Intergovernmental Oceanographic Commission

Workshop Report No. 295

Expert Meeting on Tsunami sources, hazards, risk and uncertainties associated with the Colombia-Ecuador Subduction Zone

Guayaquil, Ecuador
27–29 January 2020

UNESCO

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TABLE OF CONTENTS

page

ANNEXES

Executive Summary

In January 2020, a workshop of experts sponsored by UNESCO's Intergovernmental Oceanographic Commission was convened in Guayaquil, Ecuador. The meeting was facilitated by Working Group (WG) 1 of the Pacific Tsunami Warning System (PTWS) and brought together twenty-one experts from various disciplines and three different countries (Colombia, Ecuador and USA) and one observer from the Japan International Cooperation Agency (JICA), with the objective of understanding the tsunami hazard posed by the Colombia-Ecuador trench, evaluating the current state of seismic and tsunami instrumentation in the region and assessing the level of tsunami readiness of at-risk populations. The meeting took place in the Hotel Palace in downtown Guayaquil and was chaired by Dr Diego Arcas (USA) from NOAA's Pacific Marine Environmental Laboratory in Seattle and co-chair of IOC ICG/PTWS WG1.

As one of the meeting objectives, the experts used their state-of-the-science knowledge of local tectonics to identify some of the potential, worst-case seismic scenarios for the Colombia-Ecuador region. The scenarios were then ranked as low and high probability events by the experts. While other non-seismic tsunamigenic scenarios in the area were acknowledged, the level of uncertainty, associated with the lack of instrumentation, prevented the experts from identifying worst case scenarios for non-seismic sources. The present report synthesizes the group's findings and presents the seismic sources identified by the experts to pose the largest tsunami risk to nearby coastlines. In addition, workshop participants discussed existing gaps in scientific knowledge of local tectonics, including seismic and tsunami instrumentation of the trench and current level of readiness and exposure for at risk coastlines, including the availability of real-time tsunami warnings. The results and conclusions of the meeting are presented in this report and some recommendations are summarized in section 7.

1. BACKGROUND AND OBJECTIVES

In an effort to address tsunami exposure and vulnerability of coastal populations along some of the most tsunamigenic regions of the world, UNESCO/IOC has sponsored the organization of a series of expert meetings focused on specific regions of the globe with significant exposure to tsunami risk. This workshop in Guayaquil, Ecuador organized to address tsunami hazard associated with the Colombia-Ecuador subduction zone is amongst the first few to take place in the Pacific Ocean, under the auspices of UNESCO/IOC to address these issues.

While countries in the Colombia-Ecuador region are exposed to tsunami impact from a number of far and near field sources, the workshop was focused on assessment of the near-field hazard posed by tsunami events originating along the Colombia-Ecuador trench. These events present the shortest travel time to local coastlines, expose local populations to the highest wave amplitudes and leave little time for early warning. An essential element of tsunami preparedness, fundamental to the protection of at-risk populations from near-field tsunami events, is the development of tsunami evacuation maps that can guide the response of exposed populations during such events. Development of tsunami evacuation maps requires the design of inundation maps, which in turn require the conjunction of three different elements: (1) availability of high-resolution topographic and bathymetric data; (2) tsunami source identification; and (3) tsunami hydrodynamic models. As digital elevation models become increasingly available for locations along coastlines exposed to tsunami hazard, and the use of tsunami simulation models become ubiquitous, the search for consensus on the appropriate tsunami source or set of sources to use in the development of tsunami inundation maps becomes essential in order to provide consistent evacuation assistance to coastal populations. One of the objectives of the workshop was to provide guidance in the selection of seismic sources for the development of tsunami evacuation maps to the different responsible agencies in the region.

Tsunami hazard in the area mostly affects the populations of Colombia and Ecuador, however the study presented here may also be of assistance to other Pacific countries in addressing their far-field tsunami hazard.

2. TECTONIC SETTING OF THE COLOMBIA-ECUADOR MARGIN

2.1 THE ECUADORIAN SUBDUCTION

Ecuadorian tectonics is dominated by the oblique subduction of the Nazca under the South American plate at an azimuth of 83° and a velocity of 58 mm/yr (Kendrick et al., 2003). Most of the deformation is accumulated around the plate interface with a small amount being transmitted to the upper plate, where deformation is mainly manifested by drift of the NorAndean Sliver via the Chingual-Cosanga-Pallatanga-Puná fault system (in Ecuador), at a velocity of approximately 8-9 mm /yr (Nocquet et al., 2014; Alvarado et al., 2016; Yepes et al., 2016).

Focusing on the subduction, it is known that the Nazca Plate in the equatorial region is divided into two different domains according to age: an older one to the south of the Grijalva Fracture and the youngest one to the north. In the northern zone, different morphological features have been recognized, among them, the most important is Carnegie Range which rises approximately 2000 m above the Nazca floor, in addition, other features like the Yaquina Graben play an important role (Lonsdale, 2005).

2.1.1 Interseismic coupling (ISC) of the interface

Characteristic variations in the margin define important changes in the inter-seismic coupling (ISC) (Nocquet et al., 2014; Chlieh et al., 2014., Nocquet et al., 2017), resulting in a heterogeneously coupled margin. Geodetic models reveal that south of the Grijalva Fracture, over a length of approximately 1000 km (down to central Peru), the ISC values are mostly low or near zero (See Figure 1). Although, the ISC values were mainly low for this area, at least two earthquakes were reported here; off the Peruvian coast, with interface sources and epicenters near the trench. Both had significant magnitudes that generated tsunamis. These events occurred in 1960 (Mw 7.6) and in 1996 (Mw 7.5), respectively (Pelayo and Wiens, 1990; Ihmlé and Gómez., 1998; Bilek, 2010). The source for those events can be interpreted as coupled zones in the neighborhood of the trench that were not properly imaged by GPS (Nocquet et al., 2014) because of the distance to the monitoring points (more than 100 km).

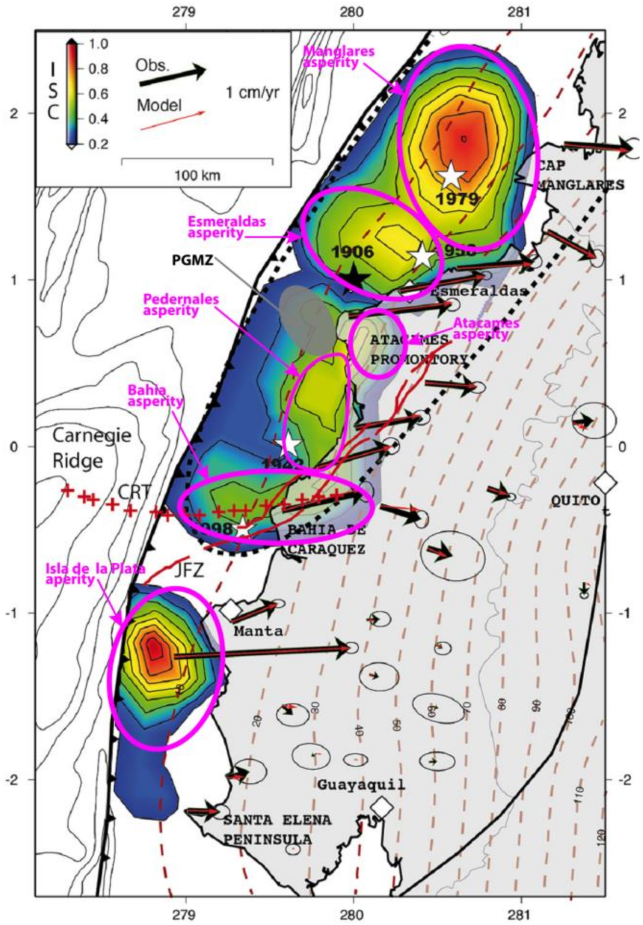

__Figure 1__. Inter-seismic coupling model (ISC) of the Ecuadorian margin. The black and red arrows represent GPS velocities and model inter-seismic data, respectively. The lavender ellipses indicate the position of asperities discussed in the text. The gray ellipse shows the Punta Galera-Mompiche (PGMZ) area. The broken black lines propose the rupture trace of the 1906 earthquake (Mw ~ 8.5-8.8). White diamonds indicate important cities (Modified from Chlieh et al., 2014). The red plus (+) symbols represent the southern extension of the Carnegie Ridge and its introduction beneath the continental margin.

Northward, approximately between 2.5°S and 0.6°S in latitude, the coupling models (Chlieh et al., 2014; Nocquet et al., 2014), denote a transition zone with a restricted area of more or less 50 km in diameter around the La Plata Island (ISC > 60%), surrounded by areas of moderate to low coupling (ISC < 30%) (Chlieh et al., 2014; Nocquet et al., 2014). Geodetic observations show that the major coupled zone remains at a depth of approximately 15 km. Seismically, La Plata Island area is the source of recurrent seismic swarms with magnitudes varying between small to moderate (Mw ≤ 6.0). This seismic behavior is a consequence of external stress induced by the occurrence of slow slip events (SSEs) (Vaca et al., 2018; Vallée et al., 2013; Jarrin, 2015; Segovia et al., 2018). SSEs are defined as continuous, non-destructive displacements on a fault with durations of days, months, years, that do not radiate seismic waves and that are recognized by geodesy (Hirose et al., 2014). The lack of seismic waves associated with these SSEs poses a significant tsunami hazard due to the absence of any natural seismic signs that a tsunami could be approaching.

Further to the north, there is a mostly coupled area between Bahía de Caráquez (Ecuador) and San Buenaventura (Colombia), with a medium coupling strip that separates coupled asperities which have reported large magnitude earthquakes since 1896. These areas are shown in Figure 1 and described next:

Bahía Asperity. To the north near Bahía de Caráquez, a W-E elongated asperity with ISC values of approximately 40-50% (Chlieh et al., 2014) is considered to be the source area of historical earthquakes with Mw ~7.0 magnitudes, such as those occurring in 1896, 1968 and 1998 (Segovia et al., 1999; Yepes et al., 2016).

Pedernales Asperity. To the north of Bahía de Caráquez (0.6°S) and Mompiche (0.3°N), the GPS data have defined an area of high ISC. Strong coupling is present between the 15 and 30 km depth (Chlieh et al., 2014). This asperity is the source of the 1942 and 2016 earthquakes, both of them reaching Mw 7.8 (GCMT; IG-EPN; Nocquet el al., 2016).

Atacames Asperity. South of Atacames, the ISC model displays a mild roughness, which is believed to have been the source of the 1976, 1983 earthquakes (GCMT) and of the two largest aftershocks following the Pedernales earthquake. The magnitudes of the events with sources in this area vary between Mw 6.6 to 6.9 (GCMT; IG-EPN).

Mompiche-Punta Galera Zone. North of 0.3°N and up to approximately 1°N, there is a coupled area of intermediate strength known as the Mompiche-Punta Galera zone (PGMZ), where periodic earthquake swarms are common (every 2 years) and are related to episodes of slow earthquakes (SSEs) (Mothes et al., 2013; Rolandone et al., 2018; Vaca et al., 2018). This area is prone to releasing a significant amount of seismic moment. The zone behaves as a propagation barrier for large earthquakes with sources originating in adjacent southern and northern asperities.

Esmeraldas Asperity. In front of Esmeraldas city, GPS information images a coupled area. This area is likely the source of the Mw 7.7 1958 earthquake (Swenson and Beck, 1996). Historical reports mention a local tsunami linked to the earthquake. Both earthquake and tsunami significantly affected Esmeraldas city and its port. There are also verbal reports of a focalized tsunami wave which sped 40 km upstream of the Esmeraldas river to the community of Viche.

Manglares Asperity. North of Esmeraldas city (Ecuador) to San Buenaventura in Colombia, there is a lengthy locked area, which is believed to have ruptured during the Mw 8.1, 1979 earthquake (GCMT, Beck and Ruff, 1984). This earthquake produced a major tsunami that affected both the Ecuadorian and Colombian coasts.

Some authors such as Kanamori and McNally (1982), suggest that the entire area, between Bahía de Caráquez and Buenaventura, would have been broken during the 1906 mega-earthquake, resulting in a rupture equivalent to Mw ~ 8.8, which triggered a huge tsunami that struck the Ecuador and Colombia coastlines, and even caused damage in Hawaii and Japan (Yoshimoto et al., 2017). Moreover, other authors point that turbidites in the Esmeraldas Canyon indicate the occurrence of one or two earthquakes similar in magnitude to the 1906 event in the last 600 years (Migeon et al, 2016).

2.2 THE COLOMBIAN SUBDUCTION

Along the Pacific margin of Colombia, the Nazca plate converges at about 53 mm / yr (at 5°N) and with an azimuth of approximately 81° (Kendrick et al., 2003). The southern margin of Colombia shares the same tectonic characteristics described for Ecuador.

2.2.1 Interseismic Coupling (ISC) for the Colombian margin

The analysis of horizontal velocities, measured by the permanent geodetic networks (GPS) of Colombia (GeoRED), Panama, Ecuador and Venezuela with respect to the stable South-American plate is described next. It must be noted that the lack of instrumentation in northern Colombia, caused by the extensive vegetation and safety problems, does not allow an appropriate coupling calculation for this region.

Coupling observations indicate that the lower limit of the seismogenic zone is about 40 km deep, unfortunately the shallowest limit is not well constrained, due to the distance between the measurement sites and the trench (Sagiya and Mora-Páez, 2020). The results show a high degree of coupling (> 80%) between latitudes 0.5°N and 2°N, with decreasing ISC values (less than 50%) towards the north (Sagiya and Mora-Páez, 2020).

