Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG-PTWS)
Steering Committee Meeting

A Progress Report
Working Group for the Southeast Pacific Region

EARLY WARNING SYSTEM FOR REGIONAL TSUNAMI IN THE SOUTHEAST PACIFIC (IOC/UNESCO – CPPS)

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1. Background

Today there is an International Tsunami Warning System for the countries of the Pacific Ocean basin. This system is very effective for places or countries that are far from the tsunami generation; consequently, it is very important that our Region counts on an “early warning system“, for epicenters located to less than 6 hours of reaction, to take the corresponding measures and actions.

The coastal zone of the Pacific has the highest risk of seismic waves due to is surrounded of a belt of great tectonic activity and a volcano chain that is called Fire Circle of the Pacific. Therefore, the Pacific Ocean is structural, topographic and seismic conditional upon serving as propitious field to vents of the telluric tensions, becoming thus, in the most active earthquake generating system of our planet and to constantly undergo terrestrial modifications due to these phenomena, and with it the potential threat of tsunami generation.

The recent events, as the earthquake of 2007 in the coast of Pisco city, originated a local tsunami too, reminded the coastal vulnerability of our Region. For this reason, Early Warning Tsunami System in the Southeast Pacific is being implemented. It looks for new ways to promote the organization and coordination between the authorities responsible for the National Warning Centers of four neighboring countries: Colombia, Chile, Ecuador and Peru, which are part of the Permanent Commission for the South Pacific (PCSP). This system is coordinated and promoted by the Directorate of Scientific Affairs of the PCSP and the Intergovernmental Oceanographic Commission (IOC/UNESCO).

2. Actions to be considered

In November 2007, the Permanent Commission for the South Pacific (PCSP), approved by Resolution Nº 12 in the VI Ordinary Assembly, the high-priority incorporation within its program of activities, the early warning tsunami system cooperation project, in support to the global systems that exist, to improve the coordination and response levels of the neighboring countries and PCSP’s member states; i.e, Colombia, Chile, Ecuador and Peru.

For this, the PCSP along with the Intergovernmental Oceanographic Commission (IOC/UNESCO), organized a Workshop on Implementation of a Regional Tsunami Warning System in the Southeast in the Dirección de Hidrografía y Navegación de la Marina (Directorate of Hydrography and
Navigation of the Navy) (Lima - Peru), in February 2008. This event met to
the national representatives of the seismic and tide gauge networks of the
region. They assessed the present conditions of the local and national
warning system as well as the education and dissemination means of the
population to this tsunamigenic events.

Also, the VII the Assembly of the PCSP decided according to the
Resolution Nº 7 the “continuance of the work on the Implementation of a
Regional Tsunami Warning System” and the “Development of a Multi
threat for other kinds of Marine Origin Risk System in the Southeast Pacific
Region”. The latter is because the countries of the region by its location, in
addition to the risk to tsunamis, are affected with the increase of the sea
level and coastal erosion, among others, as a result of the global climatic
change, as well as, to El Niño and La Niña recurrent phenomena and the
extreme events that make vulnerable our coastal profiles.

In May 2009, a Workshop for the Coordination and Monitoring to the
Regional Early Warning Tsunami System for the Southeast Pacific” was
carried out in Bogota, Colombia. Also a “Vulnerability to coastal zones
Assessment from a environmental point of view and the necessity of an
integrated management” presented by the doctor Carmen Lacambra from
Cambridge University.

3. Terms of Reference

a) To evaluate the capacities of the countries in the Southeast Pacific
Region, to provide the total coverage in warning and mitigation to
tsunami services

b) To find out the requirements of the countries in the Southeast Pacific
Region, to provide the in warning and mitigation to tsunami services

c) To promote and to facilitate the risk of tsunami studies in the Region.

d) To facilitate the cooperation in the establishment and improves of the
seismic stations and sea level networks, as well as, the communication
systems in the Region, and its interoperability, according to the
ICGP/PTWS requirements.

e) To improve the educational programs with criteria based on social, cultural
and economic regional reality.

f) To facilitate the spreading capacity on tsunami in the region, even the free
and opened data exchange.

The Group will be formed by representatives appointed by the Members
States of Colombia, Ecuador, Peru and Chile, with a Chairman and a Vice-
Chairman elected by the region.
The Regional Tsunami Early Warning System will be made up of the seismic, tide gauge and national civil defenses services, interconnected in real time, promoting the education and preparedness of the coastal population. Also, and mainly, it must consider that, due to the tsunami speed, the points next to the epicenter could receive the alert too much late.

4. Objectives

General Objective

To warn the loss of lives due to tsunamis in the countries of the Region, with an early warning system to these events. To mitigate the economic losses due to tsunami, fostering the elaboration of flood, vulnerability and risk maps, that include routes of escape and refuge zones.

Specific Objectives

a) To improve and to implement both the seismic and local and current tide gauge systems to get real time information regarding to sea level variation, as well the earthquake characteristics in each national tsunami systems of the PCSP.

b) Also, to improve the prevention system by the spreading on the alert of tsunamis to the coastal population, through mass media with good level of trustworthiness and exactitude of the same one.

c) To implement and to improve the education and awareness programs of the population on which it will have to do in case of alert to tsunami.

d) To impel the studies on the tsunami characteristics, the threat, vulnerability and risk of these phenomena in the South Pacific coasts.

5. Present Situation – First Workshop

The first Workshop on “Regional Tsunami Early Warning System for the Southeast Pacific” from February 26 to 27 2008 in the premises of the Dirección de Hidrografía y Navegación de la Marina del Perú was carried out. The Tsunami Warning National Focal Points of Chile, Peru, Ecuador and Colombia, as well as, the Seismic and Tide Gauge Monitoring Networks to the national representatives of these countries were met.

The objective of the meeting, was to evaluate the existing conditions in local both seismic and tide gauge observation systems, the regional coordination, the implementation and integration of these local and national systems to the Regional Network, that allows to monitor and alert
on time to the settler, causing the exchange and accessibility to the seismic and sea level data to a possible “Alert of Tsunami”.

