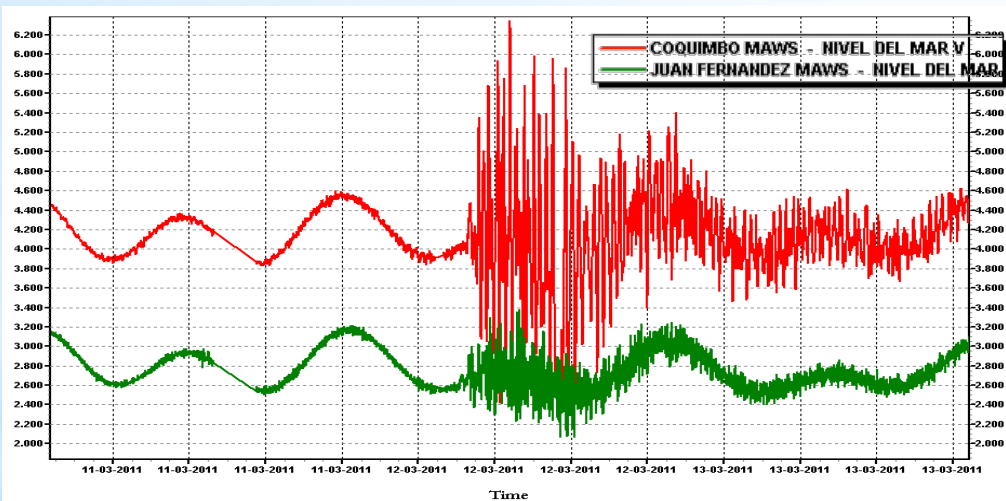
Internal control cameras



Result System National Tsunami Warning (SNAM)

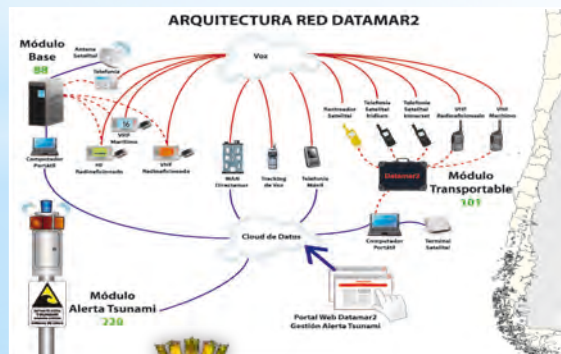
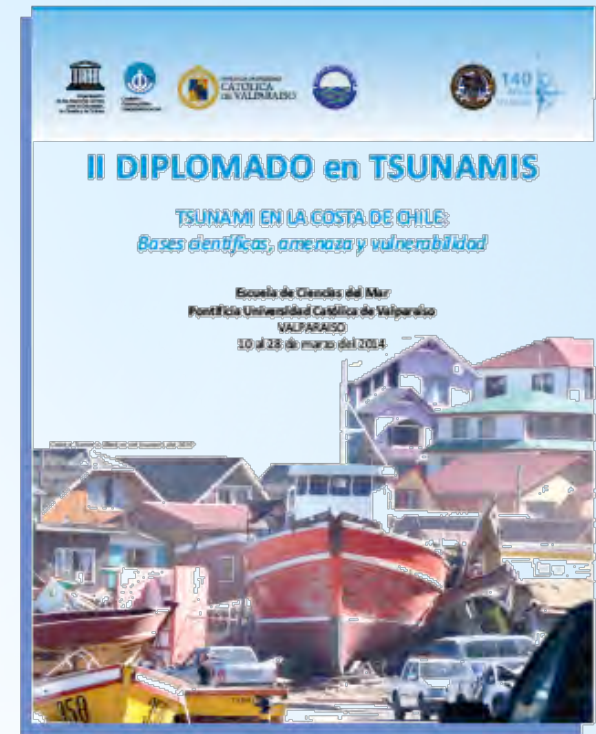
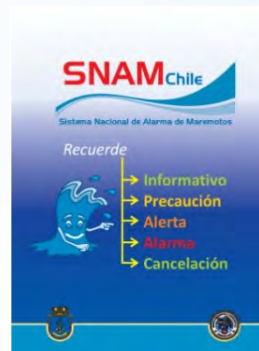


Specialization: Personal continuously trained.



Result System National Tsunami Warning (SNAM)