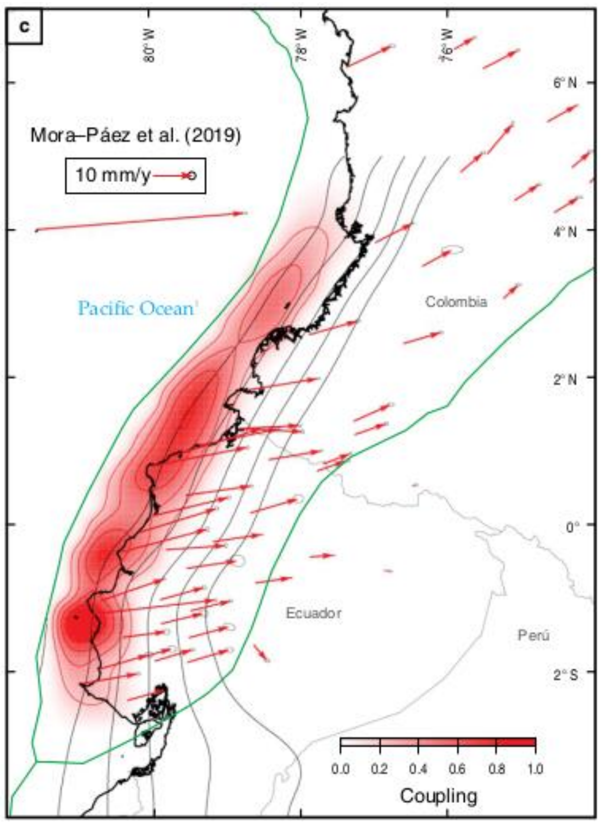

Figure 2. *Coupling distribution based on the North Andean Block motion model by Sagiya and Mora-Paez (2020). Black contour lines denote the configuration of the subducted Nazca slab every 20 km according to the Slab1.0 model ([Hayes et al., 2012](#)). Green lines are block boundaries proposed by [Bird (2003)](#).*

Despite the lack ISC information, towards the center and north of the margin, at least three earthquakes of magnitude greater than Mw 7 and with a source in the megathrust region have been reported for these areas, perhaps indicating a significant level of coupling. These events occurred in: (1) 1976 (Mw 7.3) in the Colombia-Panama border; (2) 1991 (Mw 7.2), in front of the department of Risaralda; north of Buenaventura; and (3) 2004 (Mw 7.2) in a similar location as the 1991 earthquake (Global CMT). Southern Colombia was affected by the earthquakes of 1906 (Mw ~ 8.6) and 1979 (Mw 8.1) (Global CMT).

The results presented here are a first estimation of the inter-plate coupling along the Pacific coast of Colombia. However, for a more accurate and detail assessment it is necessary to densify the geodetic network along the center and north of the Colombian Pacific (Sagiya Mora-Paez, 2020) with more instruments.

3. SEISMIC AND GEODETIC INSTRUMENTATION IN THE REGION

3.1 ECUADORIAN MONITORING NETWORKS

The Ecuadorian seismic (RENSIG) and geodetic (RENGEO) networks were both initially established in Ecuador for the purpose of monitoring volcanic activity in the Andean region. They were later extended to monitor seismic and tectonic activity throughout the country and more recently enhanced with real-time reporting, high-sample rate, GNSS stations that can be used for tsunami early-warning.

3.1.1 Ecuadorian seismic network

The Ecuadorian seismic and volcanic monitoring network began with the installation of the National Seismograph Network (RENSIG) in the late 1980s, contributing to the monitoring of tectonic and volcanic activity. The seismograph network has been improving since then; starting with short-period equipment, transitioning to broadband (BB) seismometers, and finally with the addition of some strong motion seismometers, all thanks to different projects carried out jointly with national and international organizations (major details in Alvarado et al., 2018). Currently the RENSIG stations have a spacing of approximately 50 km between them (Figure 3). Additionally, around the country and focusing on big cities, the IG-EPN installed and maintains the strong motion network which has more than 100 instruments (more detail in Alvarado et al., 2018, www.igepn.edu.ec).

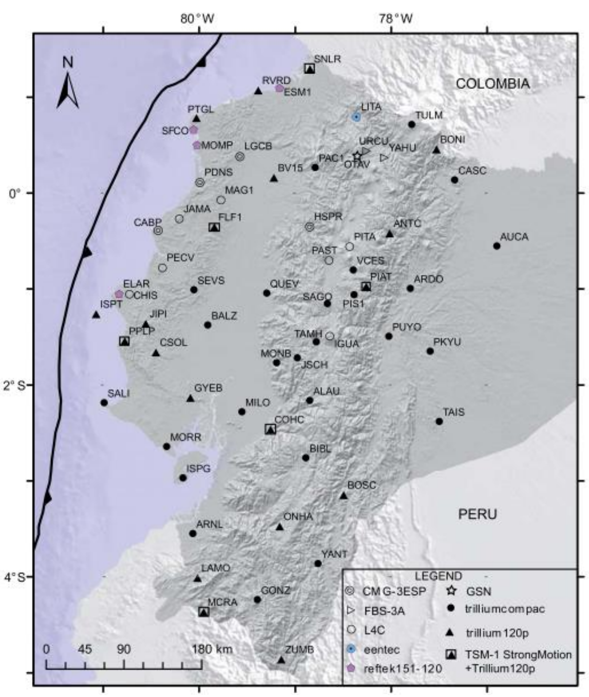

Figure 3. Distribution of the seismic network in Ecuador. From Alvarado et al. (2018)

3.1.2 The National Geodetic Network (RENGEO) of Ecuador

On the other hand, the National Geodetic Network (RENGEO) began development in 2006, with stations dedicated to monitoring volcanic deformation. The regional tectonic network started to expand especially since 2008, with GPS stations installed on northern coastal Ecuador (Mothes et al., 2013; Mothes et al., 2018; Alvarado et al., 2018). Currently, the network comprises almost 90 (Figure 4) permanent instruments, mostly equipped with dual-frequency antennas. The GPS stations are located approximately 40 km apart (Alvarado et al., 2018). Additionally, a 6-station real time GPS network is operating along the coastline between Punto Galera to San Lorenzo, near the international border with Colombia. Data are sent in real-time to the IG and shared by NTrip Caster with the University of Washington and UNAVCO. The real-time streams can be accessed at:

http://www.panga.cwu.edu/realtime/gpscockpit/

http://gaia.unavco.org/streamStatus/RT-GPS/mapsEquipment.html

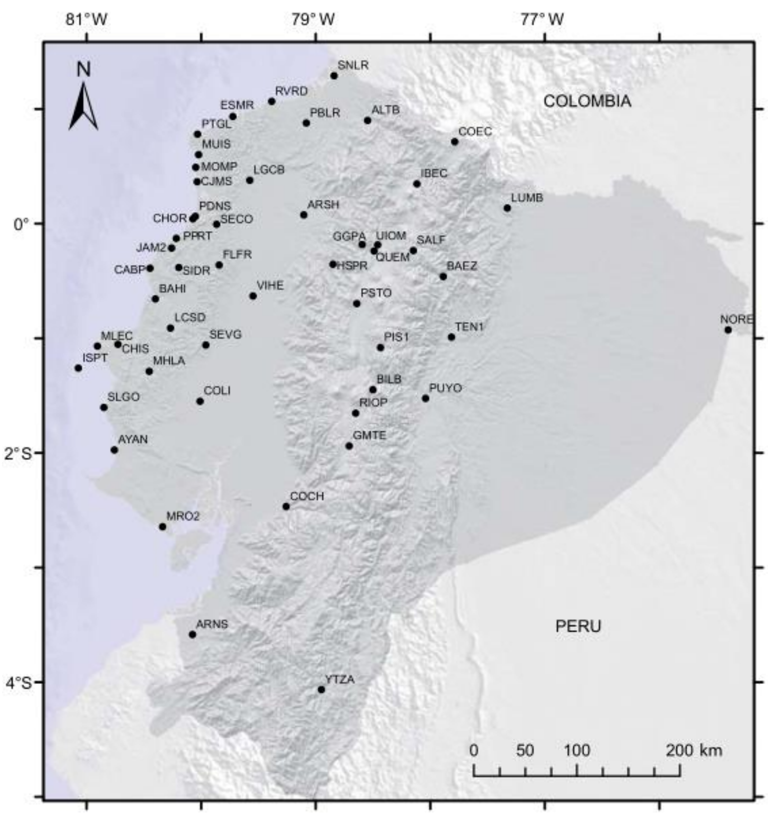

Figure 4. *Distribution of the geodetic network in Ecuador. From Alvarado et al. (2018)*

3.2 COLOMBIAN MONITORING NETWORKS

Colombia has implemented some monitoring networks in the last three decades. These networks have allowed to improve the knowledge about seismic sources, tectonics, volcanic processes and gravitatory phenomena, contributing to reduce risk to communities and infrastructure.

Presently, Colombia operates seven geophysical networks (Figure 5) including seismological, strong motion, volcanological, and geodetic Global Positioning System/Global Navigation Satellite

System (GPS/GNSS) networks. Four of these networks are relevant to this report: (1) the National Seismological Network of Colombia (RSNC, with 65 stations); (2) the National Strong Motion Network (RNAC, with 177 stations); (3) the GPS/GNSS Network for Geodynamics (GeoRED and 4) the South Western Colombian Seismological Network (OSSO, with 11 stations). We will briefly describe them with some detail next.

3.2.1 National Seismological and Strong Motion Networks

The proper development of the seismological networks started in 1993, with 13 short-period stations through a cooperative program with the Canadian Government, to which 35 digital accelerometers were later added. More recently, an improvement of the capacities of the monitoring network was implemented via several programs with the Japanese Government, United Nations Development Programme, and the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) (Vargas et al., 2018). 51 seismic stations (39 broadband and 12 short period), and almost 170 accelerometers were operational by the middle of 2017. Most of the stations feature satellite transmission of the signal to the Processing Data Center located in Bogota (Vargas et al., 2018).

3.2.2 The Southwestern Colombian Seismological Network

After the two Earthquakes with magnitude Mw 7.2 and Mw 8.1 in 1979, and Mw 5.7 in 1983 (with hundreds of fatalities), the need for a monitoring network in the Colombian Pacific margin became evident. This network began its operation in July 1987, thanks to the support of the Swiss Government (Swiss Relief Corps, University of Geneva and Seismological Service of the Federal Polytechnic School of Zurich), INGEOMINAS (now Colombian Geological Survey), and the Autonomous Corporation for the Development of Valle del Cauca. The network's headquarters was operating at the Universidad del Valle. The target of this network is to observe the seismicity and analyze the seismic risk of the southwestern region of Colombia. Currently, the network has 7 short-period stations and 19 strong-motion stations (including the network of 14 accelerographs of the Cali City).

3.2.3 The GPS/GNSS Network for Geodynamics

The "Red de Estudios de Deformación" (GeoRED) to survey crustal deformation has two principal components GNSS CORS (Continuously Operating Reference Stations) and the field stations network. The continuous network has 108 stations across the country. On the other hand, the field stations network is composed of 382 receivers. The principal objective of this set of stations is to serve for field campaigns in areas with episodes of seismic, volcanic crises, and mass movements monitoring. The network uses radio, cellular modem and satellite links to transmit the data.

GeoRED CORS has been in operation for less than 10 years. The geodetic information is shared with countries in the region and UNAVCO under the frame of the international COCONet Project.

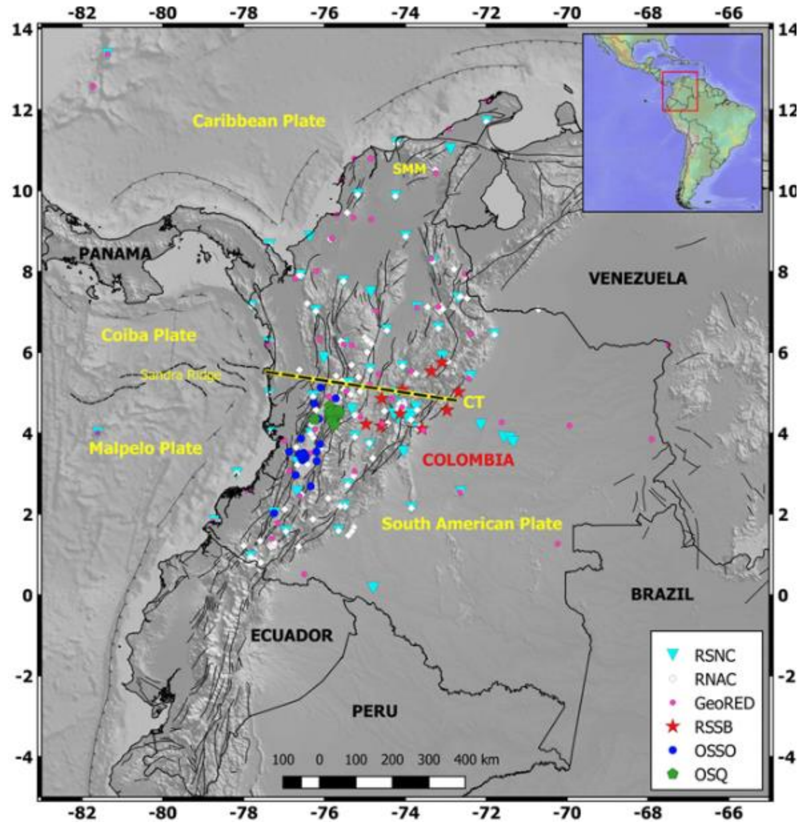

__Figure 5.__ Main geophysical networks in Colombia. Thin black lines correspond to the tectonic faults of the study zone. International borders and shorelines are represented by thick black lines. SMM, Santa Marta Massif; CT, Caldas Tear (after Vargas et al., 2018).

3.3 WATER LEVEL STATIONS IN THE REGION

It should be mentioned that in addition to the seismic and geodetic, land-based networks of Ecuador and Colombia, in terms of tsunami detection, the region also has a network of two Ecuadorian and one Colombian deep-ocean tsunami buoys (See Table 1).