At the moment, there are some deficiencies in the local observation systems, mainly, regarding the delay in receiving the information. Nevertheless, the regional coordination that will be developed looks for the integration of the local and national systems to the regional networks, spreading out beyond the political borders, which allow to monitor and to alert on time to the population.

5.1. Seismic Networks

Following are detailed the present characteristics of the seismic regional networks i.e; of the four neighboring countries:

The National Network of seismographs the Geophysical Institute (RENSIG) from Ecuador, now in operation, is based primarily on a network of 17 short period stations, 22 stations short period of Volcano Observatories (Tungurahua, Guagua Pichincha, Cotopaxi, Cayambe and Reventador). In addition to 8 and 10 RENSIG BB Volcano Observatory (Tungurahua and Cotopaxi). All these stations are transmitted in real time to the Geophysical Institute. It also has dual-frequency GPS stations on the coast, highlands and east.

The National Seismic Network (RENSIG) of Ecuador, now in operation, is based mainly on a network of 17 short period station, 22 short period stations of Volcano Observatories (Tungurahua, Guagua Pichincha, Cotopaxi, Cayambe and Reventador). In addition, it counts on to 8 and 10 RENSIG BB Volcano Observatory (Tungurahua and Cotopaxi). All these stations are transmitted in real time to the Instituto Geofísico. It also has dual-frequency GPS stations on the coast, highlands and east.

The Corporation OSSO (South West Seismic Observatory) and the Instituto de Geología y Minería (Colombian Geology and Mining Institute) (INGEOMINAS) of Colombia, count on six stations which four of them operate with a broadband and form the Colombia National Seismic Network. It has a good accessibility to the information of the stations (broadband) and a permanent attention service for the detection and warning in case of earthquakes.

The National Seismic Network of Chile, does not work in real time, but in analogous form, that is why it is necessary to transform it into a automatic processing system of epicenters. The project is considering 65 stations and 180 detection devices of seismic events. It is hoped to count on the real time positioning of the events, with a transmission no longer than five seconds. The real time transmission of the Broadband Stations, the accelerometers and the GPS will be got. Also, by means of the National Tsunami Warning System (SNAM) depends on the SHOA, counts on a TREMORS system for the determination of the moment seismic parameter.
The National Seismic Network (RSN) of the Instituto Geofísico del Perú (Geophysical Institute of Peru) is composed of broadband stations, sensors and stations GURALP analogous / digital, 41 seismic stations recording speed (seismometers) and 22 acceleration recording stations spread across the country. It has a satellite seismic telemetry system, consisting of three collection sites: Lima, Chiclayo and Arequipa, where all information is received at the Center of Camacho (Lima). It also has the TREMORS system.

5.2. Tide Gauge Networks

Listed below are the current characteristics of tide gauge networks of the four neighboring countries:

**Ecuador** has ten tide stations, managed by the Instituto Oceanográfico de la Armada (INOCAR) and three satellite stations managed by the National Oceanic and Atmospheric Administration (NOAA). There are conventional and automated equipment, these include digital Stevens brand (GS-98 and Axis), whose record is five minutes and the transmission system is mobile cellular line (GPRS) and by land, while the reception is once a day.

**Colombia**, has six tide stations, managed by the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) (Institute of Hydrology, Meteorology and Environmental Studies). It has conventional and automatic; Ott and Sutron trade whose registration and reception is every ten minutes and hours, and its transmission system is by land and satellite (GOES-12), respectively.

**Chile** has seventeen tide stations, operated by the Servicio Hidrográfico y Oceanográfico de la Armada (SHOA). (Hydrographic and Oceanographic Service of Chilean Navy) It has conventional and automatic (Vaisala Hanar and 555) whose registration is every two minutes and its satellite transmission system is GOES-NESDIS/NOAA Telnet and its reception is once per hour.

**Peru** has eleven tide stations managed by the Dirección de Hydrografía y navegacion de la Marina Peruana (DHN) (Directorate of Hydrography and Navigation of the Peruvian Navy) and three satellite stations managed by the National Oceanic and Atmospheric Administration (NOAA). It has conventional and automatic equipment; among these we have the Standard Milos and Sutron, whose record is an analogue continuous, every minute and hour. The transmission system is terrestrial, radio link and satellite (GOES-8) and receiving monthly, every minute and every three hours, respectively.

5.3. Communication Systems
Both stations that form the seismic and national tide gauge networks do not have continuous and real-time communication systems is noted. Also, these networks operate independently, without a continuous transmission system with the national warning center.

Although in recent years, the media have improved a lot with the internet, which makes possible to transmit messages automatically and within seconds from a communication center to dozens of recipients at a time, there are also obstacles in the same feature, such as low speed of internet that some institutions have and make sometimes impossible the fast transmission of alerts to the whole region. It must be noted that the earthquake that generated a tsunami is capable of affecting terrestrial communications systems and make it impossible to use for sending alert messages. Then, it requires similar devices that operate independent of vulnerable terrestrial systems (radio and satellite communications).

5.4. Warning Systems for coastal population

It is important to determine the threat, to guide the alert to issue the statement. For this, it has been observed that there are no sirens in many coastal towns, which could be used to frighten the public. For the time being, social media, such as radio and television and traditional media in the villages could be used as the only possibility.

On the other hand, here is the name and organizations responsible for the national tsunami warning and evacuation systems of the countries of the region:

**Ecuador**
- National Tsunami Warning System (SNAT)
  Responsible: Instituto Oceanográfico de la Armada del Ecuador (INOCAR)
  The Regional Tsunami Information Center is included within this system which works in Santa Cruz Station in the Galapagos Islands.
- Secretaria Nacional de Gestión de Riesgo (National Secretariat for Risk Management) (SNGR)

**Colombia**
- National Tsunami Detection and Warning System (SNDAT)
  Responsibilities: Comisión Colombiana del Océano (CCO) (Colombian Ocean Commission)
  La Corporación OSSO
  Dirección General Marítima (DIMAR)
5.5. Information and education for population

The knowledge level varies between different sectors of government and population in the countries of this region, but due to recent events, the interest in this matter has increased. The experience of the earthquake - tsunami of 2007 (Peru) and of this year (Chile) have been very traumatic experiences and are still in our thoughts.