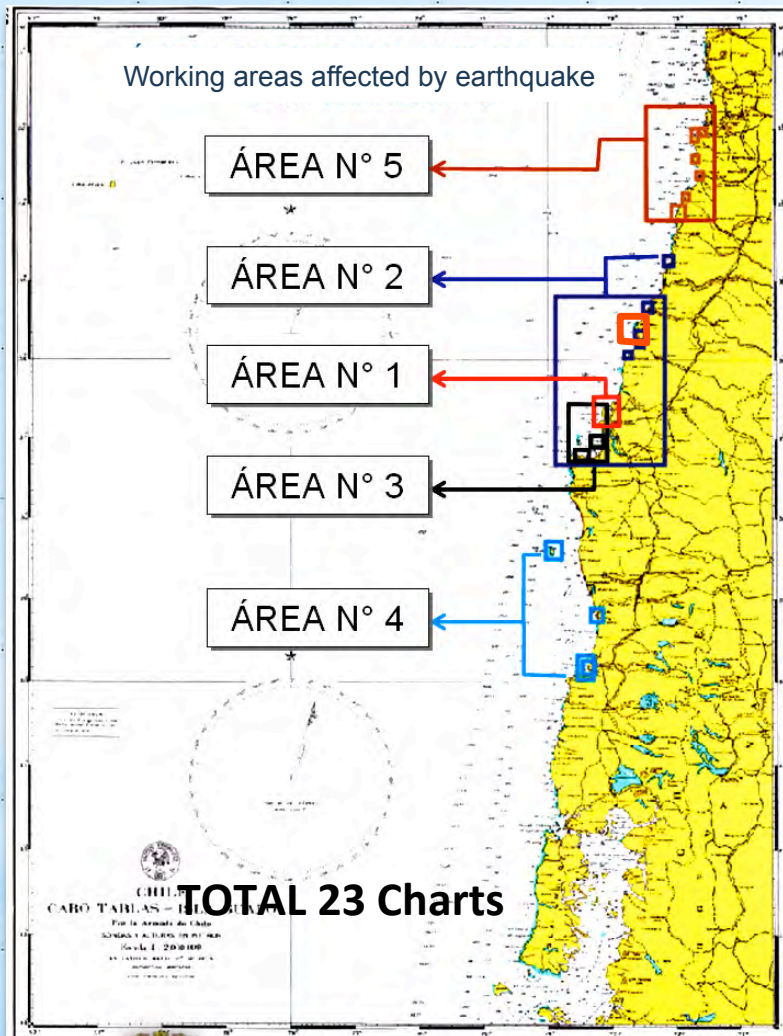
- Diffusion to the community, books, flyers, web based information.
- Tsunami Exercises: National and International.
- Increased personnel: For SNAM operation and a Head of Service and Service Professional oceanographers.