Buoy ID	Country	Deployment date	Status	Last recovery of high resolution Data (15 seconds sample rate)
32489	Colombia	December-2014	Non Operational	12-04-2020 (15-minute sample rate)
32067	Ecuador	February-2014	Not Transmitting	N/A
32066	Ecuador	November-2019	Not Transmitting	N/A
32069	Ecuador	November-2019	N/A	N/A

***Table 1**. As of 12 June 2020, buoys 32489, 32067and 32066 are not transmitting. High resolution time series of 15 seconds sample time are available from NGDC servers (https://www.ndbc.noaa.gov/dart.shtml) which have records of past tsunami.*

Both countries also operate a network of coastal tide stations with the Ecuadorian and Colombian networks consisting of 10 and 21 stations (although only 6 Pacific ones) respectively, covering their continental and insular margins.

Details of the Ecuadorian and Colombian Pacific networks are reflected in Tables 2 and 3.

Localidad	Latitud	Longitude	Sensor Type	Sampling Frequency	Transmission Frequency	Operational Observations
San Lorenzo	1.2956	78.8421	Pressure Encoder	10 minutes	1 minute	Estación cerca al borde costero Ecuador - Colombia
Esmeraldas	0.9909	79.6466	Pressure	10 minutes	1 minute	
Bahía de Caráquez	-0.6064	80.4229	Pressure Encoder	10 minutes	1 minute	
Manta	-0.9396	80.7260	Pressure	10 minutes	N/A	
Isla Puná	-2.7346	79.9119	Encoder	10 minutes	1 minute	
Puerto Bolívar	-3.2612	80.0860	Pressure Encoder	10 minutes	1 minute	Estación cerca del borde costero Ecuador - Perú
Guayaquil	-2.1953	79.8798	Encoder		1 minute	
La Libertad	-2.2177	-80.9064	Pressure Radar Encoder	1 minute 1 minute 5 minutes	5 minutes	University of Hawaii
Baltra – Galápagos	-0.433	-90.283	Pressure Radar Encoder	1 minute 1 minute 5 minutes	5 minutes	University of Hawaii
Santa Cruz – Galápagos	-0.752	-90.307	Pressure Radar Encoder	1 minute 1 minute 5 minutes	5 minutes	University of Hawaii

Table 2. *Tide Gauge Stations, Ecuadorian National Network*

Station Name	Equipment Type	Status	Longitude	Latitude	Sampling Frequency	Main Transmission System	Time to Transmit
Tumaco EMMA	Meteorological and Tidal Automatic Satellite	Operational	-78.7287	1.82011	1 minute	GPRS	2 minutes
Malpelo EMMA	Meteorological and Tidal Automatic Satellite	Operational	-81.6042	4.002577	1 minute	GPRS	2 minutes
Juanchaco EMMA	Meteorological and Tidal Automatic Satellite	Operational	-77.3591	3.915	1 minute	GPRS	2 minutes
Buenaventura EMAR	Automatic Tidal Station Satellite	Operational	-77.082	3.892	1 minute	GPRS	2 minutes
Bahía Solano EMMA	Meteorological and Tidal Automatic Satellite	Operational	-77.4119	6.232778	1 minute	Inmarsat	10 minutes
Bahía Málaga EMMA	Meteorological and Tidal Automatic Satellite	Operational	-77.3275	3.9725	1 minute	GPRS	2 minutes

Table 3*. Tide Gauge Stations, Colombian National Network (only Pacific Stations are listed)*

4. THE COASTS OF ECUADOR AND COLOMBIA, TSUNAMI-RELEVANT ENVIRONMENTAL, GEOMORPHOLOGICAL AND SETTLEMENT CHARACTERISTICS

Seen at regional scale, the primary source of local tsunamis for Ecuador and Colombia, the subduction zone, could be regarded as uniform, while at a local scale its historical complexity and diversity emerge as does its potential for large events along its approximately 1300 km of coastline. A similar situation arises with the exposed coast of Ecuador and Colombia: a flat tropical coast, rather distant from the Andean chain and its foothills. Only at a more local scale does great variation in its landforms and vegetation become evident. Most of these characteristics are relevant to tsunami exposure, vulnerability and mitigation options.

While the northernmost segment of Colombia's coast (N-Chocó) does have mountain ranges in close proximity to the coastline (Serranía del Baudó), the remaining coast, down to the border with Ecuador, is formed by lowlands without significant elevations, with several large deltas (Mira, Patía, San Juan, Baudó), covered with mangrove forests and dissected by extended estuarine systems, tidal channels and rivers.

Ecuador's coast also has some segments with mangrove forests, mainly in northern Esmeraldas province and in the bay of Guayaquil, but the most prominent feature in Ecuador's coastal region is the Cordillera Costera, a chain of low altitude ranges aligned with the coastline over most of its extension, and rendering a rather dry climate along the coast. This coastal fringe is far less dissected than the coast of the Colombian lowlands, as the coastal ranges act as a watershed for the rainier Andean slopes. In general, the types and density of vegetation follows the regional rainfall gradient, with Chocó being one of the rainiest regions worldwide and the Manabí province being mainly a tropical savanna climate.

These natural conditions in turn determine largely what can and must be done to manage the tsunami hazard and risk on each coastal segment. For instance, emplacement and reliable operation of monitoring instruments on the coastline of Colombian lowlands and its very soft soils is very difficult. While tsunami early warning and evacuation are worldwide still the main strategy for reduction of risk to human life, for many settlements in this region, the design of evacuation paths is limited to 'run inland!' or just impossible (on barrier islands). On the other hand, the still dense and extended mangrove forest could offer protection for people and dwellings behind it.

In addition to these geomorphological and natural features which provide rather obvious determinants of settlement and building patterns, other complex processes and interaction of historical developments must have led to the present differences between coastal settlements along the Ecuador and Colombia seafront. For instance, Guayaquil was from early on – mid-XVIth century – a main hub for Spanish activities on its eastern Pacific possessions, and during the republican era the second political and economic center of Ecuador. Meanwhile, the major settlements on Colombia's Pacific coast were not integrated in institutional networks and regional economical processes until mid-XIXth century. Historical documents from before that time are very scarce. During the colonial period, transport of extracted gold was done over inland routes.

While Ecuador's coast has an extended network of roads, both along its whole extension and to the inland, the Colombian coast is linked to the inland by only two roads (Buenaventura and Tumaco) and a few small airports. There are no roads along the coast, where rivers, estuaries, channels and swamps currently render waterways the only feasible means of transport.

Patterns of settlement and building are not very different on the two coasts. The type of livelihoods based on harvesting nearby sea and land, was in most cases the determining factor for the selection of settlement sites. Buildings are mostly vernacular, precarious stilt houses made with local vegetable materials (with no resistance to either earthquakes or tsunami), although some have experienced a transition to more modern and rigid construction materials in some villages, and to reinforced concrete structures in the larger settlements. Hamlets and villages that seek protection behind mangrove forests are the exception. Settlements right on the beachfront are common, even where nearby hills would offer safer ground, both from storm flooding and tsunami inundation. Small hamlets on the coastline and inside the network of estuaries in Colombia's deltas are almost countless. Most victims of the 1906 and 1979 tsunamis were reported from settlements right on the coastline or in inlets; most of these settlements have been rebuilt after these disasters at the exact same location.

Thus, there are important differences in exposure and vulnerability between the coasts of Ecuador and Colombia; these have to lead to different strategies and actions towards tsunami risk reduction. These differences could make cooperation between the two countries even more significant and efficient.

5. STATE OF EVACUATION MAPPING ALONG THE COLOMBIA/ECUADOR COASTLINE

Ecuador is located in the northwest of South America, where at least two tectonic plates interact and make it a potentially tsunami generating area, as evidenced by a number of historical events in the region. In 1906, an earthquake of Mw 8.8 (current studies estimate its magnitude Mw 8.4) generated a tsunami with height ranging between 2 and 6 meters off the coast of Esmeraldas; In May 1942 a Mw 7.8 earthquake occurred off the Ecuadorian north coast, but did not generate a tsunami, while in January 1958 and December 1979, earthquakes with Mw 7.7 and Mw 8.2 occurred with the generation of tsunami waves in both cases. In the central sector of the Ecuadorian coast, the earthquake of 1933 with magnitude 6.9 generated tsunami waves that reached up to 2.5 meters in Santa Elena.

The southern coastline of the country was also impacted by a tsunami generated by an earthquake of magnitude Mw 7.8 in December 1953. On August 4, 1998, an earthquake occurred in the city of Bahía de Caráquez, however without the generation of destructive tsunami waves in this case. On April 16, 2016 a strong earthquake shook the town of Pedernales, with no apparent destructive tsunami waves either, however the event was felt throughout the Ecuadorian territory and in some sectors of the coastal margin it was possible to observe the unusual withdrawal of the ocean in the aftermath. Despite the short, recorded history of tsunami impacts, Ecuador has been part of the Pacific Tsunami Warning System since 1976 and its functions include assessing the tsunami threat off the coast of Ecuador, as well as the development of tsunami flood maps.

Flood maps are the input that the National Risk and Emergency Management Service uses to prepare, together with the coastal municipalities, their evacuation plans in the event of tsunamis. The elaboration of the maps began in 1990 with the support of the United Nations and the objective of this task is both: to estimate the potential impact from sources near the Ecuadorian coasts and to carry out the assessment of the danger of tsunamis in the Ecuadorian coasts. In order to complete these studies, it has been necessary to propose several tsunamigenic scenarios. The flood map is a tool that will assist local governments in the decision-making process, for managing tsunami alerts and will also inform residents and tourists of the hazard and expected response to become tsunami-resilient populations.

Data from different sources such as General Bathymetric Chart of the Oceans (GEBCO), Oceanographic Institute of the Navy of Ecuador (INOCAR), Geographical Military Institute of Ecuador (IGM), Risk and Emergency Management (SNGRE) and the National Service were used to prepare the tsunami flood maps. For each study, four domains or computational meshes of different resolutions (810 m, 270 m, 90 m and 30 m) were built. The modeled scenarios were based on historical data with the worst-case scenario designed as a multi-segment fault plane composed of five segments, which generated an earthquake of magnitude Mw 8.4 and a seismic moment release of Mo 3.82E + 21, thus achieving an event as real as possible. The vertical displacement and initial deformation were obtained through the Okada model of deformation of an elastic half-space (Okada, 1985) and the hydrodynamic TUNAMI-N2 model (developed by Tohoku University) was used to simulate the propagation and impact of the tsunami; TUNAMI-N2 is governed by non-linear shallow water theory equations.

The model input data is made up of the four computational meshes that are read as domainn.txt (n = 1,2,3 and 4); the files of the synthetic tidal stations called outpointn.txt (n = 1,2,3 and 4) and which are points along the Ecuadorian coast where it is necessary to know the heights and arrival times of the tsunami waves; and the deformations resulting from the Okada model for each of the meshes which will be called Defornn (n = 1,2,3 and 4).

Numerical simulation using TUNAMI-N2 generates new files that are: zdomainn (elr_n00000.dat, n = 1,2,3 and 4) containing the heights of the tsunami waves; maxn.dat (n = 1,2,3 and 4) that provides the maximum heights of the tsunami; Inund.dat which is the maximum flood (only for the area of interest) and Pointn.dat (n = 1,2,3 and 4) corresponding to the synthetic marigrams (providing heights and arrival times of the waves at different points of the coast). The simulation process lasts more than seven hours, and the tasks prior to this simulation took more than three months to be executed; this is due to the fact that factors such as the quality of the data, both bathymetric and topographic are often very dispersed and it is necessary to find an appropriate interpolation method to construct the grid covering the entire domain; the lack of computational memory in view of the large amount of information that is handled; the updating of licenses for software management without interruptions and on a smaller scale, the scarce knowledge of new software which makes the process become very slow in some of its phases and therefore in its total development. Three examples of tsunami inundation maps developed by INOCAR for the coastal communities of Crucita, Atacames y Salinas are shown in Figure 6.

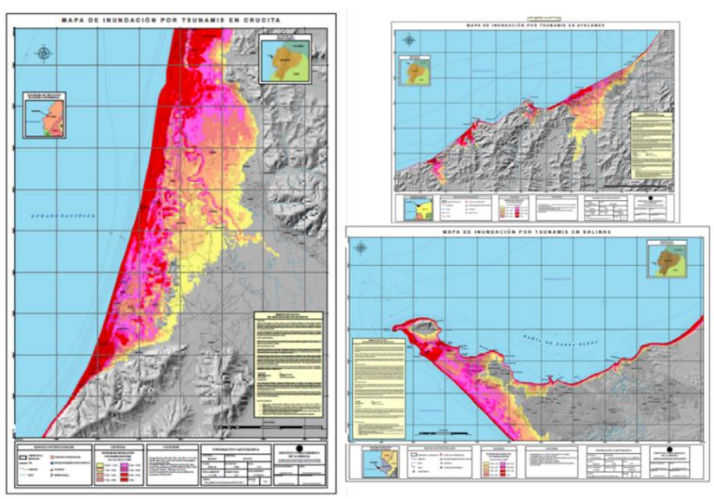

Figure 6. *Tsunami Inundation maps for the coastal communities of Crucita, Atacames and Salinas. Source: JICA-INOCAR, 2019.*

Inundation maps shown in Figure 6 were developed by numerical simulation (TUNAMI-N2) of seismic rupture scenarios derived from hypothetical or historical seismic sources located within the polygons of Zone Galera 1, Zone Isla de la Plata and Zone of Salinas (Figure 7) and using fault parameters based on the subduction zone earthquakes of 1901, 1906, 1933, 1958, 1979 and 2016, and with parameter values quite similar to the ones identified in Figure 7 and Table 4 of this report, but they represent tsunami flooding from a Mw 8.4 (Yoshimoto et al, 2017) and based on mean high water.