The countries of the region agree with education is one of the most effective tools to mitigate this phenomenon. Therefore, the mitigation function, will be aimed at diminishing the impact of tsunami, and includes the contribution provided to civil society through the preparation of flooding charts and education to the population that spreads each institution.

The responsibilities of the warning systems as well as those of an immediate evacuation of people and mitigation must be well defined by the mandates that have national organizations. In addition, each country should know the type of alert broadcasted, type of tsunami generated, contingency and evacuation plans, etc. It should also shared information and its dissemination through the press as a means to disseminate the alerts / alarms, with caution, to get a real contribution to disseminate the information.

There is a lot of very good quality material on the threat of tsunami warning systems, protective measures in Spanish and English language elaborated by the International Early Tsunami Warning System in the Pacific. This material is easily accessible, free, and may be disseminated by the various organizations involved in Civil Protection, Ministry of Education, NGOs. It must be highlighted that the reading material for different school levels produced by Chile,
Conclusions and Recommendations

Conclusions:

- The coordination will be made by the region through both channels that recognize the Regional Group, which are: the IOC and PCSP.
- To improve the existing conditions in both seismic and local tide gauge observation systems, promoting the data exchange and accessibility through standard protocols to a possible "Tsunami Warning." Both the seismic and tide stations should be transmitted in real time, at least every five minutes so that all national warning centers in the region also received this information in real time. For this, we must standardize equipment and methodologies.
- Each country must consider economic resources in the short, medium and long term, with the aim of implementing and improving the Tsunami Warning System in the region.
- The Chilean delegation, will manage a request to the NOAA, to obtain high-frequency channels for the regional data transmission regional of the sea level in real time, using the GOES satellite.
- Finally, this Group must continue working and to maintain dynamics through electronic mail, until a new meeting.

Recommendations:

- To prioritize the implementation of standards monitoring platforms and incorporate new technologies for transmission and data accessibility, and thus minimize damage and to improve the efficiency of the evacuation plans of the population.
- It is recommended that the seismic services must be incorporated to the works, meetings, discussions and decisions of the Group, since they are a key link in the warning systems.
- It is recommended training workshops aimed specifically at journalists to improve the trustworthy spreading by mass media, of the alerts with a good level of confidence in the accuracy of the same one.
• To improve the education and awareness programs of the population to learn how to respond to tsunamigenic events that can cause major disasters.
• Regarding the tsunami exercises, it is proposed to carry out communications via fax, email and satellite telephone. In addition, communications exercises should be performed without notice, to assess the status of response, with the participation and integration of Colombia through the OSSO Corporation and Pacific Central Pollution Control CCCP (now Centro de Investigaciones Oceanográficas e Hidrográficas del Pacífico CCCP).

6. Implementation of the System – Second Workshop

The second international workshop on "Coordination and Monitoring of the Regional Tsunami Early Warning System for the South East Pacific" was carried out at the Club Militar Nueva Granada in Bogota-Colombia, from 28 - 29 May 29, 2009, attended by Tsunami Warning National Focal Points of Chile, Peru, Ecuador and Colombia, as well as national representatives of the Seismic and Tide Gauge Monitoring Network in those countries.

The specific objective of this workshop was to enhance knowledge, exchange information and experiences among States and institutions invited to manage the tsunami risk, strengthening institutional capacities and the articulation of the Regional Tsunami warning, according to the initiative to "improve local capacities for early warning, mitigation of tsunamis in South Pacific countries", agreed by Chile, Peru, Ecuador, Colombia supported by the Permanent Commission for the South Pacific (PCSP) and the Intergovernmental Oceanographic Commission (IOC / UNESCO).

6.1. Progress of the work

6.1.1. Ecuador

• To install two stations to measure the sea level (Esmeralda in 2009 and Santa Clara in 2010.) is planned. The present stations in Ecuador unfortunately are not suitable for measurement and real time transmission.
• To install 14 stations both in the coastal profile and in the island, through a project with the Southern Command of the United States Embassy is also planned.
• With regard to research and development of flood charts have made great progress and this has resulted in new publications that are available to local authorities
• Similarly, we have developed spreading and educational materials for the preparation of the population.
• INOCAR has prepared a comprehensive project waits funding, which includes two DART buoys, a complete change of the Sea Level Monitoring System, Staff recruitment and resources for risk studies.
• In addition, the Servicio Nacional de Sismología y Vulcanología (SENAS & V) has submitted a project that includes instrumental networks with 66 broadband stations, 105 accelerometers, 51 GPS stations, which broadcast on various media. This project is fully funded by the Secretariat of Science and Technology and shall be implemented in two years.
• We must emphasize that to establish Distributed and Subsidiary Centers is essential to define common standards and formats, and to secure the distribution and simultaneous access to data.
• Currently, the (Senacyt) project to install and have real-time data, including satellite transmission, 65 BB (SENACYT DNA), about 50 accelerometers (to avoid saturation) and 51 GPS is in progress.
• The processes and calculations of the seismic parameters (location, depth, size) and send the information to institutions co-responsible for monitoring and tsunami alert threat in Ecuador (INOCAR, SNGR) are automated.
• The seismic monitoring will include reception and data, processing; and delivery of information every day of the year, with the presence of at least one person with ability to respond in case of an earthquake.
• In relation to data access, the Instituto Geofísico has wide experience in the use of the mechanisms of transmission through the electrical interconnection system that is robust and redundant. Therefore, tests were made to share information with the Sparks station, which was successful.
• On 28 November 2009 the Santa Cruz Station of Marine Research Center, located in Ayora Harbor Master on Santa Cruz Island of Galapagos Archipelago was inaugurated. From this station the INOCAR, perform oceanographic and hydrographic work, as well as environmental monitoring tasks. The installation of the station is the beginning of the great project called "Implementation of the Galapagos Marine Research Center (CIMAG), which has established the Regional Tsunami Information Center, which would integrate the regional system.
• The latter center was installed to take care of potential threats of tsunamis in a immediately and differentiated
way in Galapagos Islands, both in its monitoring phase and in the subsequent stages of response. With the installation of the Tsunami Regional Information Center, the Navy of Ecuador has given an important step in risk managing before these threats. With the presence of specialized personnel and the implementation of appropriate monitoring systems, it has provided the Galapagos province of a body on technical and scientific advice, permanently ready and available to take care of information requirements of authorities and the general public. It may have an alternate command in case the Information Centre which is currently in the city of Guayaquil cannot perform their duties.