- Training and agreements: JICA / UC - UCH. - PUCV - PUCs.
- Establishment of a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



Installing new multibeam PSH Cabrales



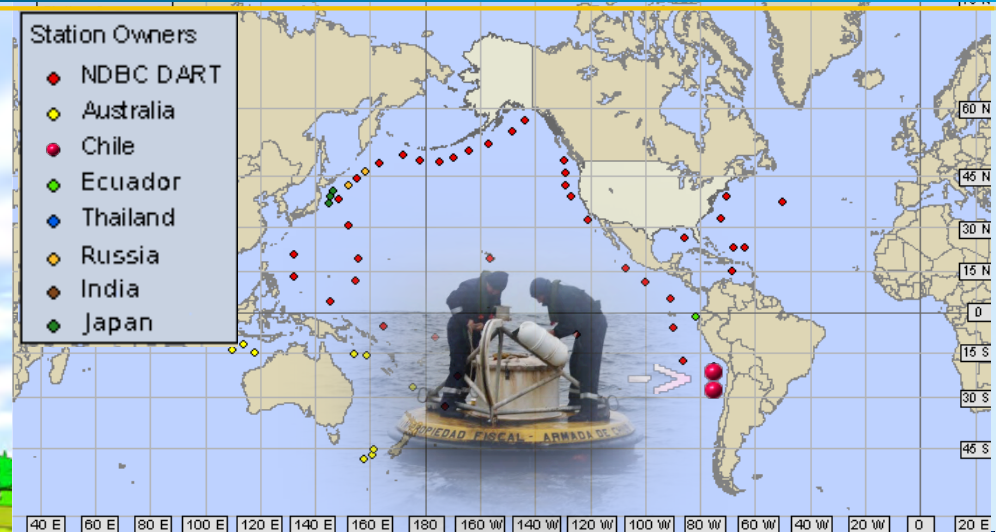
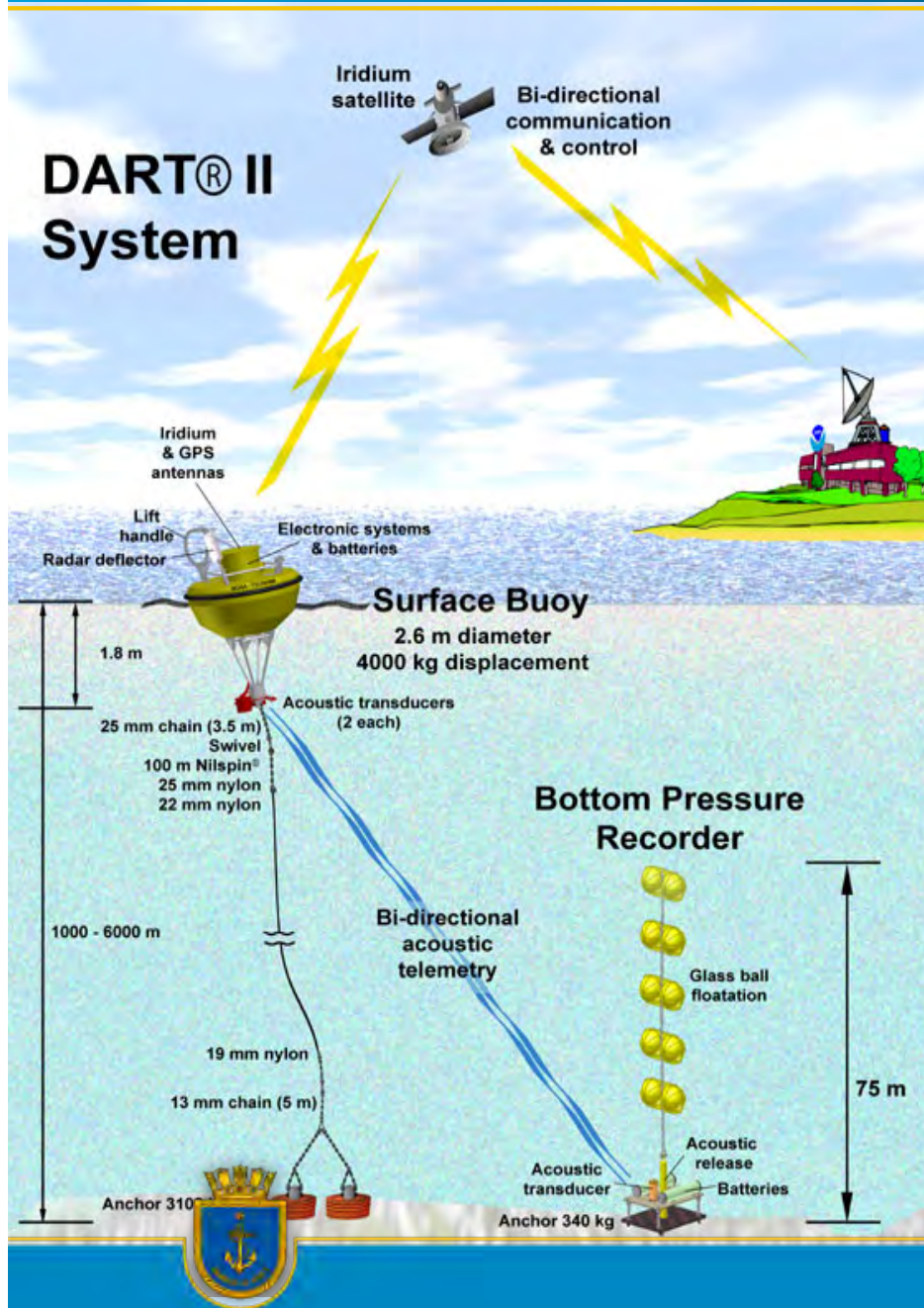
Post Earthquake and Tsunami Challenge