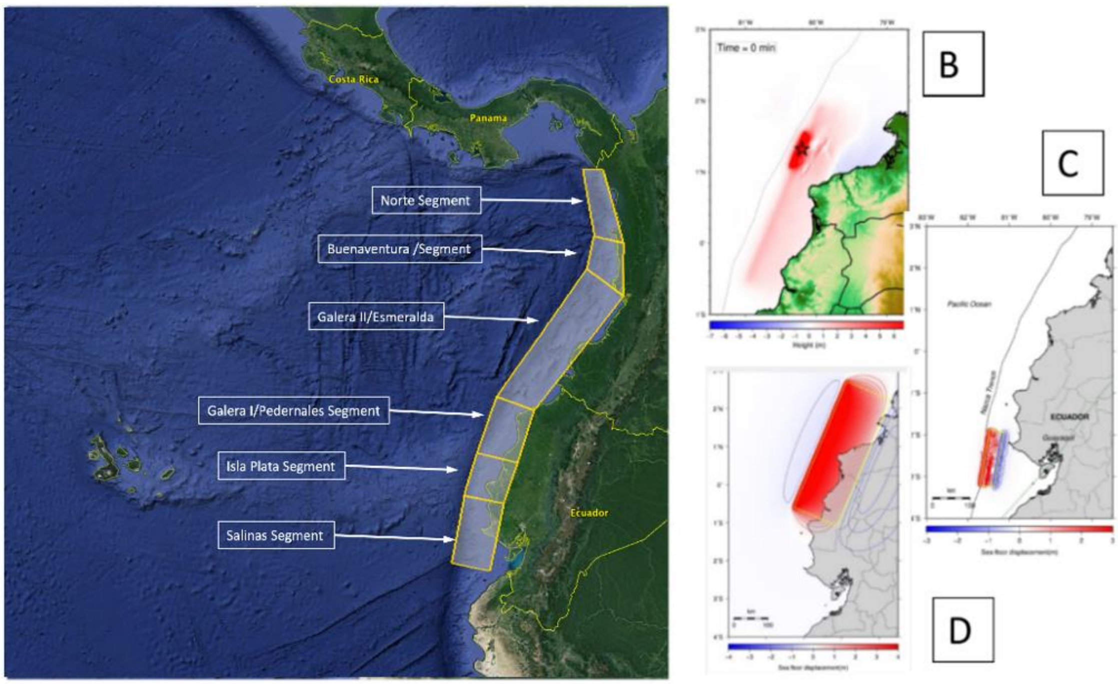

Figure 7. A*. Potentially tsunamigenic areas along the Colombia-Ecuador margin.* ***B****. Initial deformation for a Mw8.4 hypothetical heterogeneous source used in the Esmeraldas inundation study. Source: JICA-INOCAR, 2020.* ***C****. Scenarios for tsunami hazard assessment in Salinas. Source: Arreaga, 2020.* ***D****. Initial deformation for a Mw8.8 homogeneous-slip, worst-case scenario source for tsunami damage study in Manta. Source: Noboa S. (2016).*

In conclusion, in Ecuador, tsunami flood maps are the responsibility of the Navy Oceanographic Institute (INOCAR) focal point of PTWS, while the preparation of evacuation maps is the task of the National Risk and Emergency Management Service (SNGRE), coordinator of the emergency in the country. These maps constitute a tool for the determination of evacuation routes, safe places and contingency plans of local governments. The flood maps are prepared with local and global data, however there is a great need to improve the quality and resolution of this information in order to improve this process and the accuracy of the results. The continuity of studies focused on understanding the focal mechanisms of tsunami generation is necessary and will help to determine better scenarios. The need to create a regional working group to define progress and new methodologies for developing flood maps, establish a format for development, and promote joint work between countries is a task that will undoubtedly strengthen tsunami studies at the local and regional levels.

5.1 TSUNAMI INUNDATION MAPS AS INSTRUMENTS FOR THREAT ANALYSIS AND DAMAGE ESTIMATE USING FRAGILITY CURVES

Arrival times and wave amplitudes along the modeled coastal area together with model data of the depth and extent of the inundation on a 30-meter resolution grid, allows for the estimation of wave damage if census and land registry statistics are available.

Following the fragility curves methodology (Koshimura et al,2009), (Mas et al, 2012), INOCAR has related the computed inundation depth with likely damage to life and property. For this study, fragility curves developed for the Banda Aceh region of Indonesia have been used, due to the lack of such curves for the Ecuadorian coast due to the lack of data regarding the hydrodynamic characteristics of a near-field tsunami. With these limitations, it was estimated that in the town of Manta approximately 1093 people and 542 buildings could be affected by a Mw 8.8, uniform-slip seismic rupture with a focal depth of 14 km immediately offshore of the Ecuadorian coastline. Of the 8,800 people living along the exposed coast of Manta, 13% of the total population would be at risk and 24% of the houses out of a total of 2,238 could collapse or be affected in some way (Noboa S., 2016).

Determination of the seismic source together with the sea level conditions (low, mean or high tide) during a tsunami, influence the intensity and effects of the event. In the case of Esmeraldas, a heterogeneous slip distribution source base on the study of Yoshimoto et al. (2007), with Mw 8.4 and extreme high-tide for the sea level conditions were selected, resulting in inundation depths in excess of 7 meters (Figure 8). The application of fragility curves resulted in an estimated 31,000 people affected and a total of 9,772 damaged structures (Noboa S., 2020).

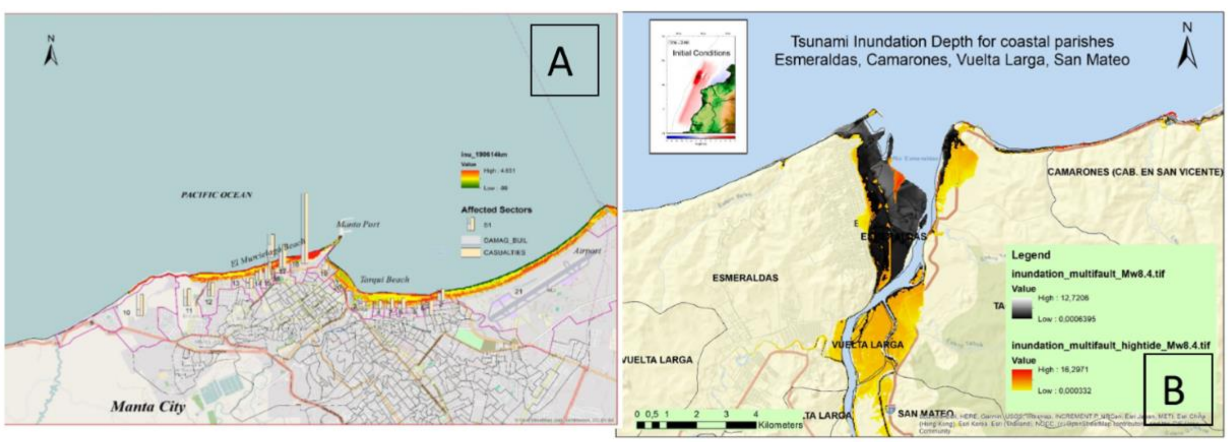

***Figure 8. A**. Tsunami Inundation Zone in Manta. Source (Noboa, 2016). **B**. Tsunami Inundation Zone in Esmeraldas. Source: JICA-INOCAR, 2019.*

Once near-field tsunami sources were identified by the meeting of experts, there remains the responsibility to continue with the tsunami modeling work to determine exposed and at-risk areas along the Ecuadorian coast, both on the islands and continental margin with the objective to continue strengthening population resiliency.

6. ANALYSIS OF POTENTIALLY TSUNAMIGENIC SOURCES

6.1 SINGLE-SEGMENT RUPTURE SCENARIOS

For tsunami modeling of tectonic sources in the Colombia-Ecuador subduction zone, the proposed sources are defined taking into account: coupled areas and the strength of coupling, historical earthquake patterns, and assumptions based on identification and mapping of tsunami deposits. In this section possible seismic parameters are estimated including length, width, depth, fault slip and strike, dip and rake angles based on information from past earthquakes from a certain source region or from marine geophysical data. In the case of the rake angle, the worst-case scenario is assumed, so it is fixed at 90°. The names of the sources have been proposed taking into account representative population centers close to them and in general, they do not necessarily coincide with those used for asperities described in the section on tectonics. The overall location and extent of the sources have been represented in Figure 9 and Table 4 which summarizes the proposed segments and parameters of the sources identified along the Colombo-Ecuador margin.

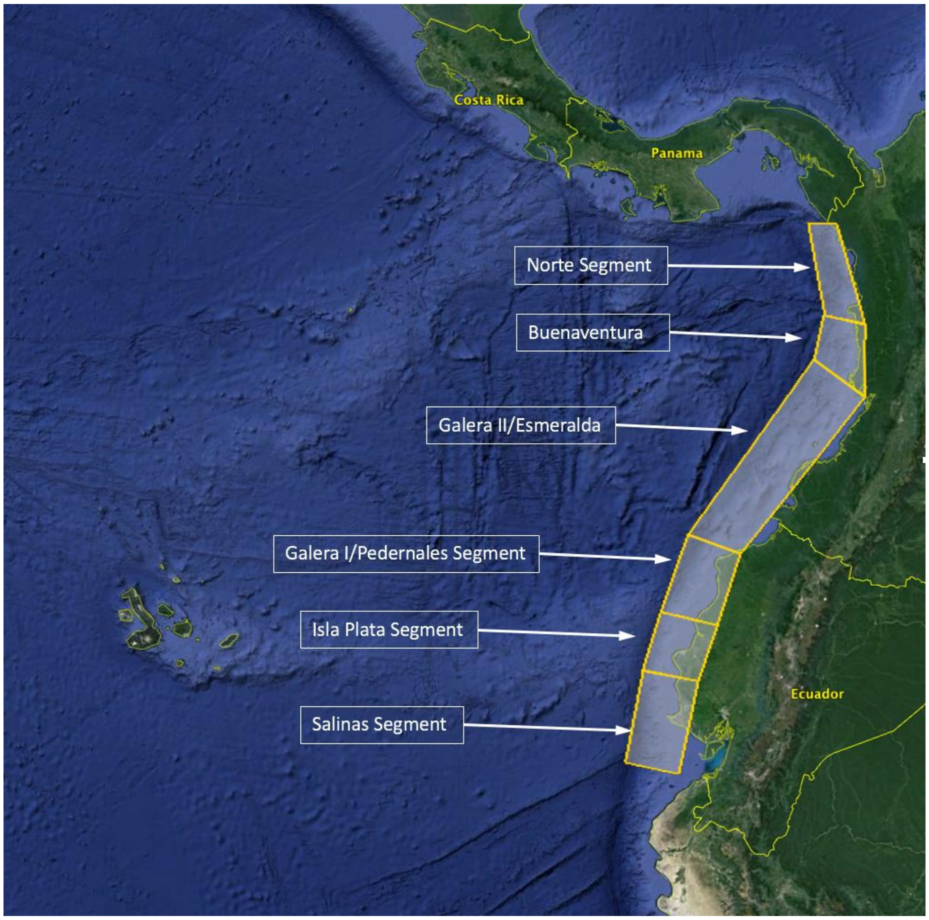

Figure 9. *Approximate extents of the different tsunamigenic segments identified along the Colombia-Ecuador margin by the workshop experts. Each of these segments is expected to rupture independently from the others except the Galera/Esmeraldas and Galera Buenaventura Segment that could also rupture in combination.*

	Segment Name	Length (km)	Width (km)	Depth (km)	Slip (m)	Dip (deg)	Rake (deg)	Strike (deg)	Lat*** (deg)	Lon*** (deg)	Mw
1	Norte	170	90	20	1.4	20	90	341	6.33	282.17	7.9
2	Buenaventura	160	100	15	2.6	15	90	13	4.79	282.28	8.1
3	Galera II/Esmeraldas	450	100	20	7.4	16*	90	30	2.33	280.99	8.7
4	Galera I/Pedernales	110	80	22	3.4	21*	90	25	0.14	279.70	8
5	Isla Plata	130	80	15	2.6	10*	90	15	-0.91	279.31	8
6	Salinas	200	80	20	3.7	15**	90	5	-2.42	279.08	8.2

*Based on Global CMT information, ** Graindorge et al. (2004), *** Fault Position refers to the center of the fault plane.

Table 4. *Proposed parameters of seismic sources with potential to generate tsunamis.*

Additionally, since the coordinates of the fault planes are given as the location of the center of the fault plane, Table 5 lists the coordinates of the corner points of each fault plane for each segment, for convenience.

		Fault Plane Corner Points							
	Segment Name	Lon (deg)	Lon (deg)	Lon (deg)	Lon (deg)	Lat (deg)	Lat (deg)	Lat (deg)	Lat (deg)
1	North	282.7798	282.0581	281.556	282.2795	5.728	5.4805	6.9237	7.1719
2	Buenaventura	282.5379	281.6902	282.013	282.8624	3.9897	4.1843	5.5851	5.3902
3	Galera II/Esmeraldas	280.3495	279.6016	281.6235	282.3727	0.35934	0.79055	4.2921	3.86
4	Galera I/Pedernales	279.7912	279.1831	279.6007	280.2088	-0.44778	-0.16423	0.73132	0.44778
5	Isla Plata	279.4949	278.8242	279.1267	279.7972	-1.5615	-1.3817	-0.2538	-0.43349
6	Salinas	279.3416	278.6558	278.8135	279.4983	-3.3449	-3.2848	-1.4951	-1.5551

Table 5. *Coordinates of the corner points for each of the 6 proposed fault segments.*

The 6 single-segment scenarios identified represent credible events of large, but not extreme magnitude. They are more likely to occur than other larger events comprised of combinations of some of these segments and described under the Multi-Segment Rupture Scenarios (Section 6.2), therefore these are considered by the experts to have higher probability of occurrence. Given the above parameters for the single-segment ruptures, the moment magnitude of the potential events was computed based on the following formulas:

$$M_w = \frac{2}{3} log_{10}(M_o) - 10.7$$

with

$$M_o = \mu \underline{u} S$$

Where μ is the shear modulus of the Earth crust, estimated at $\mu = 4.0 \times 10^{11}\ dynes/cm^2$, $\underline{u}$ is the average or homogeneous slip amount in cm and S is the surface area of the rupture in cm^2.