6.1.2. Colombia

- Currently, the National Seismic Network of Colombia - USR of INGEOMINAS is implementing the installation and operation of broadband stations at least 1 per 200 kilometers in the Pacific and Atlantic coasts. It has also been installed a station at Malpelo and has a second front broadband stations about 200 km from the coast to achieve a good range of the Colombian coast. It has 27 remote stations strategically located in the mainland and plans to have 43 in 2012.
- It is currently investigating the causes and processes that originate earthquakes, identify the seismic zones and to assess their potential. Also study the propagation of seismic waves in the country and build an adequate database to develop and bring to the seismic hazard studies in the country.
- It is planned in the near future, installing stations in Juradó (JUR), Cartagena (CAR), San Andres (SAN), or Istmina o Sipí (IST) and Chiriguaná (CHR) under the Update Instrumental plan of the Volcano and Seismic National System of Colombia. It was also planning to install accelerometers with satellite broadcast stations on the Pacific coast.
- One of the first results are the flood charts due to tsunami of near origin to the town of Tumaco, Buenaventura Bay, Málaga Bay and Salahonda population, prepared by the DIMAR through its Pacific Oceanographic and Hydrographic Research center CCCP. These products support the Local Committees for Disaster Prevention and Treatment (CLOPAD).
- Studies on the generation of natural barriers to mitigate the devastating energy of tsunami events have been carried out. Consequently, Centro de Investigaciones Oceanográficas e Hidrográficas del Pacífico (CCCP) Carried out a project entitled "Proposal for the
regeneration of the island, el guano as a protector tool of the population of Tumaco to Tsunami."  

- In March 2009, the Tsunami Warning Centre (CAT) of the Dirección General Marítima, in the premises of the Centro de Investigaciones Oceanográficas e Hidrográficas del Pacífico (CCC P), located in the city of Tumaco, Departamento de Nariño was launched.  

- Participation in evacuation drills carried out in the city of Tumaco in 2005 and 2009, invited as observers to the delegations of the tsunami warning systems of Chile, Peru and Spain on behalf of the Tsunami Warning Centre (CAT) which serves as technical support to the National Tsunami Warning System  

- Also, Dirección General Marítima -DIMAR in the of Tumaco Bay, Buenaventura Bay and Malpelo island, in the Colombian Pacific installed three tide stations in March 2009. The stations has radar sensors (Malpelo, Tumaco and Buenaventura) and pressure sensors (Tumaco and Buenaventura). The stations broadcast currently via GOES satellite every hour (300 bds) to a DRGS station in Bogota. However, they can transmit at 1200 bds to high-speed channels. In addition, the Tumaco and Buenaventura stations have a redundant system transmitted via VHF to a coastal station. NOAA is expected to provide high frequency channels of 5 to 15 minutes.

6.1.3. Chile  

- Maintenance of the sea level stations located along the coast of Chile was carried out each six months, for optimum operating state and resolving some equipment failures caused by environmental conditions and in some cases by the action of others.  

- The SHOA considers the acquisition of new sea level stations, MAWS model, which are equipped with better technology; allowing the installation of additional oceanographic sensors, greater storage capacity and different types of transmission.  

- The replacement process will begin in 2010, for a redundant system, providing the national tide gauge network for increased reliability and better responsiveness under the National Tsunami Warning System. (SNAM).  

- Subsequent to the replacement of sea-level stations in the MAWS model, a densification process of the sea level sensors will be carried out from the north of the country. Moreover, the frequency of broadcast stations to a period of five minutes, almost real-time will be increased, to monitor in situ the variations caused by
tsunamigenic events. This information will be transmitted via the satellite link and fiber optics.

- On the other hand, the new Chilean Seismic Network considers installing new stations, which will have broadband seismometers, accelerometers and GPS. These instruments are connected in real time to the new Data Processing Center (DPC) through a satellite communication system and a internal communication network. This will be complemented with many strong motion instruments.

- During the year 2009 began the Call for a bid to purchase new seismic equipment and now Chile is making the necessary arrangements to get the appropriate components for the CDP.

- It is estimated that during the first half of 2010, will begin the installation of new seismic stations and will finish with a complete and wide national network approximately at the end of 2012.

- With regard to making for Tsunami Flood Charting (CITSU) has launched updates to the numerical models used to improve outcomes in coastal communities potentially threatened by the risk of tsunamis.

6.1.4. Perú

- Development of Flood Chart in case of Tsunami in 78 coastal towns in the TIME model (implementation phase).
- Update audio visual educational material on the topic of prevention of tsunamis.
- Education of coastal populations around the coast of Peru, giving talks, exhibitions, distribution of reading material, videos, doing drills, etc., Explaining the tsunami phenomenon.
- The Instituto Nacional de Defensa Civil - INDECI has established jointly with the National Universities of the country, postgraduate courses on Disaster Management for Sustainable Development.
- Development of "lessons learned", because of the Nazca and tsunamis occurred in Chimbote 1996, Camaná 2001, Pisco 2007 and Chile 2010. These should be used by the ICG / PTWS, to conduct post-tsunami assessments in the region.
- Experience in communication exercises in case of Tsunami in the region with countries such as Chile, Ecuador and Colombia.
- Exchange information on progress in case of tsunamis with Ecuador, Chile and Colombia.
- Consultancy via Internet with the Civil Defense of Colombia during their evacuation drills in case of
tsunamis and information on the establishment of a National Tsunami Warning Center.