ÁREA N° 5 Entre Punta Pite a Punta Topocalma	5100	Punta Pite a Punta Topocalma	
	5111	Bahía y Puerto Valparaíso	
	5112	Punta Ángeles a rada de Quintay	
	5113	Rada el Algarrobo	
	5114	Aproximación a Puerto San Antonio	Lev. 2013
	5115	Puerto San Antonio	Lev. 2013
ÁREA N° 2 Desde Rada Llco a Golfo de Arauco	5411	Bahia Cumberland	✓
	5300	Cabo Carranza a Golfo de Arauco	✓
ÁREA N° 1 Bahías de Concepción y San Vicente	5311	Caletas en la Costa de Chile	✓
	6110	Bahías Concepción y San Vicente	✓
	6111	Puertos Talcahuano, Lirquén y Penco	✓
	6112	Bahía San Vicente	✓
	I-6105-E	Bahía Concepción	✓
	I-6112-A	Muelle norte, Isla Quiriquina	✓
ÁREA N° 3 Golfo de Arauco	I-6113	Caleta Las Casas – Isla Quiriquina	✓
	I-6117	Base Naval Talcahuano	✓
	6120	Golfo de Arauco	✓
ÁREA N° 4 Desde Golfo de Arauco a Bahía Corral	6121	Bahía Coronel	✓
	6122	Fondeaderos en la Costa de Chile	✓
	6000	Golfo de Arauco a Bahía Corral	
	6131	Puertos desde Golfo de Arauco a Isla Mocha	
	6231	Isla Mocha	
	6241	Bahía y Puerto Corral	