In what follows we present a brief explanation for the selection of the proposed rupture segments and show computed tsunami wave amplitude results from simulating the regional propagation of those sources in deep water along the Colombia-Ecuador border, including the Galapagos Islands using the MOST code (Titov and González, 1997). Tsunami propagation in deep water from each of the proposed segments was modeled. Note that modeling values obtained represent amplitude of the tsunami wave in deep water, which is expected to be lower than those in shallow coastal waters (not modeled here).

Two sources with potential to generate tsunamis are proposed along the Colombian stretch of the trench. These sources have been defined based on the inter-seismic coupling models for the southern margin and the occurrence of historical earthquakes of magnitude Mw 7.2+ in the central (Buenaventura) and north margins.

Historical seismicity covers a relatively short period, therefore in terms of seismic data for the Colombian margin availability is limited. However, the instrumental seismic record indicates that sources for earthquakes of strong magnitudes above Mw 7, took place in 1976, 1979, 1991 and 2004. Three of them had origin in the central and northern margin of the Colombian trench.

The first occurred on July 11, 1976 near the border between Colombia and Panama. According to the Global CMT, this event had a magnitude Mw 7.3, however it shows a high-angle focal mechanism and mostly a strike slip movement, which are not typical for an interface source.

The earthquake of November 19, 1991 of magnitude Mw 7.2 (Global CMT), has a significant variation in depth. According to Global CMT its hypocenter is located at 19 km, whereas Duputel (2015) in NEIC reports the hypocenter at 30 km depth. The thrust mechanism indicates consistence with an interface source.

Finally, the earthquake on November 15, 2004, with a magnitude Mw 7.2 and depth of 16 km (Global GMT), has its epicenter on the Colombian margin, north of Buenaventura. The low-angle reverse mechanism is also coherent with a source at the interface.

Based on the reported earthquakes, two possible sources are defined between Buenaventura and the Colombia-Panama border: North Source and Buenaventura Source.

North Source. The first one is called the North Source and is estimated to extend from the northern edge of the border with Panama to the region of the Bajo Baudó (~ 5.3°N), where a strong change in the trench direction, from approximately 330° to an almost East-Westerly direction is noted.

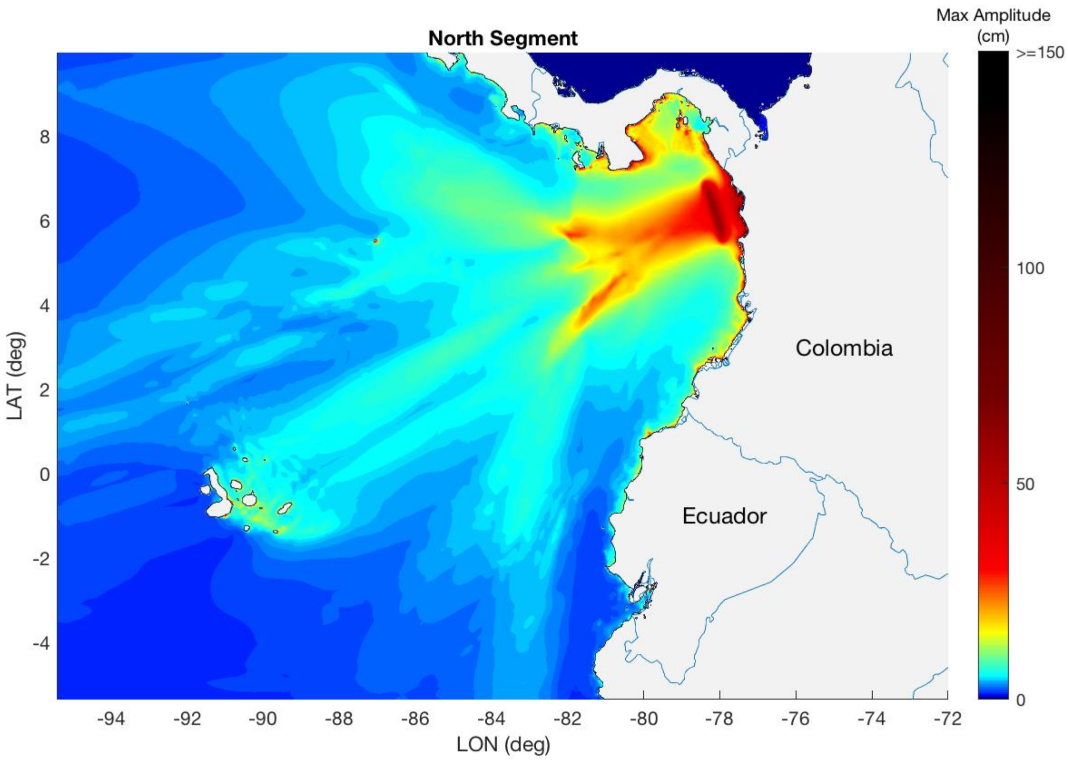

Figure 10. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the North segment source using MOST/ComMIT. Modeling shows maximum impact along the northern coast of Colombia and southern Panama. The presence of the Galapagos Islands in the region seems to focus a significant amount of energy in that direction.*

Figure 10 shows modeling results of a tsunami generated by the North source segment in Table 4. Preliminary results in deep water show a maximum tsunami offshore amplitude of less than 1 meter with most of the energy focusing in the northern coast of Colombia and southern Panama. There is one main tsunami energy beam directed initially in the southwest direction, which splits into three separate branches, one heading north, one southwest which directly impacts the Galapagos Islands and a third one directed towards the South Pacific.

Buenaventura Source. The second source, named here Buenaventura, extends from the southern edge of the North source segment to an approximate latitude of 3.8°N.

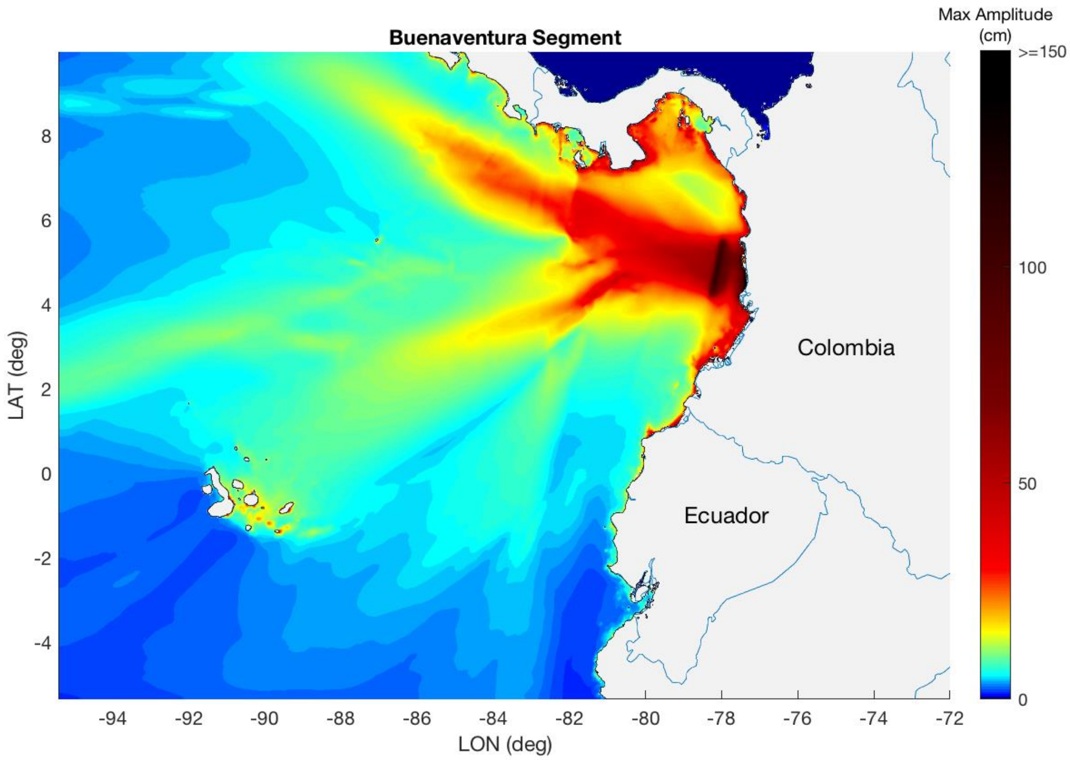

Figure 11. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the Buenaventura segment source using MOST/ComMIT. Modeling shows maximum impact along the central and southern coast of Colombia with significant focusing along the coast of Panama. The presence of the Galapagos Islands in the region seems to focus a significant amount of energy in that direction.*

Figure 11 shows preliminary modeling results of the Buenaventura source in the central Colombian coast. This source generates a tsunami with a maximum offshore amplitude of approximately 1 meter with the largest waves affecting the central coast of Colombia. As in the case of the North source, there seems to be one main tsunami energy beam that splits up into three smaller branches, one of them directed to the northwest and the other two directed to the west and southwest respectively, with the one directed southwest impacting the Galapagos Islands.

Esmeraldas-Buenaventura source. In this case, a source that extends from the Buenaventura region to the north of Esmeraldas is proposed (Table 4). The likely estimated magnitude for this source is estimated at Mw 8.4-8.7. This source would comprise a rupture area that includes the source areas of the 1958 (Swenson and Beck, 1996) and 1979 (Beck and Ruff, 1984) earthquakes.

Figure 12 shows preliminary modeling results of the generated tsunami from this source with a maximum tsunami offshore amplitude between 4 and 5 meters and most of the wave energy focusing in the northern coast of Ecuador and southern coast of Colombia. The main tsunami energy beam is directed towards the northwest possibly affecting some areas of the Central America coast particularly along the seaboard of Costa Rica, however, not much impact is observed along the coastal areas of Panama.

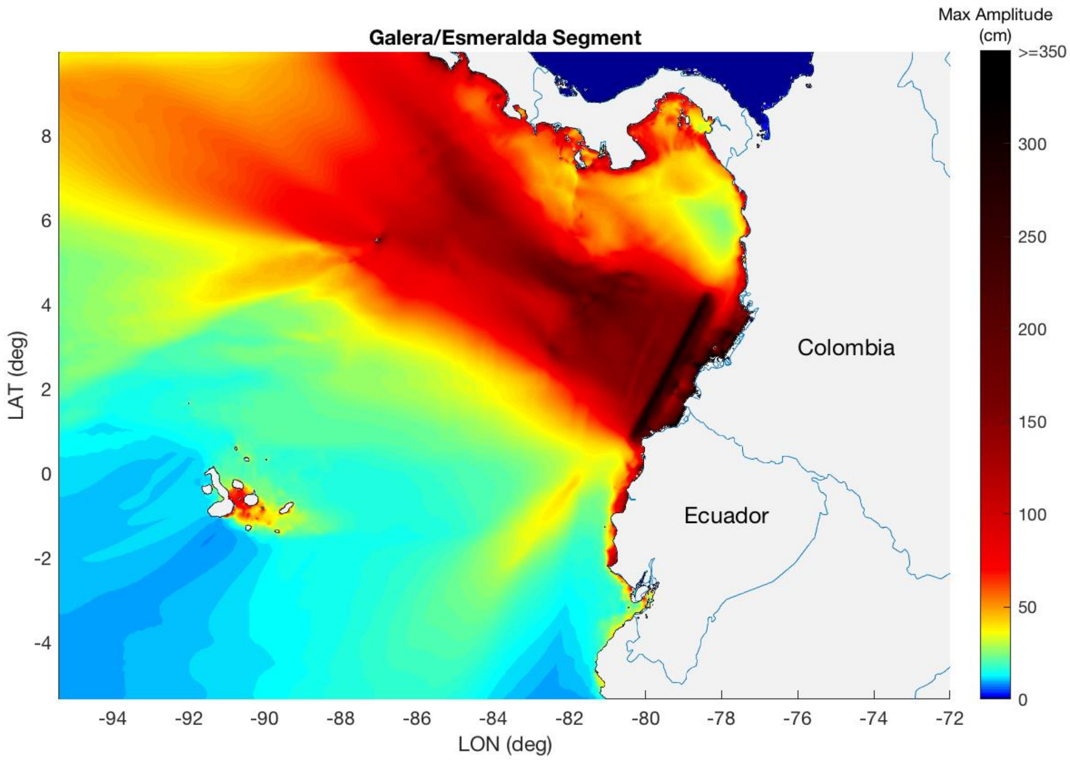

Figure 12. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the Esmeraldas/Buenaventura segment source using MOST/ComMIT. Modeling shows maximum impact along the northern coast of Ecuador and southern Colombia, with the offshore tsunami energy travelling North-west away from the region.*

Pedernales Source*.* This source extends along the rupture zone of the 1942 and 2016 earthquakes, so the estimated magnitude for this source is Mw 7.8. In the case of the 1942 (Swenson and Beck, 1996) and 2016 earthquakes (GCMT, IG-EPN, Nocquet et al., 2016) the source is relatively deep (between 15 and 30 km). These depths have also been corroborated with the coupling models. For the 2016 Pedernales earthquake, only sea-surface choppiness was reported, with waves < 50 cm. In the case of a shallower rupture, the possibility of generating a tsunami with destructive characteristics would increase.

Figure 13 shows preliminary modeling results of a tsunami generated from this source with a maximum tsunami offshore amplitude between 2 and 3 meters and most of the tsunami impact focused on the central coast of Ecuador closest to the location of the rupture. The tsunami energy beam is widely distributed with three main branches directed south towards the South Pacific, to the northwest just north of the Galapagos Islands and further north approximately parallel to the coast of Central America.