- Optimization and modernization in communications with the agencies involved in our National system.
- Advice and review of scientific papers on tsunamis for publication in magazines, newsletters, conferences, etc.
- Implementation and optimization of software for the determination of the occurrence of tsunamis and the calculation of arrival times.
- Implementation of numerical modeling of tsunamis for different seismic scenarios.
- Modernization of the National Tide Gauge Network with the acquisition of ten new radar-sea level stations, with continuous recording and real time transmission via telephone line, interconnected to the National Tsunami Warning.
- Currently tide gauge information is shared with the UHSLC and NOAA / PTWC.
- Implementation of a broadband seismic stations and accelerometers.
- Acquisition of seismic stations with independent satellite instruments to speed up the transmission of the earthquake occurred to the authorities of the Instituto Nacional de Defensa Civil.
- To continue to implement the "Marine Science" Education Project; first in Naval High school and later at national level, to improve knowledge and maritime awareness and care of our marine environment since childhood.

6.2. Conclusions y recommendations

Conclusions:

- The next meeting will be held in May 2010 in Guayaquil, Ecuador.
- The recommendations and commitments were evaluated in the February 2008 meeting, held in Lima, showing progress.
- The Chilean delegation, reported that the request to the NOAA, about getting high-frequency channels for regional sea level data transmission in real time using the GOES satellite, was successful and NOAA will provide the codes.
- The invitation was reiterated by Colombia to participate in the Drill tsunami that took place in the Municipality of Tumaco, on August 14, 2009. The General Secretariat of the PCSP stated that would be made to participate and support the attendance of one delegate per member country of the PCSP.
**Recommendations:**

- The technical conclusions of the Geophysics and Oceanographic (Tides) Working Groups, should be developed and implemented as soon as possible.
- Regarding the tsunami exercise, it is proposed that they must carry out with communications; such as, fax, email and satellite telephone. In addition, communication exercises must be without previous notice to assess the response capacity. They must also include the participation and integration of Colombia through the OSSO Corporation and Centro de Investigaciones Oceanográficas e Hidrográficas del Pacífico CCCP.
- For the current 2009-2010 period, Peru is responsible for the coordination of the Regional Group to comply with their commitments.
- Peru, which holds the Presidency of the Regional Working Group on TsunamiWarning and Mitigation in the South Pacific Region, will take the requirements of the different tsunami-related agencies to the PTWS.

**Geophysics Seismic Network Working Group**

- Within the existing alarm systems in the world, sea level measurements networks in real time, recorded almost all the physical processes that occur in the ocean. These networks are very important because of their multiple applications, specifically for tsunami detection and warning, and they are one of the most used methods for monitoring and confirmation of these events.
- Currently, the tidal stations of national networks are deployed and upgraded with automatic continuous recording equipment, reception and transmission with redundant systems, ie via telephone and satellite.
- It is recommended to adopt the methodology, analysis and processing, as suggested by the Global Sea Level Observing System (GLOSS) to standardize the systems in the Region.
- It should also ensure the exchange of information and inclusion of these stations in the international banks of the Servicio Permanente del Nivel Medio del Mar (Permanent Service for Mean Sea Level - PSMSL) and Archivo Conjunto del Nivel del Mar (Joint Archive for Sea Level - Jaslo), with the collaboration del Centro del Nivel del Mar de la Universidad de Hawai (University of Hawaii Sea Level Center - UHSLC) and the Administración Nacional Oceánica y Atmosférica (National Oceanic and Atmospheric Administration - NOAA).

### 6.3. Permanent Working Group on Geophysics – Seismic Affairs

In the framework of the International Meeting on Climate Change - El Niño Southern Oscillation and its impacts on Southeast Pacific
Region, held in Guayaquil - Ecuador, from 26 to 28 August, 2009, the Special Session of the Permanent Working Group on Geophysics Seismic Affairs, formed in the Second Workshop of the Regional Tsunami Early Warning System in the South Pacific. This session was attended by the national seismic networks representatives of the PCSP’s member states, who presented their progress about the system.

Following, the main conclusions and recommendations resulting from the session:

- It is requested to the General Secretariat of the PCSP, recalled Mr. Bernardo Aliaga, representative of the IOC, assign codes for the seismic institutions of the Regional Warning System of PCSP have direct access to the PTWS, CTBTO Network and "Real Time" information on the Occurrence of an Earthquake and Tsunami worldwide.

- It is important to develop and implement in the Southeast Pacific Ocean region as well as local and national level, the simulation models of occurrence of tsunamis. For this purpose, special / specific data of each area are needed as well as seismic conditions. These can be supplied by the Seismic Research institutions participating in this meeting. They can also assist in the formation of a "library" of local information, containing national and regional information for its application in the "modeling simulations or studies tsunamigenic events occurred" in the South Pacific region or have affected the Region.

- It is also important to understand and implement adequate information from the aspect models to improve seismic simulation results.

- Given the above, we request that the IOC and PCSP plan a "Tsunami Modeling Course for South Pacific Region", aimed at seismic and tide gauge components, which evaluates the progress in this area among PCSP’s member states and explaining, in detail, how you take and integrate seismic data in these models so that the institutions responsible for Seismic Studies of the PCSP’s member states, can review and suggest ways you can do a better contribution. Similarly, the course is expected to give the basic tools to understand how to develop the Joint Seismic Modeling / tidal gauge and to provide tools to work jointly between Seismic and Oceanographic Components to review the models that have been developed for real cases or simulated in the Southeast Pacific Region and to develop regional, national and local mode. It is recommended that this course was developed as workshop, with a length of four or five days.