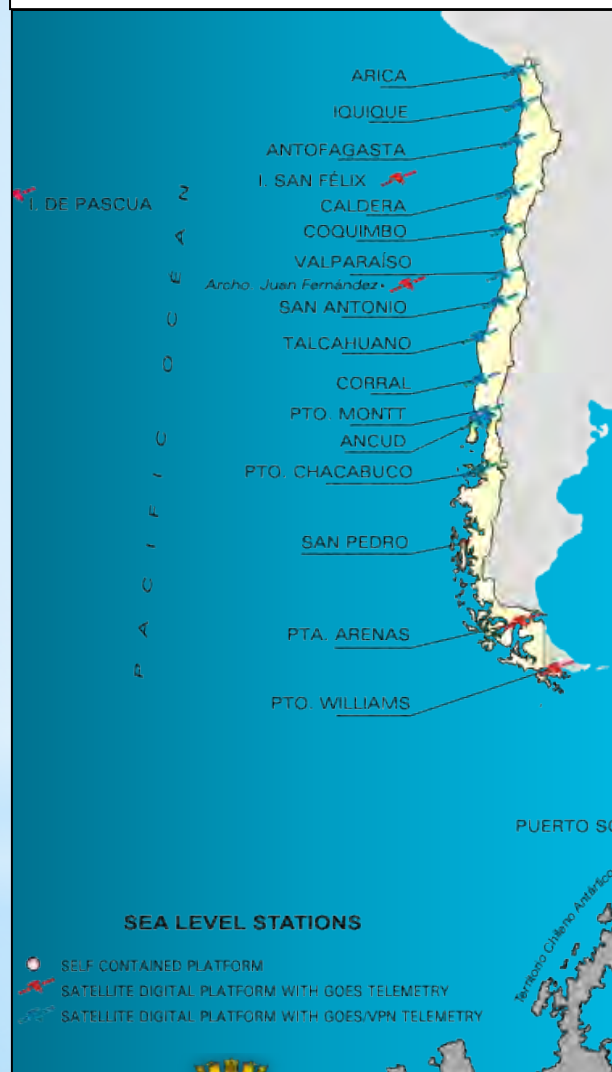


Dart Buoy



Post Earthquake and Tsunami Challenge

SEA LEVEL STATIONS BEFORE 27F: Total 20



SEA LEVEL STATIONS CURRENT SITUATION: Total 40



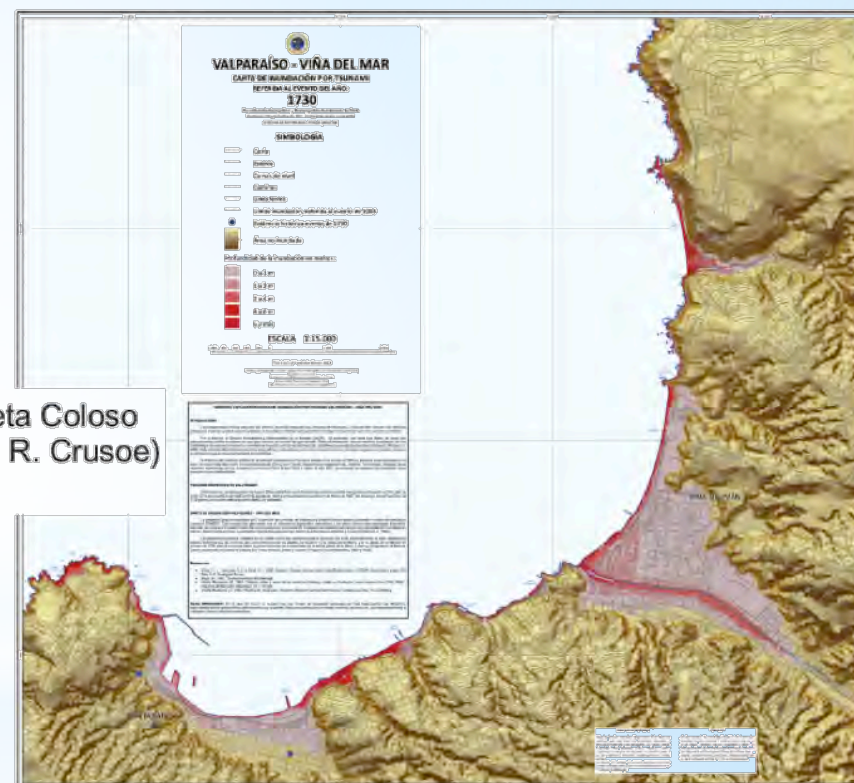
Tsunami Inundation Charts 2010 - 2016

Existing Charts (38)

- | | |
|--------------------------------------|---------------------------------------|
| 1.- Arica | 20.- Pascua, La Perouse Anakena |
| 2.- Iquique | 21.- Algarrobo |
| 3.- Tocopilla | 22.- San Antonio |
| 4.- Mejillones | 23.- Constitución |
| 5.- Antofagasta | 24.- Tomé |
| 6.- Taltal | 25.- Penco/Lirquén |
| 7.- Chañaral | 26.- Talcahuano |
| 8.- Caldera/Calderilla/bahía Inglesa | 27.- San Vicente |
| 9.- Huasco | 28.- Coronel |
| 10.- La Serena | 29.- Lebu |
| 11.- Coquimbo | 30.- Corral |
| 12.- Los Vilos | 31.- Maullin 1:20000 |
| 13.- Papudo | 32.- Maullin 1:5000 |
| 14.- Zapallar | 33.- Ancud |
| 15.- Quintero/Ventana/Horcón | 34.- Aysén |
| 16.- Concon/Ritoque | 35.- Chacabuco |
| 17.- Valparaíso/Viña del Mar | 36.- Antofagasta sur a Caleta Coloso |
| 18.- Pascua Hanga Roa/Hanga Piko | 37.- Bahía Cumberland (Is. R. Crusoe) |
| 19.- Pascua Hanga Hotuiti | 38.- Lota/Coronel |

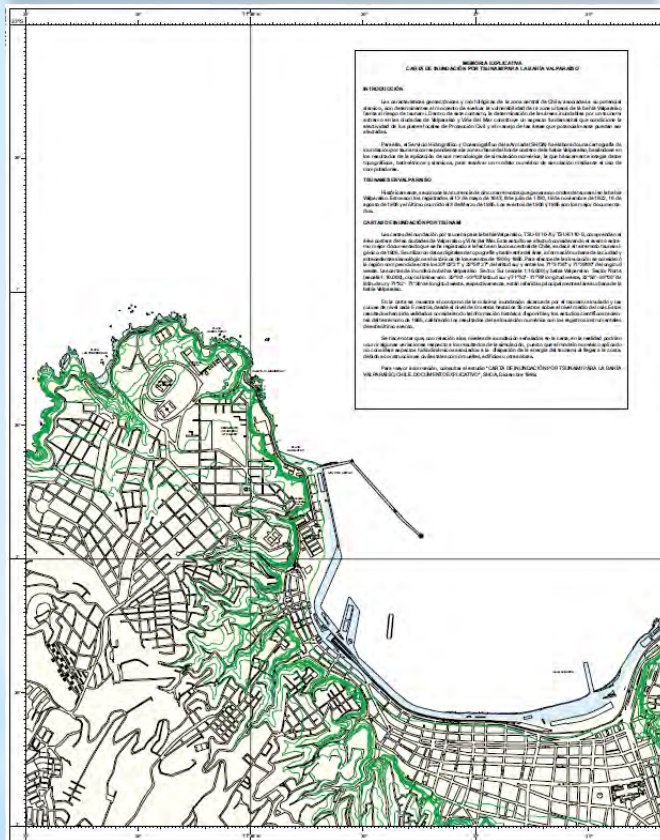
Charts to be edited 2015 to 2016

- | | |
|----------------------|-----------------|
| 39.- Punta Arenas | 45.- Pisagua |
| 40.- Puerto Williams | 46.- Cobquecura |
| 41.- Pichilemu | 47.- Trehuaco |
| 42.- Puerto Saavedra | 48.- Coelemu |
| 43.- Tirúa | |
| 44.- Quellón | |