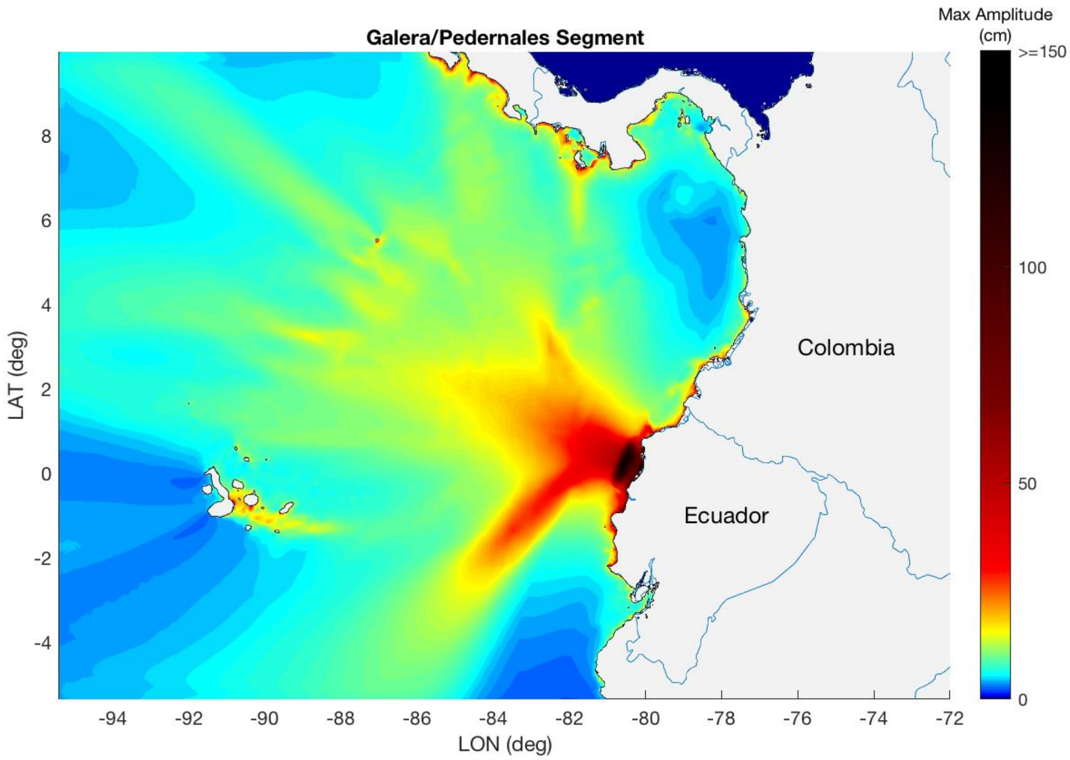

Figure 13. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the Pedernales segment source using MOST/ComMIT. Modeling shows maximum impact along the central coast of Ecuador with a main energy beam travelling North-west and a secondary one directed towards the South-west.*

Isla Plata source*.* As described in the tectonics section, the Isla de la Plata area presents a high degree of seismic coupling, however, there is no historical evidence of strong magnitude earthquakes being generated in this area. In the case of a full rupture of the Isla de la Plata source zone, an earthquake with approximate magnitude Mw 7.8 could be generated. Furthermore, taking into account that the coupled area extends to approximately the limit of the trench, the possibility of generating a major tsunami is minimal, given the greater water depth.

Figure 14 shows preliminary modeling results of the Isla de la Plata source with a maximum tsunami offshore amplitude of approximately 2 meters and most of the tsunami impact focused on the central coast of Ecuador from Quigue in the north to Port of Bayóvar. The offshore tsunami energy beam is directed towards the Galapagos Islands almost following a waveguide, with not much focusing on other far-field directions.

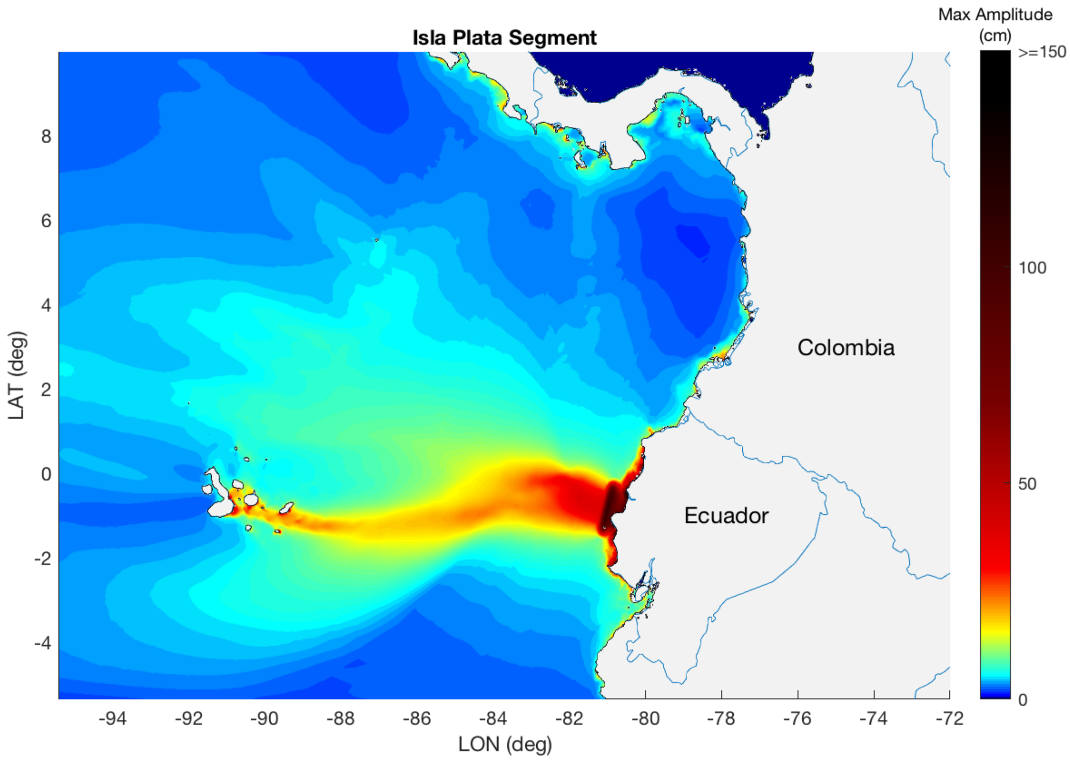

Figure 14. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the Isla Plata segment source using MOST/ComMIT. Modeling shows maximum impact along the central coast of Ecuador with the main energy beam directed towards the Galapagos Islands.*

South of Salinas source. According to GPS observations, this area does not show evidence of significant coupling and no significant historical events have been reported. However, assuming the possibility of similar conditions to those reported further north, the possibility of a tsunami from this area cannot be excluded. In this case and motivated by the identification of tsunami deposits two kilometers inland from Playas de Villamil (2.6398 S, 80.3927 W) (Chunga, 2002; Chunga and Toulkeridis, 2014; Ioualalen et al., 2014), an earthquake of Mw 8.1 is suggested for this area.

Figure 15 shows preliminary modeling results of the Salinas source with a maximum tsunami offshore amplitude of approximately between 1 and 2 meters and most of the tsunami impact focused on the southern coast of Ecuador including Isla Puná and the Guayaquil Bay. The offshore tsunami energy beam is directed just north of the Galapagos Islands which seem to be heavily impacted by the tsunami. Little focusing is observed away from the main energy beam.

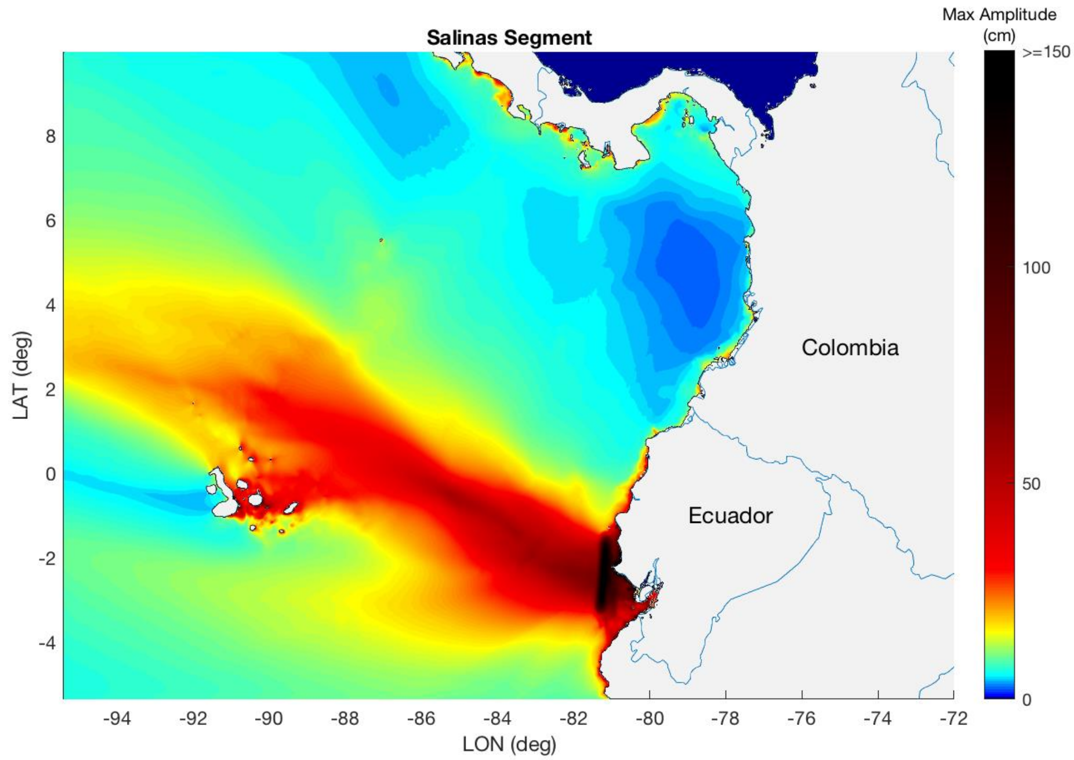

Figure 15. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the Salinas segment source using MOST/ComMIT. Modeling shows maximum impact along the southern coast of Ecuador with the main energy beam directed towards the North-west in the direction of the Galapagos Islands.*

6.2 MULTI-SEGMENT RUPTURE SCENARIOS

The events described in this section represent obviously, larger magnitude scenarios that are less likely to occur than those presented in Section 6.2, therefore these multi-segment scenarios are considered by the experts to have lower probability of occurrence.

Punta Galera-Buenaventura Source. This source is the combination of the Galera I/Pedernales and Galera II/Esmeraldas segments (segments 3 and 4) of Table 4 with exact parameters given in Table 6. For this source, an area that covers a rupture from Buenaventura in Colombia to roughly Bahía de Caráquez in Ecuador encompassing the Esmeraldas-Buenaventura plus the Pedernales segments in Table 4 is suggested, based on the proposed rupture for the 1906 earthquake (Mw ~ 8.6-8.8) (Kanamori and McNally, 1982; Okal, 1992; He et al., 2017; Yoshimoto et al., 2017). Even though within this area, the PGMZ zone has acted as a propagation barrier; according to Kaneko et al. (2010), low coupling areas such as the PGMZ can sometimes behave as propagation barriers, but under certain conditions (stronger magnitudes) ruptures might break through them. This could be the case, for the 1906 earthquake that according to Kanamori and MacNally (1982) reached a magnitude Mw 8.8. For this area, with an estimated rupture from Bahía de Caráquez to Buenaventura, the event's magnitude would be Mw 8.9.

Figure 16 shows preliminary modeling results of the combined source of segments 3 and 4 (Galera I/Pedernales and Galera II/Esmeraldas) of Table 6. The maximum tsunami offshore amplitude is almost 3 meters close to the rupture area. Most of the onshore tsunami energy impacts the northern coast of Ecuador and southern coast of Colombia most heavily. Offshore of the generation area, this source shows a wide beam of tsunami energy directed towards the northwest, north of the Galapagos Islands which do not seem to be heavily affected by the tsunami generated by this source.