- It is also recommended to carry out the next meeting on Seismic and tide gauge components during the workshop, as separate groups and then together to build an integrated and harmonious the Regional Tsunami Early Warning System in the
Southeast Pacific and to think about its integration as a part of the Regional (Early) multi-hazard Warning System and Rapid Response.

- It is recommended to keep on developing the Regional Tsunami Early Warning System in the Southeast Pacific, encouraging the rapid consolidation of the work, with a good level of interaction between the tide gauge and seismic components.

- In this order, to develop and implement a good level of communication between Seismic and tide gauge components to exchange information, quickly and efficiently, both during the time of occurrence of a tsunamigenic phenomenon as continuous integration of information in the Participating institutions Network of the system to facilitate timely response capacity, permanently. It is expected that this can be achieved in two years. For this, we need the support of the IOC and PCSP. At this moment, data can be exchanged at the academic level. At the end of the year, it is expected to integrate data between border stations of the Member States of the Regional Tsunami Early Warning System.

- It is expected that each institutions of Seismic Studies of the Southeast Pacific Region report to others, and the PCSP, how is exchanging data with the PTWS System.

- PCSP is requested to have a long-term commitment to support the process of building and consolidating the regional tsunami early warning system to set a priority on the opportunities that are happening due to Component Seismic work. Similarly, it is requested to collect the pretensions and multiple ideas, as actions that provides and recommends the Seismic Component.

- It is ratified the commitment of all responsible institutions for Seismic Studies of the Region; i.e, to share data and information available for the proper functioning of the Regional Tsunami Early Warning System.

- Each institution that performs seismic studies will seek to collect as much data for incorporation into regional studies.

- It was agreed to evaluate and recommend courses, workshops, seminars and other forms of training necessary for the proper functioning of the system to present to PCSP, including events that are proposed in each annual activities program.

- Similarly, it was agreed to evaluate and recommend the meetings to be undertaken and which will be in conjunction with the Group of Oceanography - Tides, as a Permanent Working Group on Geophysics - Seismic / tide gauge Matters, to make a good monitoring and have a sucessful improvements to the Regional Tsunami Early Warning System in South East Pacific.

- To encourage PCSP to support the Working Group and the Regional Early Warning System. Give special support for the year 2010 for the above mentioned Course and Working Group Meeting with the two components (Seismic and Oceanographic / Tides), scheduled since the last meeting of Bogotá which will be held in May 2010. It is needed this support at least for the next
four years, and thank you for the trust, PCSP will give us which will consolidate the ongoing functioning (moving from permanent program of the Region, or being within a Regional Protocol or integrated as a special project or as part of a regional multi-hazard warning system) of the Regional Tsunami Early Warning System and Seismic Working Group as the basis of the system.

- To recommend to PCSP, a visit of the expert technical advice on Tsunami Early Warning Systems, Mr. Victor Orphan, advisor that the IOC and PCSP introduced in the meeting in Bogota. Mr. Orphan will be requested to offer an explanation and general information on possibilities for a good conformation of Regional Warning System, and to provide positive experiences and developments of the Warning System that he works, and that belongs to the United States and Puerto Rico, and the Caribbean Warning Tsunami System where he works from Puerto Rico University, Campus de Mayagüez. It is requested a visit of four days in each seismic institution of the PCSP to assess their work and their situation in relation to the Regional System, and recommend how they might implement Caribbean Tsunami Warning System in the Pacific Region Southeast. This is an urgent call to be "good" and "adequately" prepared to deal with an efficient early warning system to a possible tsunami, before it happens, and not in response to the occurrence of a major disaster with many losses of human lives and extensive material damage.

- It was recommended to the IOC and PCSP that seismic Institutes representatives of the PCSP’s member states participate in the process and exercises that allow the regional project approved by DIPECHO. It is considered that this integration and participation, will allow to see some aspects and elements that give best Local Alert System, to provide local education, national and regional levels according to seismic surveys, and provide experiences to the best conformation from field seismic, the Regional Tsunami Early Warning System.

- It is recommended that future meetings should be planned the tsunami warning exercises between the seismic surveys and research institutions dedicated to ocean - tide gauge at the national level and also with the seismic and tide gauge components at the Regional Southeast Pacific System, with the support of the IOC and PCSP. Besides, it must consider all communications aspects and communication protocols, or integration of homogeneous communications. Each institution will review and give suggestions and recommendations to the IOC and PCSP to improve these communications in "real time". Also, to do an exercise "on table" without leaving their institution, at a regional level to test the quality and safety (stability of communications in case of loss of electrical power, telephone and radio) between the institutions that form the system of the seismic field with the oceanographic field.
Each institution shall consider and recommend the work streams that could develop the media (newspapers, magazines, radio and television) for the dissemination of our current progress and of the Regional Warning System, and must have a dissemination strategy for the projects or reports that teach the community how to act and behave in case of tsunami warning. The result will be forwarded to the IOC and PCSP for their implementation.

As a result of the work developed through the International Consultant, Mr. Masahiro Yamamoto of the IOC of UNESCO, and seismic networks representatives of the PCSP’s member states, there has been a progress in the formation of a good Tsunami early warning system. For this, he support its continuity and ensures an efficient and continuous service, so that the system is operational and functional at the earliest opportunity.

However, to achieve the foregoing, shall be conditioned first seismographic stations and communications to receive information on the characteristics of the earthquake (magnitude, epicenter and hypocenter) in real time, in the national tsunami warning each one of the four countries of the PCSP. With relation to the tidal stations this is already achieved.

7. “Learning mechanisms adapted to the preparedness and response to tsunami at communitarian level in Colombia, Ecuador, Peru and Chile project”

Due to it is important to promote the education of the coastal population on its vulnerability to tsunamis, is developing a project called “Learning mechanisms adapted to the preparedness and response to tsunami at communitarian level in Colombia, Ecuador, Peru and Chile", which establishes the political mechanisms and technical cooperation of the countries of the South Pacific Region.