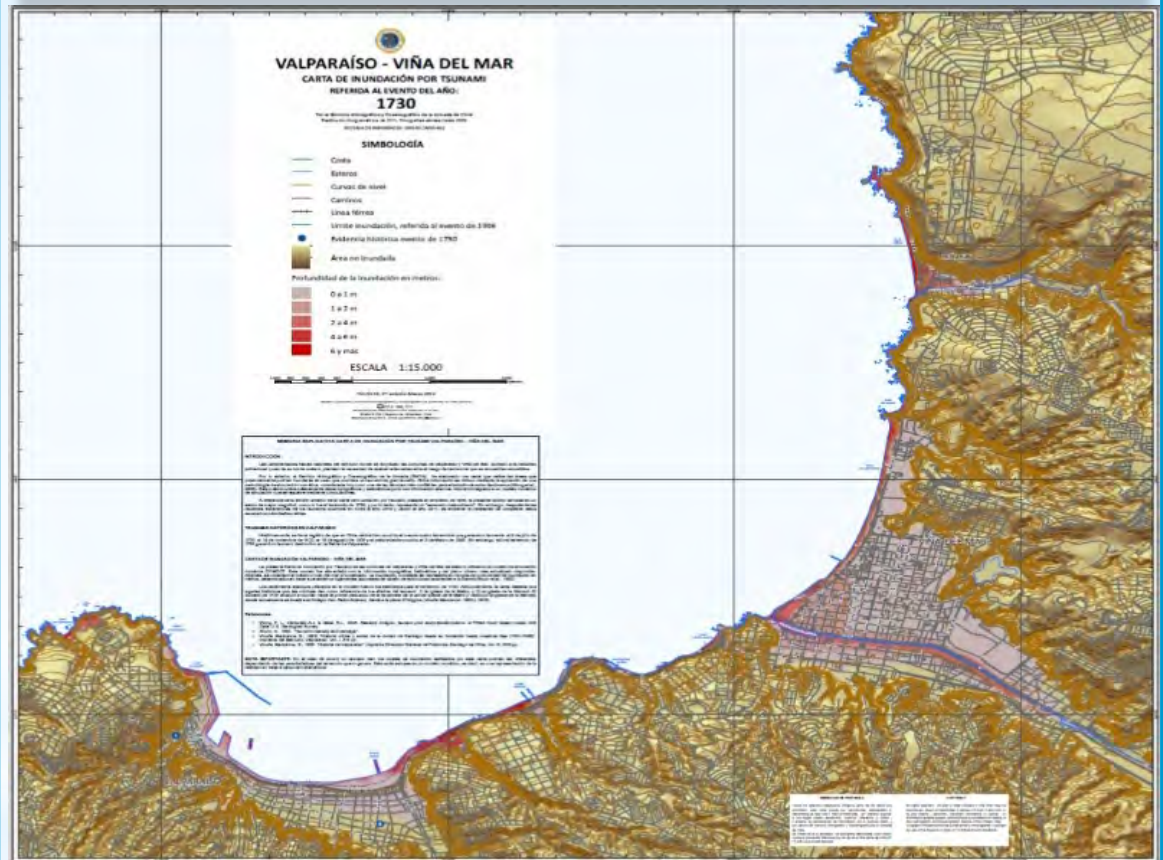


Tsunami Inundation Charts 2010 - 2016

Inundation Old Charter Valparaíso



Valparaíso - Viña del mar

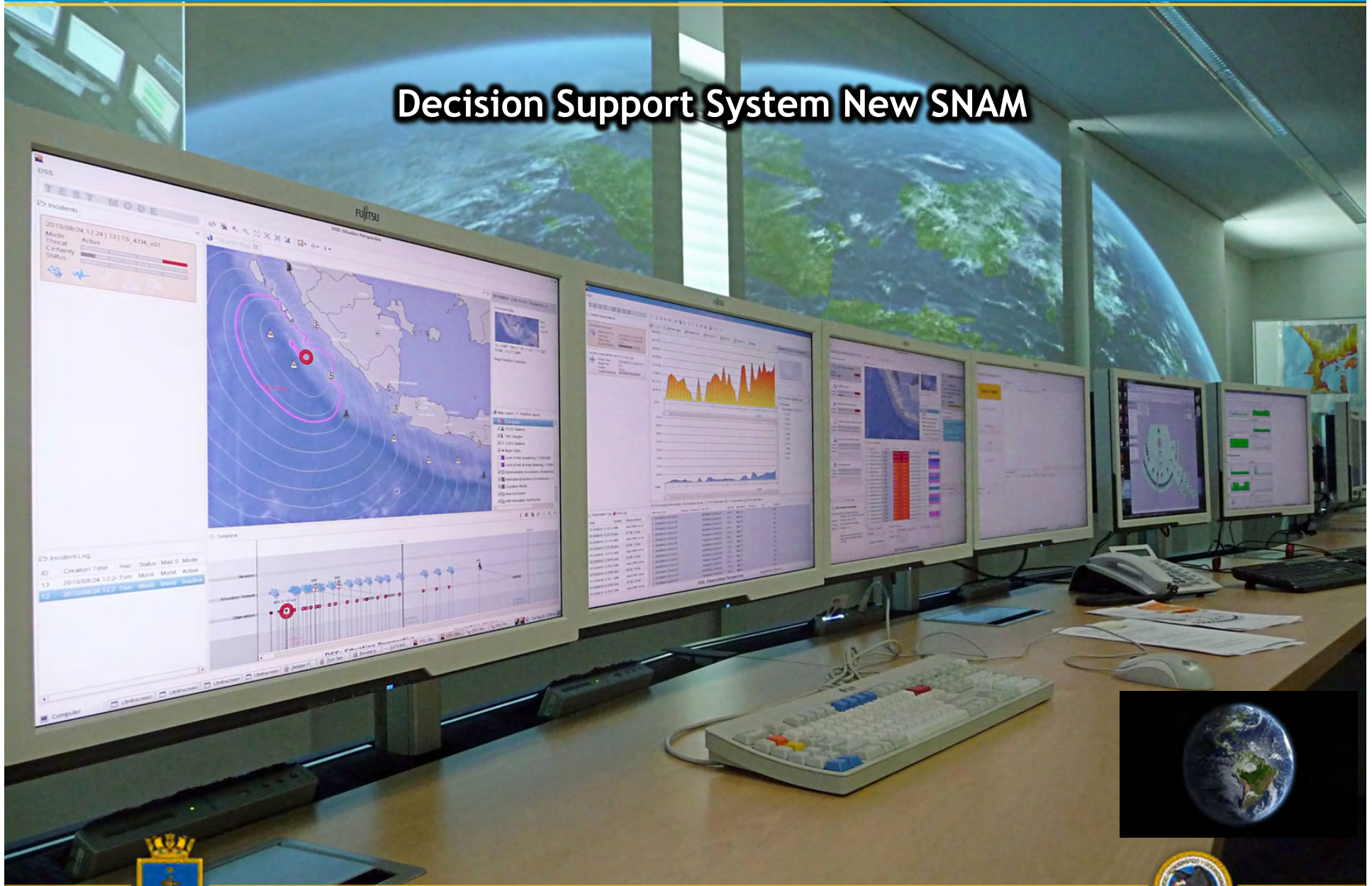


Decision Support System New SNAM

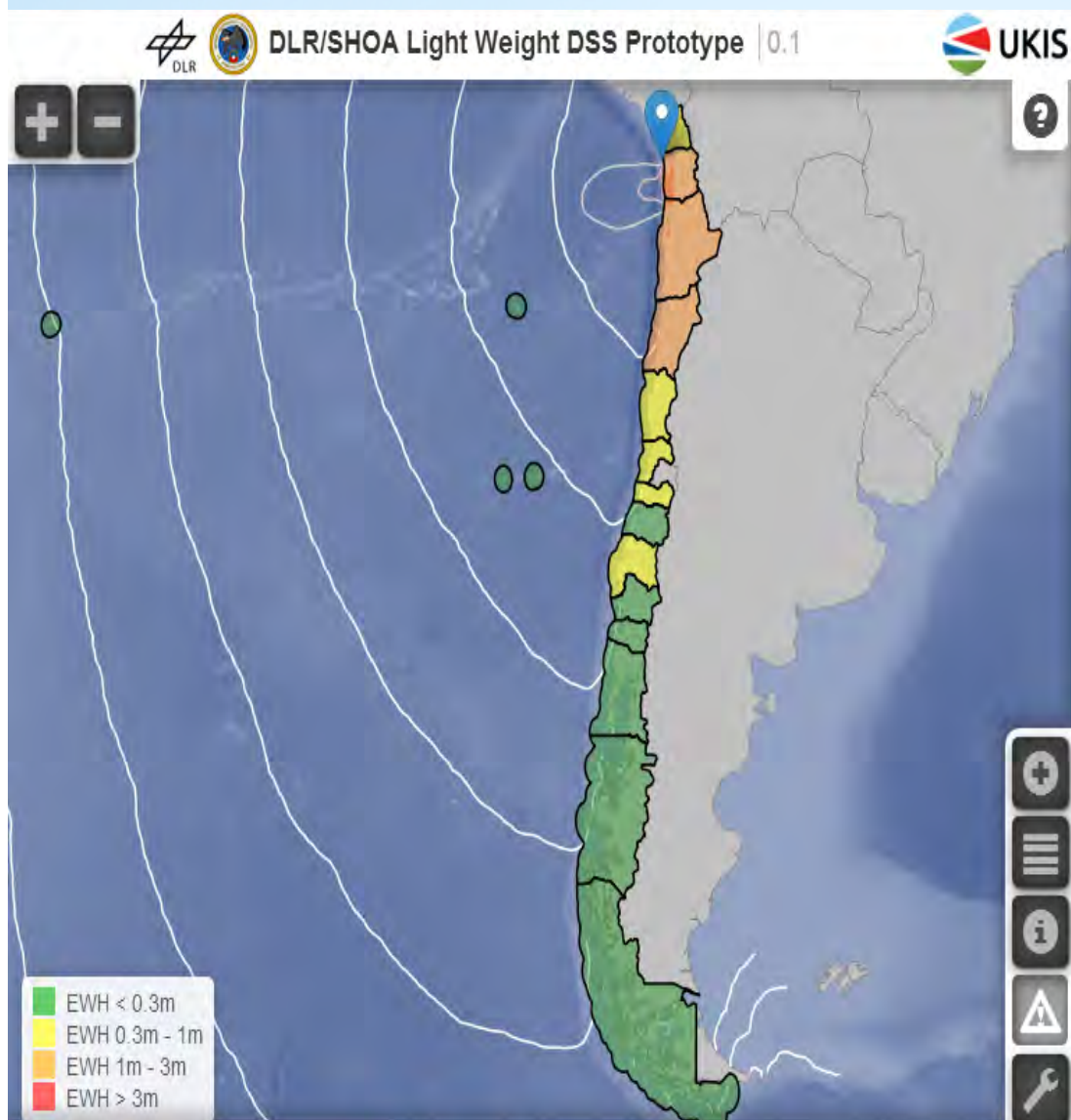


OUR CHALLENGE

Decision Support System New SNAM



DLR/SHOA Tsunami Iquique Mw 8.2



I Region de Tarapaca	2.7	1.4	0h:01m:60s
II Region de Antofagasta	2.5	0.4	0h:01m:60s
III Region de Atacama	1.2	0.2	0h:48m:37s
XV Region Arica y Parinacota	0.7	0.3	0h:22m:31s
VIII Region del Bio - Bio	0.4	0.1	2h:08m:50s
IV Region de Coquimbo	0.4	0.1	1h:10m:17s
V Region de Valparaiso	0.4	0.2	1h:40m:30s
VI Region del Libertador General Bernardo O'Higgins	0.4	0.1	1h:49m:57s
VII Region del Maule	0.3	0.1	2h:00m:12s
IX Region de la Araucania	0.2	0.1	2h:40m:00s
X Region de los Lagos	0.2	0.0	2h:54m:17s
XI Region de Aisen del General Carlos Ibañez del Campo	0.2	0.0	3h:32m:35s
San Felix	0.1	0.1	1h:37m:46s
XIV Region de Los Rios	0.1	0.1	2h:43m:51s
XII Region de Magallanes y la Antartica chilena	0.1	0.0	4h:27m:57s
Archipelago Juan Fernández	0.1	0.1	2h:13m:18s



DLR/SHOA Tsunami Iquique Mw 8.2



DLR/SHOA Light Weight DSS Prototype | 0.1



UKIS



Matching #401

Created: 2015-04-01T10:13:20Z

based on Observation(s)

ID	Date/Time (UTC)	Mag	Lon	Lat	Depth
401	2015-04-01T10:21:15Z	8.3	-71.00	-31.00	30 km