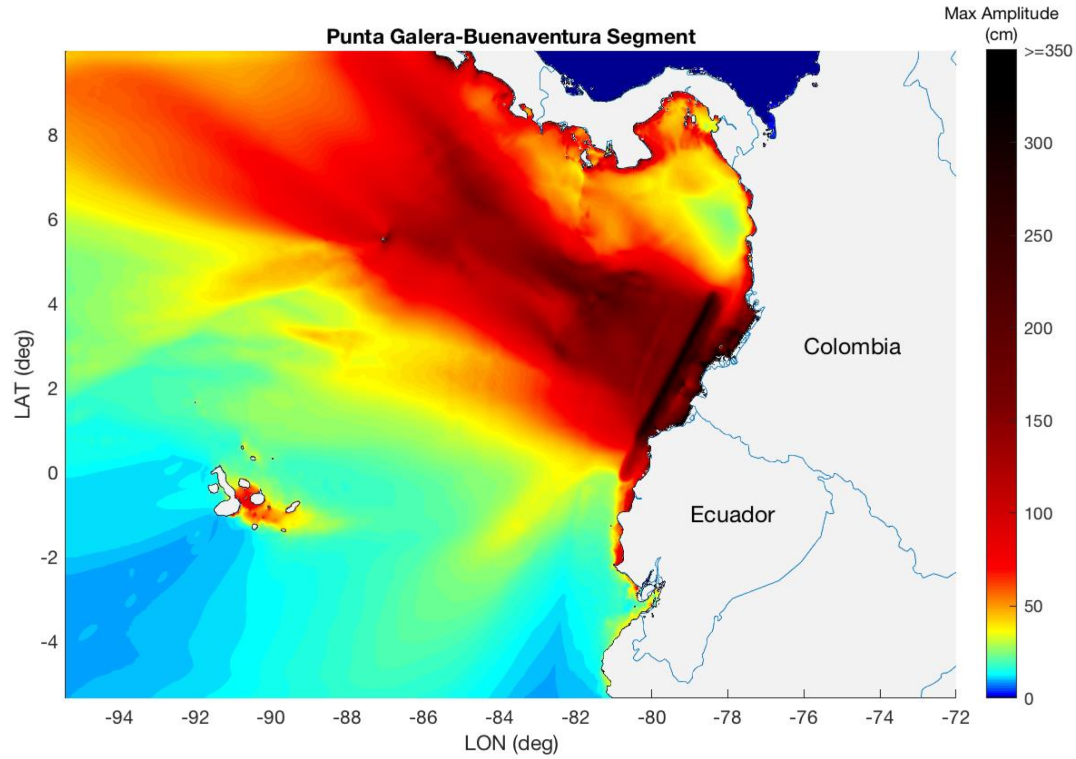

Figure 16. *Maximum computed tsunami wave amplitude in the Colombo-Ecuador region from the combination of the Pedernales and Esmeraldas segments using MOST/ComMIT. Modeling shows maximum impact along the northern coast of Ecuador and southern coast of Colombia. Due to the large size of this event (Mw 8.7-8.9) impact almost everywhere in the region is severe, although the offshore-travelling energy beam is directed North-west away from the region.*

	Segment Name	Length (km)	Width (km)	Depth (km)	Slip (m)	Dip (deg)	Rake (deg)	Strike (deg)	Lat (deg)	Lon (deg)	Mw
3 + 4	Galera I/ Pedernales+GaleraI I/Esmeraldas	560	80/100	22/20	3.4/7.4	21/16	90/90	25/30	0.14/ 2.33	279.70 /280.9 9	8.7-8.9

Table 6. *Proposed parameters of the combined seismic sources composed of the Pedernales and Esmeraldas segments.*

6.3 FAR-FIELD AND NON-SEISMIC SOURCES

Additionally, it is understood that earthquakes of significant magnitude generated in other regions of the Pacific Ocean can generate tsunamis with the potential to affect the coasts of Colombia and Ecuador. Events related to extreme volcanic activity in the Galapagos Islands are also considered to have the capacity to trigger tsunamis, even though the latter situation is unlikely.

7. CONCLUSIONS AND RECOMMENDATIONS

This report presents a careful analysis of the tectonic setting of the Colombo-Ecuadorian continental margin, as well as a detail review of the historical seismic record in the region. The results of both analyses underscore the exposure of the Colombian and Ecuadorian coasts to the tsunami hazard. Of particular interest is the propensity of the region to generate “slow earthquakes”, also known as “tsunami earthquakes”. These are slow slip seismic events, capable of releasing a significant amount of stress. They also tend to be extremely tsunamigenic when the duration of the event is in the order of a tens of minutes to several hours. With no perceptible shaking that could alert coastal populations, the potential of these events to cause massive casualties and damage should not be underestimated, particularly for coastal areas without an effective Tsunami Warning System that in combination with an evacuation plan could help at-risk populations respond appropriately during a tsunami event.

This report has also presented the current capabilities deployed in the region in terms of instrumental networks with special emphasis on seismic and geodetic networks that will help in the rapid characterization of seismic events and evaluation of their tsunami potential.

The detailed and extensive modeling work that has been performed in both Colombia and Ecuador to generate tsunami evacuation maps has also been reviewed, especially the very detailed work performed in the Ecuadorian margin and the proposed use of model data obtained during these simulations in combination with fragility curves to obtain an estimate of losses and casualties for the modelled scenarios.

Engaging scientific debate by the experts during the 3 days of the workshop resulted in the identification of the largest credible tsunamigenic scenarios, the experts believe can be expected in the region and resulting in tsunamis of varying levels of severity. The scenarios were clearly identified and their fault planes defined in terms of their characteristic parameters: focal location, length, width, dip angle, strike angle, rake angel and estimated slip amount. The possible combination of several of these rupture segments that could results in yet more severe events was also considered. All values were tabulated for ease of use by the community.

Preliminary deep-water tsunami simulations from each of the rupture segments and segment combinations identified were performed using the Nonlinear Shallow Water code MOST, through its graphical user interface, ComMIT. The numerical simulations provide a preliminary representation of tsunami energy distribution in the region which can be used to address which scenario will be particularly damaging for a specific coastal area, and can help identify which communities might require more detailed, high-resolution, inundation modeling.

This committee of experts, strongly encourages that:

- The sources identified in this report are shared and used by the relevant agencies in addressing the tsunami hazard for coastal areas of Ecuador and Pacific coast of Colombia, as they represent credible worst-case scenarios for the region. Use of these sources by both countries would result in consistency of results in communities across country boundaries resulting in added credibility and increased acceptance of the results.

- The possibility of enhancing the existing network of deep-water tsunami sensors known as Tsunameters is highly encouraged, particularly given the high-risk of slow-slip seismic events in the region. Events that may go undetected by traditional seismic networks, but are capable of generating large tsunamis that could be detected in the water.

- The enhancement of the geodetic networks is also recommended as these instruments can also detect slow slip events and can also assist with rapid, early forecasting of tsunamis. It is, therefore advisable that when adding new stations to the existing networks, an effort is made to deploy, high-frequency, real-time reporting stations to ensure their use, not only for scientific applications, but for tsunami early warning as well.

- Since both countries, Colombia and Ecuador share the common threat of tsunamis, the maximum level of coordination between Emergency Management authorities in each country is strongly recommended so that consistency is brought to the solution of the problem and efforts are not duplicated.

8. ACKNOWLEDGEMENTS

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ANNEX II

AGENDA

Guayaquil, Ecuador (Hotel Palace) Chair: Diego Arcas

	Agenda Item	Time	Session Facilitator/Presenter
1.1	Welcome and introductions/role of CPPS, IOC and ICG-PTWS	09:00 – 09:15	Mentor Villagomez/Wilfried Strauch
1.2	Overview of meeting aims/objectives/IOC requirements and expectations of experts meeting	09:15 – 09:45	Bernardo Aliaga
1.3	Discussion on regional and global implications: ▪ How this work will impact our understanding of the hazard and risk ▪ What are the impacts on science research? ▪ What are the constraints?	09:45 – 10:30	Local Seismic Expert Sandro Vaca (Ecuador) Viviana Dionicio (Colombia)
	Group Photo	10:30 – 10:45	
	Morning Break		
1.4	Presentation and discussion of 'what do we want to achieve?' and key priorities. Discuss meeting outcomes (Ocean Decade)	11:15 – 13:00	Diego Arcas
1.5	Current state scientific update (Introduction to the Afternoon session) per discipline (30mins each):		
	Lunch		
1.5.1	Tsunami Modelling	14:00 – 14:30	Diego Arcas
1.5.2	Seismology-slow earthquakes	13:00 – 13:30	Emile Okal
1.5.3	Paleotsunamis along Ecuatorian coasts	13:30 – 14:00	Kervin Chunga
1.5.4	GNSS/Geodesy - GPS Network Operating on the Ecuadorian-Esmeraldas section of the coastline	14:00 – 15:30	Brendan Crowell/ Patricia Mothes
1.5.5	Tsunami Early Warning (Ecuador)	15:30 – 16:00	Willington Rentería
1.5.6	Tsunami Early Warning (Colombia)	16:00 – 16:30	Ronald Sanchez
1.5.7	Tsunami Early Warning (CATAC-Central America) for Colombia-Ecuador sources	16:30 - 17:00	Wilfried Strauch
	Day 1 Close		

2 FOCUS: Finalize Science Topics and Open Discussion on Seismic Source			
2.1	Re-confirm and reflection on scientific updates from the previous day. Next steps for the day	09:00 – 09:30	Diego Arcas
2.2	State of Evacuation Mapping and Emergency Response in Colombia	09:30 – 10:00	Ronald Sanchez
2.3	State of Evacuation Mapping and Emergency Response in Ecuador	10:00 – 10:30	Patricia Arreaga Vargas/Sharl Noboa
	Morning Break		
2.4	Benefits of Standardized HA	11:15 – 12:15	Gloria López
2.5	Lessons learnt at OSSO, Colombia, on environment and exposed population, Threat and Support to Mitigation	12:15 – 13:00	Hansjurgen Meyer
	Lunch		
2.6	Open Group discussion on source identification: • Worst Credible Scenario (MCE) • Mmax • Segmentation • Deterministic vs. probabilistic approaches - what scenarios we are suggesting. • Uncertainty in source parameters	14:00 – 17:00	Group Discussion
	Day 2 Close		
3 FOCUS: Open Discussion on Tsunami Source Impact and Report Planning			
3.1	Re-confirm and test meeting outcomes following Day 3 (what can/we need to achieve and priorities)	09:00 – 09:30	Diego Arcas
3.2	Elicitation process on seismic source model to support tsunami discussions (potential models that can be tested)	09:30 – 10:30	Group Discussion
	Morning Break		
3.3	Group discussion	11:00 – 13:00	Group Discussion
	Lunch		
3.4	Group Discussion (cont'd)	14:00 – 15:30	Group Discussion
3.5	Summary and conclusions on group discussion	15:30 – 16:00	Diego Arcas
3.6	Report Assignments and Deadlines	16:00 – 16:45	Diego Arcas/Group
4 FOCUS: Public Awareness Event and Closing			
4.1	Public Awareness Event	17:00 – 18:30	TBD
4.2	Closing Remarks	18:30	TBD
	Day 3 Close		

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3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean; Monte Carlo, 9-14 September 1974.	E,F E (out of stock)
4	Report of the Workshop on the Phenomenon known as 'El Niño'; Guayaquil, Ecuador, 4-12 December 1974.	E (out of stock) S (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources; Kingston, Jamaica, 17-22 February 1975	E (out of stock) S
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Suva, Fiji, 1-6 September 1975.	E
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/UNESCO/ EAC; Nairobi, Kenya, 25 March-2 April 1976.	E, F,S, R
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters; Penang, 7-13 April 1976	E (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience; Mauritius 9-13 August 1976.	E, F, S, R
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring; Monaco, 14-18 June 1976	E, F E (out of stock) R
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976.	E, S (out of stock)
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12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects; Fort-de-France, Martinique, 28 November-2 December 1977.	E, F, S
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area; Port of Spain, Trinidad, 16-18 January 1978.	E, S
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas; Abidjan, Côte d'Ivoire, 2-9 May 1978	E, F
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific; Santiago de Chile, 6-10 November 1978.	E (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	E, F, R
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS); Moscow, 9-11 April 1979.	E
17 suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System; Moscow, 2-6 April 1979.	E
18	IOC/UNESCO Workshop on Syllabus for Training Marine Technicians; Miami, U.S.A., 22-26 May 1978 (UNESCO reports in marine sciences, No. 4 published by the Division of Marine Sciences, UNESCO).	E (out of stock), F, S (out of tock), R
19	IOC Workshop on Marine Science Syllabus for Secondary Schools; Llantwit Major, Wales, U.K., 5-9 June 1978 (UNESCO reports in marine sciences, No. 5, published by the Division of Marine Sciences, UNESCO).	E (out of stock), S, R, Ar
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources; Bandung, Indonesia, 17-21 October 1978	E
21	Second IDOE Symposium on Turbulence in the Ocean; Liège, Belgium, 7-18 May 1979.	E, F, S, R
22	Third IOC/WMO Workshop on Marine Pollution Monitoring; New Delhi, 11-15 February 1980.	E, F, S, R
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific; Tokyo, 27-31 March 1980.	E, R
24	WESTPAC Workshop on Coastal Transport of Pollutants; Tokyo, Japan, 27-31 March 1980.	E (out of stock)
25	Workshop on the Inter-calibration of Sampling Procedures of the IOC/ WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters; Bermuda, 11-26 January 1980.	E (Superseded by IOC Technical Series No.22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region; Mexico City, 24 September- 5 October 1979.	E, S
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Nouméa, New Caledonia, 9-15 October 1980.	E
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes. Lima, 20 April-5 May 1980.	E
29	WESTPAC Workshop on Marine Biological Methodology; Tokyo, 9-14 February 1981.	E
30	International Workshop on Marine Pollution in the South-West Atlantic; Montevideo, 10-14 November 1980.	E (out of stock) S
31	Third International Workshop on Marine Geoscience; Heidelberg, 19-24 July 1982.	E, F, S
32	UNU/IOC/UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E, F, S
32 Suppl.	Papers submitted to the UNU/IOC/ UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR); Halifax, 26-30 September 1963.	E
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa); Tenerife, 12-17 December 1963.	E, F, S
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific; Suva, Fiji, 3-7 October 1983.	E
36	IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, Portugal, 28 May-2 June 1984.	E
36 Suppl.	Papers submitted to the IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984	E
37	IOC/UNESCO Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs; Colombo, 8-13 July 1985.	E
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region; Basrah, Iraq, 8-12 January 1984.	E
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific; Suva, Fiji, 24-29 September 1985.	E
40	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications; Sidney, B.C., Canada, 29-31 July 1985.	E
40 Suppl.	First International Tsunami Workshop on Tsunami Analysis, Prediction and Communications, Submitted Papers; Sidney, B.C., Canada, 29 July-1 August 1985.	E
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2); Dakar, Senegal, 28 October-1 November 1985.	E
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean; Venice, Italy, 23-25 October 1985.	E
44	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E (out of stock) S
44 Suppl.	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities, Submitted Papers; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E
45	IOCARIBE Workshop on Physical Oceanography and Climate; Cartagena, Colombia, 19-22 August 1986.	E
46	Reunión de Trabajo para Desarrollo del Programa "Ciencia Oceánica en Relación a los Recursos No Vivos en la Región del Atlántico Sud-occidental"; Porto Alegre, Brasil, 7-11 de abril de 1986.	S
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence; Townsville, 1-6 December 1966	E
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on 'Ocean Science in Relation to Non-Living Resources (OSNLR)'; Havana, Cuba, 4-7 December 1986.	E, S
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on 'El Niño'; Guayaquil, Ecuador, 27-31 October 1986.	E
50	CCALR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR); Paris, France, 2-6 June 1987.	E
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations; Lae, Papua-New Guinea, 1-8 October 1987.	E
52	SCOR-IOC-UNESCO Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere; Paris, France, 6-10 May 1985.	E
53	IOC Workshop on the Biological Effects of Pollutants; Oslo, 11-29 August 1986.	E
54	Workshop on Sea-Level Measurements in Hostile Conditions; Bidston, UK, 28-31 March 1988.	E
55	IBCCA Workshop on Data Sources and Compilation, Boulder, Colorado, 18-19 July 1988.	E
56	IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Cleveland, Australia, 24-30 July 1988.	E
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms; Takamatsu, Japan, 16-17 November 1987.	E
58	International Workshop on the Technical Aspects of the Tsunami Warning System; Novosibirsk, USSR, 4-5 August 1989.	E
58 Suppl.	Second International Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness,	E