This project is developed under the VI Action Plan for South America, presented by the Regional Office of Education for Latin America and the Caribbean and the Intergovernmental Oceanographic Commission (IOC) and is prepared in cooperation with the institutions that host the Tsunami Warning Center for Colombia (DIMAR / CCCP, CCO), Ecuador (INOCAR), Chile (SHOA) and Peru (DHN), and is funded by the European Commission Humanitarian Office (ECHO). The project also is in charge of UNESCO. It has a length of fifteen months. Its implementation began in September 2009 and the coordinator is the Director of Scientific Affairs of the Permanent Commission South Pacific (PCSP).

The project aims to increase the awareness and advance preparation against the risk of tsunamis in vulnerable communities. Also, it promoted through learning and community participation a response to these events. This training center is considered as the hub of community preparedness.
in case of tsunami. The community prepares plans, evacuation maps and decides the installation of standard signaling indicating flood areas and escape routes. The provision of sirens connected to the warning centers is also considered. Evacuation drills are made and then, this experience is documented.

Implementation is planned in four areas or scenarios: Esmeraldas, Esmeraldas (Ecuador), Tumaco, Nariño (Colombia), Penco, Tomé and Colonel Bio Bio region (Chile) and Callao, Lima (Peru).

Expected Results:

- Student population and educational communities with knowledge and skills developed in tsunami risk management. Local operational plans for risk reduction, prepared for execution in the targeted communities.
- Local operational plans for risk reduction, prepared for execution in the targeted communities.
- Mechanisms and inter-agency coordination of tsunami warning developed and established between oceanographic institutes and national education authorities.

Activities

- To develop and to implement training modules on tsunami risk management to show and explain to the community the tools and concepts such as: the cause of the disasters, earthquakes and their indicators, the tsunami characteristics, flood maps and evacuation routes, preparation and interpretation of tsunami warnings.
- To develop and monitor risk mitigation plans using the drills, appropriate tsunami evacuation routes tsunami and safety plans for the population in general.
- To develop evacuation exercises with the communities.
- To develop workshops on coordination mechanisms between the civil defense authorities, public and private institutions, NGOs, aid agencies, regional and international organizations, education authorities and communication means.

8. Annexes

8.1. List of tsunami events in South America

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<tr>
<th>No.</th>
<th>Date</th>
<th>Magnitude</th>
<th>Affected region</th>
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<td>March 15, 1657</td>
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<td>October 20, 1687</td>
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<td>October 28, 1746</td>
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<td>Perú</td>
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<td>4</td>
<td>August 13, 1868</td>
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5 January 31, 1906 8.7 Ecuador - Colombia
6 August 17, 1906 8.4 Chile
7 December 12, 1908 8.2 Perú
8 April 6, 1943 8.2 Chile
9 December 12, 1953 7.3 Ecuador - Perú
10 January 19, 1958 7.8 Ecuador - Colombia
11 May 22, 1960 9.6 Chile
12 November 20, 1960 7.7 Perú
13 October 17, 1966 8.2 Perú
14 December 28, 1966 7.6 Chile
15 December 21, 1967 7.6 Chile
16 October 03, 1974 8.1 Perú
17 December 12, 1979 8.1 Ecuador - Colombia
18 October 04, 1983 7.6 Chile
19 March 3rd, 1985 7.9 Chile
20 February 5, 1988 7.2 Chile
21 February 21, 1996 7.5 Perú
22 November 12, 1996 7.7 Perú
23 June 23, 2001 8.4 Perú
24 August 15, 2007 7.9 Perú
25 February 27, 2010 8.8 Chile

8.2. List of contact person, Regional Coordinators

<table>
<thead>
<tr>
<th>Name / Position</th>
<th>Organization / Address</th>
<th>Telephone / E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernardo Aliaga</td>
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<tr>
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<td></td>
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<tr>
<td>Priscila Molina</td>
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</tr>
</tbody>
</table>

8.3. List of National Technical Committees on Warning Tsunamis (CTN-AT)

<table>
<thead>
<tr>
<th>Country</th>
<th>Name / Position</th>
<th>Organization / Address</th>
<th>Telephone / E-mail</th>
</tr>
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<tbody>
<tr>
<td>Ecuador</td>
<td>Edwin Pinto</td>
<td>Instituto Oceanográfico de la Armada del Ecuador Departamento de Ciencias del Mar Av. 25 de Julio Vía Puerto Marítimo, Base Naval Sur Guayaquil-Ecuador</td>
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<td>Germán Escobar</td>
<td>Centro Control Contaminación del Pacifico Director</td>
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</tr>
<tr>
<td>País</td>
<td>Nombre y Cargo</td>
<td>Dirección</td>
<td>Teléfonos</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Chile</td>
<td>Gerente proyecto “Centro Nacional de Alerta de Tsunami CAT”</td>
<td>Vía El Morro, Capitanía de Puerto, San Andrés de Tumaco Nariño-Colombia</td>
<td><a href="mailto:jefcccp@dimar.mil.co">jefcccp@dimar.mil.co</a></td>
</tr>
<tr>
<td></td>
<td>Miguel Vásquez</td>
<td>Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA)</td>
<td>+56 32 2266682 +56 32 2266542 (Fax)</td>
</tr>
<tr>
<td></td>
<td>Coordinador Nacional</td>
<td>Errázuriz 254 Playa Ancha, Valparaíso-Chile</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Departamento de Oceanografía Centro Nacional de Alerta de Tsunamis del SHOA</td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td>C. de F. Walter Flores</td>
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<td>+51 1 6136767 Ext. 6460 +51 1 6136767 Ext. 6429 +51 1 6136759 (Fax)</td>
</tr>
<tr>
<td></td>
<td>Jefe del Dpto. Oceanografía</td>
<td>Departamento de Oceanografía</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gustavo Laos</td>
<td>Jr. Roca 2da. Cuadra con Av. Gamarra, Chucuito-Callao</td>
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</tr>
<tr>
<td></td>
<td>Coordinador Nacional</td>
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## 8.4. List of contact person, Warning and Evacuation System