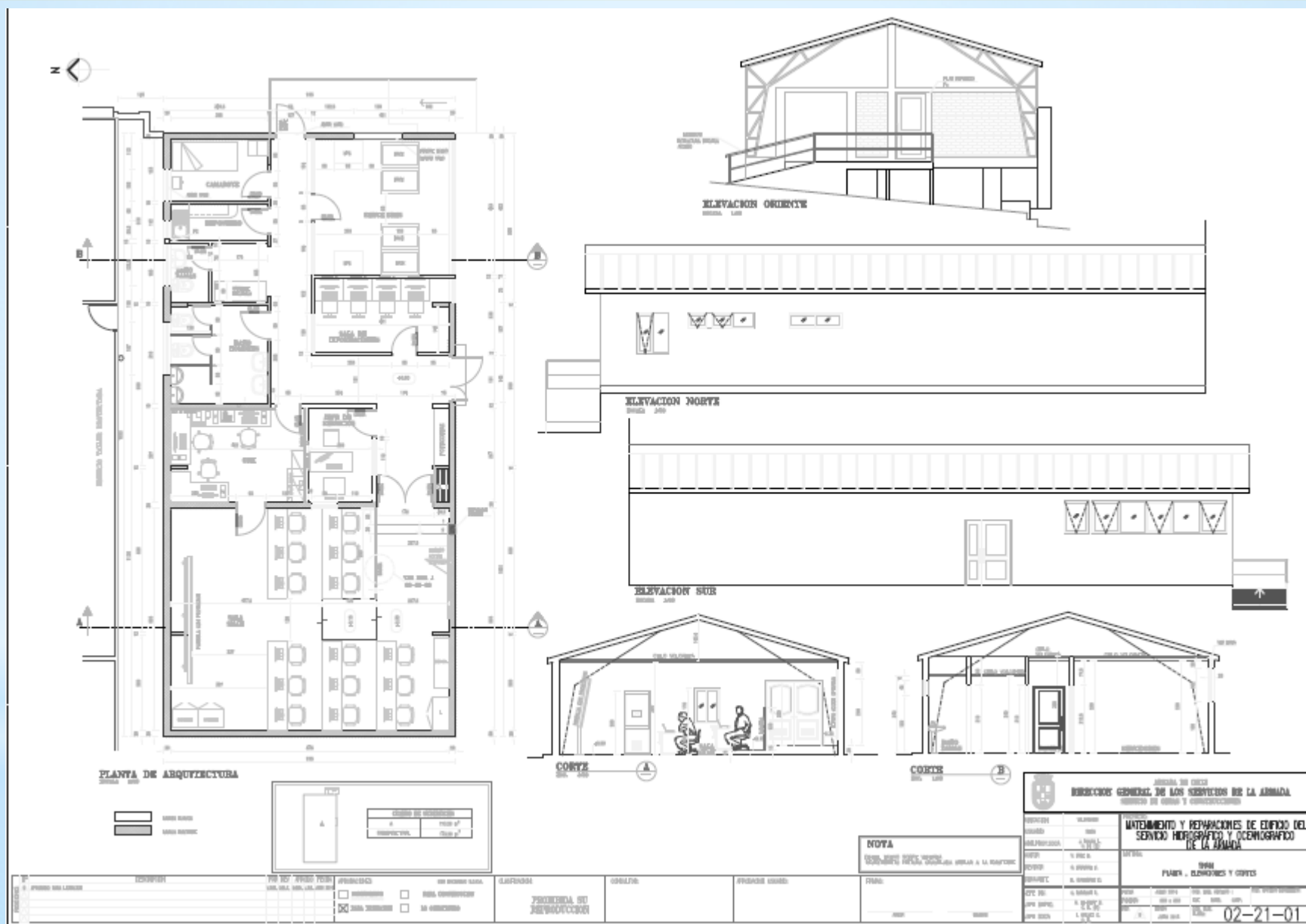
Scenario

Scenario ID: r2012_m030_mw8_50_dep030_n0131_10h

Region	maxWH	medianWH	minETA
IV Region de Coquimbo	4.2 m	2.3 m	0h:00m:00s
V Region de Valparaiso	3.4 m	1.9 m	0h:06m:26s
III Region de Atacama	2.5 m	0.5 m	0h:17m:07s
VI Region del Libertador General Bernardo O'Higgins	2.4 m	0.9 m	0h:29m:34s
VII Region del Maule	1.5 m	0.7 m	0h:41m:10s
II Region de Antofagasta	1.5 m	0.2 m	0h:49m:24s
VIII Region del Bio - Bio	1.1 m	0.3 m	0h:49m:59s
Archipelago Juan Fernández	1.1 m	0.5 m	1h:04m:57s
San Felix	1.0 m	0.3 m	1h:26m:08s
I Region de Tarapaca	0.7 m	0.3 m	1h:25m:33s
IX Region de la Araucania	0.7 m	0.4 m	1h:21m:26s
XIV Region de Los Rios	0.5 m	0.2 m	1h:25m:03s
X Region de los Lagos	0.5 m	0.1 m	1h:35m:59s
XI Region de Aisen del General Carlos Ibañez del Campo	0.4 m	0.1 m	2h:14m:13s
XV Region Arica y Parinacota	0.3 m	0.2 m	1h:46m:37s
XII Region de Magallanes y la Antartica chilena	0.3 m		3h:09m:39s



NEW SNAM/ UNDER CONSTRUCTION



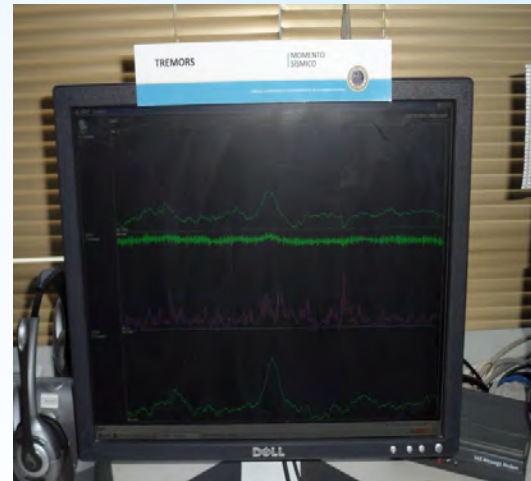
NTWC: FIRST STEPS



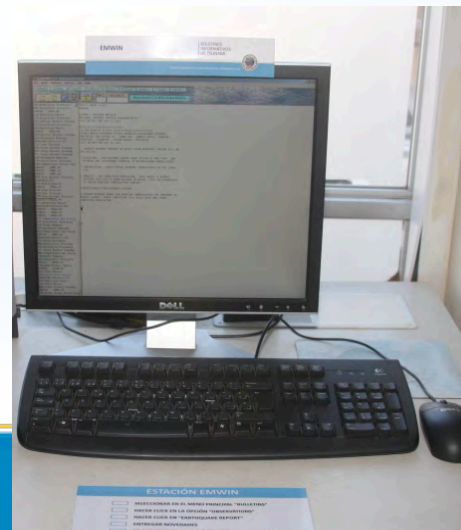
- Two computers
- Fax
- Telephone



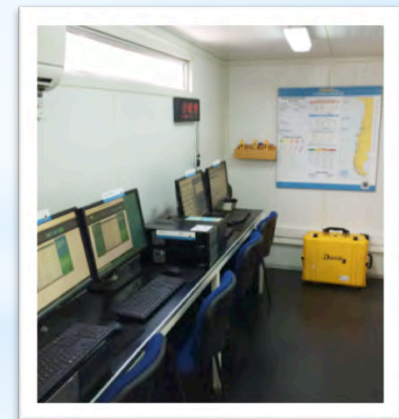
NTWC: FIRST STEPS



- 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.

**TALCAHUANO 28th
FEBRUARY 2010**





Contribution of hydrography in global development



Hydrography – Much more than just nautical charts!



Hydrography – Many users..... Many applications!





Actively contributing to the development of the country