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<th>Organization / Address</th>
<th>Telephone / E-mail</th>
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<tbody>
<tr>
<td>Ecuador</td>
<td>Ma. del Pilar Cornejo</td>
<td>Secretaría Nacional de Gestión de Riesgo (SNGR)</td>
<td>+593 2 2549119, +593 2 2235497 (fax)</td>
</tr>
<tr>
<td></td>
<td>Secretaria Nacional</td>
<td>Colina y San Ignacio N26-16 Esq., Ecuador</td>
<td><a href="mailto:mariadelapilarcornejo@gmail.com">mariadelapilarcornejo@gmail.com</a>, <a href="mailto:direccion@snriesgos.gov.ec">direccion@snriesgos.gov.ec</a></td>
</tr>
<tr>
<td></td>
<td>Leila Zambrano</td>
<td></td>
<td>+593 4 2683882 ext. 2548</td>
</tr>
<tr>
<td></td>
<td>Asesora Técnica</td>
<td></td>
<td><a href="mailto:leiladania@gmail.com">leiladania@gmail.com</a>, <a href="mailto:lizambrano@snriesgos.gov.ec">lizambrano@snriesgos.gov.ec</a></td>
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<tr>
<td>Ecuador</td>
<td></td>
<td>Instituto Oceanográfico de la Armada del Ecuador (INOCAR)</td>
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<td>Email: <a href="mailto:maria@inocar.com">maria@inocar.com</a></td>
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<tr>
<td>Colombia</td>
<td></td>
<td>Corporación OSSO Sismológico de Sur Occidente</td>
<td>+57 2 6827662</td>
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<tr>
<td></td>
<td></td>
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<td>Email: <a href="mailto:hjm_osso@yahoo.com">hjm_osso@yahoo.com</a></td>
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<tr>
<td>Colombia</td>
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<td>Comisión Colombiana del Océano (CCO)</td>
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<tr>
<td></td>
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<td>Centro de Alerta de Tsunami (CAT)</td>
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<td>Jaime Rajoosa</td>
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<tr>
<td>Colombia</td>
<td>Luz Amanda Pulido</td>
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<tr>
<td></td>
<td>Directora</td>
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<tr>
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<td>Graciela Ustariz</td>
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<tr>
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**Chile**

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<tr>
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<td>Errázuriz 254 Playa Ancha, Valparaíso-Chile</td>
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<td>C. de C. Miguel Vásquez Arias</td>
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| Natalia Silva                                   | Oficina Nacional de Emergencia del Ministerio del Interior (ONEMI) |
| Coordinadora Gestión Científica Técnica de la División Protección Civil | Beauchef 1637 / 1671, Santiago-Chile |
| Johaziel Jamett/Vicente Núñez                    |                                                                  |
| Centro de Alerta Temprana (CAT)                |                                                                  |

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<tr>
<th>Chile</th>
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**Perú**

<table>
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<tr>
<td>Ing. Erick Ortega</td>
<td></td>
</tr>
<tr>
<td>Ing. César Jiménez</td>
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</tbody>
</table>

| Guillermo Alvizuri                              | Sistema Nacional de Defensa Civil (INDECI) |
| Director Nacional de Operaciones                | Calle Ricardo Angulo Ramírez N° 694 Urb. Corpac - San Isidro, Lima-Perú |
| Arístides Mussio                                |                                             |
| Director Regional                               |                                             |

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### 8.5. List of contact person, Seismic Network

<table>
<thead>
<tr>
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<th>Name / Position</th>
<th>Organization / Address</th>
<th>Telephone / E-mail</th>
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<tbody>
<tr>
<td>Ecuador</td>
<td>Hugo Yépes Director</td>
<td>Instituto Geofísico – Escuela Politécnica Nacional Ladrón de Guevara E11-253, Apartado 2759 Quito - Ecuador</td>
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</tr>
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<td>Instituto de Geología y Minería (INGEMINAS) Red Sismológica Nacional de Colombia – RSNC (opera 24 horas), Diagonal 53 No. 34-53, Bogotá D.C.</td>
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<td>Ing. Hernando Tavera Director del CNDG - Sismología del IGP</td>
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</tbody>
</table>

### 8.6. List of contact person, Tide Gauge Network

<table>
<thead>
<tr>
<th>Country</th>
<th>Name / Position</th>
<th>Organization / Address</th>
<th>Telephone / E-mail</th>
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</thead>
<tbody>
<tr>
<td>Ecuador</td>
<td>Edwin Pinto Jefe del Departamento de Ciencias del Mar Patricia Arreaga Ángel Chavez Mario Lizano (Investigadoras Oceanográficas e Hidrógrafo)</td>
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</tr>
<tr>
<td>Colombia</td>
<td>Germán Escobar Componente Oceanográfica (nivel del mar)</td>
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<tr>
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<td>C. de C. Miguel Vásquez Arias Departamento de Oceanografía</td>
<td>Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) Carrera 10 No. 20-30, Bogotá D.C.</td>
<td></td>
</tr>
<tr>
<td>Perú</td>
<td>C. de F. Walter Flores Servat Jefe del Dpto. Oceanografía Ing. Carol Estrada Ludeña Jefa de Sección Mareas</td>
<td>Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA) Errázuriz 254 Playa Ancha, Valparaiso-Chile</td>
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</tr>
<tr>
<td>Perú</td>
<td></td>
<td>Dirección de Hidrografía y Navegación de la Marina de Perú (DHN) Jr. Roca Cuadra 2 y Av. Gamarra S/N, Urb. Chucuito, Callao-Perú</td>
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