No.	Title	Languages
	Observation and Instrumentation. Submitted Papers; Novosibirsk, USSR, 4-5 August 1989.	
59	IOC-UNEP Regional Workshop to Review Priorities for Marine Pollution Monitoring Research, Control and Abatement in the Wider Caribbean; San José, Costa Rica, 24-30 August 1989.	E, F, S
60	IOC Workshop to Define IOCARIBE-TRODERP proposals; Caracas, Venezuela, 12-16 September 1989.	E
61	Second IOC Workshop on the Biological Effects of Pollutants; Bermuda, 10 September-2 October 1988.	E
62	Second Workshop of Participants in the Joint FAO-IOC-WHO-IAEA-UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region; Accra, Ghana, 13-17 June 1988.	E
63	IOC/WESTPAC Workshop on Co-operative Study of the Continental Shelf Circulation in the Western Pacific; Bangkok, Thailand, 31 October-3 November 1989.	E
64	Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Phuket, Thailand, 25-31 September 1989.	E
65	Second IOC Workshop on Sardine/Anchovy Recruitment Project (SARP) in the Southwest Atlantic; Montevideo, Uruguay, 21-23 August 1989.	E
66	IOC ad hoc Expert Consultation on Sardine/ Anchovy Recruitment Programme; La Jolla, California, U.S.A., 1989	E
67	Interdisciplinary Seminar on Research Problems in the IOCARIBE Region; Caracas, Venezuela, 28 November-1 December 1989.	E (out of stock)
68	International Workshop on Marine Acoustics; Beijing, China, 26-30 March 1990.	E
69	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
69 Suppl.	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Submitted Papers; Leningrad, USSR, 28-31 May 1990.	E
70	IOC-SAREC-UNEP-FAO-IAEA-WHO Workshop on Regional Aspects of Marine Pollution; Mauritius, 29 October - 9 November 1990.	E
71	IOC-FAO Workshop on the Identification of Penaeid Prawn Larvae and Postlarvae; Cleveland, Australia, 23-28 September 1990.	E
72	IOC/WESTPAC Scientific Steering Group Meeting on Co-Operative Study of the Continental Shelf Circulation in the Western Pacific; Kuala Lumpur; Malaysia, 9-11 October 1990.	E
73	Expert Consultation for the IOC Programme on Coastal Ocean Advanced Science and Technology Study; Liège, Belgium, 11-13 May 1991.	E
74	IOC-UNEP Review Meeting on Oceanographic Processes of Transport and Distribution of Pollutants in the Sea; Zagreb, Yugoslavia, 15-18 May 1989.	E
75	IOC-SCOR Workshop on Global Ocean Ecosystem Dynamics; Solomons, Maryland, U.S.A., 29 April-2 May 1991.	E
76	IOC/WESTPAC Scientific Symposium on Marine Science and Management of Marine Areas of the Western Pacific; Penang, Malaysia, 2-6 December 1991.	E
77	IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of Sea-Level Changes on the Western Indian Ocean Coasts and Islands; Mombasa, Kenya, 24-28 June 1991.	E
78	IOC-CEC-ICES-WMO-ICSU Ocean Climate Data Workshop Goddard Space Flight Center; Greenbelt, Maryland, U.S.A., 18-21 February 1992.	E
79	IOC/WESTPAC Workshop on River Inputs of Nutrients to the Marine Environment in the WESTPAC Region; Penang, Malaysia, 26-29 November 1991.	E
80	IOC-SCOR Workshop on Programme Development for Harmful Algae Blooms; Newport, U.S.A. 2-3 November 1991.	E
81	Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control; Paris, France, 12-13 October 1992.	E
82	BORDOMER 92: International Convention on Rational Use of Coastal Zones. A Preparatory Meeting for the Organization of an International Conference on Coastal Change; Bordeaux, France, 30 September-2 October 1992.	E
83	IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 12-13 October 1992.	E
84	Workshop on Atlantic Ocean Climate Variability; Moscow, Russian Federation, 13-17 July 1992	E
85	IOC Workshop on Coastal Oceanography in Relation to Integrated Coastal Zone Management; Kona, Hawaii, 1-5 June 1992.	E
86	International Workshop on the Black Sea; Varna, Bulgaria, 30 September – 4 October 1991	E
87	Taller de trabajo sobre efectos biológicos del fenómeno «El Niño» en ecosistemas costeros del Pacífico Sudeste; Santa Cruz, Galápagos, Ecuador, 5-14 de octubre de 1989.	S only (summary in E, F, S)
88	IOC-CEC-ICSU-ICES Regional Workshop for Member States of Eastern and Northern Europe (GODAR Project); Obninsk, Russia, 17-20 May 1993.	E
89	IOC-ICSEM Workshop on Ocean Sciences in Non-Living Resources; Perpignan, France, 15-20 October 1990.	E
90	IOC Seminar on Integrated Coastal Management; New Orleans, U.S.A., 17-18 July 1993.	E
91	Hydroblack'91 CTD Intercalibration Workshop; Woods Hole, U.S.A., 1-10 December 1991.	E
92	Réunion de travail IOCEA-OSNLR sur le Projet « Budgets sédimentaires le long de la côte occidentale d'Afrique » Abidjan, côte d'Ivoire, 26-28 juin 1991.	E
93	IOC-UNEP Workshop on Impacts of Sea-Level Rise due to Global Warming. Dhaka, Bangladesh, 16-19 November 1992.	E
94	BMTC-IOC-POLARMAR International Workshop on Training Requirements in the Field of Eutrophication in Semi-enclosed Seas and Harmful Algal Blooms, Bremerhaven, Germany, 29 September-3 October 1992.	E
95	SAREC-IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 23-25 November 1993.	E
96	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Zanzibar, United Republic of Tanzania, 17-21 January 1994.	E
96 Suppl.	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 1. Coastal Erosion; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
96 Suppl	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 2. Sea Level; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
97	IOC Workshop on Small Island Oceanography in Relation to Sustainable Economic Development and Coastal Area Management of Small Island Development States; Fort-de-France, Martinique, 8-10 November, 1993.	E
98	CoMSBlack '92A Physical and Chemical Intercalibration Workshop; Erdemli, Turkey, 15-29 January 1993.	E
99	IOC-SAREC Field Study Exercise on Nutrients in Tropical Marine Waters; Mombasa, Kenya, 5-15 April 1994.	E
100	IOC-SOA-NOAA Regional Workshop for Member States of the Western Pacific - GODAR-II (Global Oceanographic Data Archeology and Rescue Project); Tianjin, China, 8-11 March 1994.	E
101	IOC Regional Science Planning Workshop on Harmful Algal Blooms; Montevideo, Uruguay, 15-17 June 1994.	E
102	First IOC Workshop on Coastal Ocean Advanced Science and Technology Study (COASTS); Liège, Belgium, 5-9 May 1994.	E
103	IOC Workshop on GIS Applications in the Coastal Zone Management of Small Island Developing States; Barbados, 20-22 April 1994.	E
104	Workshop on Integrated Coastal Management; Dartmouth, Canada, 19-20 September 1994.	E
105	BORDOMER 95: Conference on Coastal Change; Bordeaux, France, 6-10 February 1995.	E
105 Suppl.	Conference on Coastal Change: Proceedings; Bordeaux, France, 6-10 February 1995	E
106	IOC/WESTPAC Workshop on the Paleographic Map; Bali, Indonesia, 20-21 October 1994.	E
107	IOC-ICSU-NIO-NOAA Regional Workshop for Member States of the Indian Ocean - GODAR-III; Dona Paula, Goa, India, 6-9 December 1994.	E
108	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Paris, France, 9-12 May 1995.	E
108 Suppl.	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Submitted Papers; Paris, France, 9-12 May 1995.	E
109	First IOC-UNEP CEPPOL Symposium; San José, Costa Rica, 14-15 April 1993.	E
110	IOC-ICSU-CEC regional Workshop for Member States of the Mediterranean - GODAR-IV (Global Oceanographic Data Archeology and Rescue Project) Foundation for International Studies, University of Malta, Valletta, Malta, 25-28 April 1995.	E
111	Chapman Conference on the Circulation of the Intra-Americas Sea; La Parguera, Puerto Rico, 22-26 January 1995.	E
112	IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials (GESREM) Workshop; Miami, U.S.A., 7-8 December 1993.	E
113	IOC Regional Workshop on Marine Debris and Waste Management in the Gulf of Guinea; Lagos, Nigeria, 14-16 December 1994.	E
114	International Workshop on Integrated Coastal Zone Management (ICZM) Karachi, Pakistan; 10-14 October 1994.	E
115	IOC/GLOSS-IAPSO Workshop on Sea Level Variability and Southern Ocean Dynamics; Bordeaux, France, 31 January 1995	E
116	IOC/WESTPAC International Scientific Symposium on Sustainability of Marine Environment: Review of the WESTPAC Programme, with Particular Reference to ICAM, Bali, Indonesia, 22-26 November 1994.	E
117	Joint IOC-CIDA-Sida (SAREC) Workshop on the Benefits of Improved Relationships between International Development Agencies, the IOC and other Multilateral Inter-governmental Organizations in the Delivery of Ocean, Marine Affairs and Fisheries Programmes; Sidney B.C., Canada, 26-28 September 1995.	E
118	IOC-UNEP-NOAA-Sea Grant Fourth Caribbean Marine Debris Workshop; La Romana, Santo Domingo, 21-24 August 1995.	E
119	IOC Workshop on Ocean Colour Data Requirements and Utilization; Sydney B.C., Canada, 21-22 September 1995.	E
120	International Training Workshop on Integrated Coastal Management; Tampa, Florida, U.S.A., 15-17 July 1995.	E
121	Atelier régional IOC-CERESCOR sur la gestion intégrée des zones littorales (ICAM), Conakry, Guinée, 18–22 décembre 1995	F
122	IOC-EU-BSH-NOAA-(WDC-A) International Workshop on Oceanographic Biological and Chemical Data Management, Hamburg, Germany, 20-23 May 1996	E
123	Second IOC Regional Science Planning Workshop on Harmful Algal Blooms in South America; Mar del Plata, Argentina, 30 October–1 November 1995.	E, S
124	GLOBEC-IOC-SAHFOS-MBA Workshop on the Analysis of Time Series with Particular Reference to the Continuous Plankton Recorder Survey; Plymouth, U.K.,4-7 May 1993.	E
125	Atelier sous-régional de la COI sur les ressources marines vivantes du Golfe de Guinée ; Cotonou, Bénin, 1-4 juillet 1996.	E

No.	Title	Languages
126	IOC-UNEP-PERSGA-ACOPS-IUCN Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden. Jeddah, Saudi Arabia, 8 October 1995.	E
127	IOC Regional Workshop for Member States of the Caribbean and South America GODAR-V (Global Oceanographic Data Archeology and Rescue Project); Cartagena de Indias, Colombia, 8-11 October 1996.	E
128	Atelier IOC-Banque Mondiale-Sida/SAREC-ONE sur la Gestion Intégrée des Zones Côtières ; Nosy Bé, Madagascar, 14-18 octobre 1996.	E
129	Gas and Fluids in Marine Sediments, Amsterdam, the Netherlands; 27-29 January 1997.	E
130	Atelier régional de la COI sur l'océanographie côtière et la gestion de la zone côtière ;Moroni, RFI des Comores, 16-19 décembre 1996.	E
131	GOOS Coastal Module Planning Workshop; Miami, USA, 24-28 February 1997	E
132	Third IOC-FANSA Workshop; Punta-Arenas, Chile, 28-30 July 1997	S/E
133	Joint IOC-CIESM Training Workshop on Sea-level Observations and Analysis for the Countries of the Mediterranean and Black Seas; Birkenhead, U.K., 16-27 June 1997.	E
134	IOC/WESTPAC-CCOP Workshop on Paleogeographic Mapping (Holocene Optimum); Shanghai, China, 27-29 May 1997.	E
135	Regional Workshop on Integrated Coastal Zone Management; Chabahar, Iran; February 1996.	E
136	IOC Regional Workshop for Member States of Western Africa (GODAR-VI); Accra, Ghana, 22-25 April 1997.	E
137	GOOS Planning Workshop for Living Marine Resources, Dartmouth, USA; 1-5 March 1996.	E
138	Gestión de Sistemas Oceanográficos del Pacífico Oriental; Concepción, Chile, 9-16 de abril de 1996.	S
139	Sistemas Oceanográficos del Atlántico Sudoccidental, Taller, TEMA;Furg, Rio Grande, Brasil, 3-11 de noviembre de 1997	S
140	IOC Workshop on GOOS Capacity Building for the Mediterranean Region; Valletta, Malta, 26-29 November 1997.	E
141	IOC/WESTPAC Workshop on Co-operative Study in the Gulf of Thailand: A Science Plan; Bangkok, Thailand, 25-28 February 1997.	E
142	Pelagic Biogeography ICoPB II. Proceedings of the 2nd International Conference. Final Report of SCOR/IOC Working Group 93; Noordwijkerhout, The Netherlands, 9-14 July 1995.	E
143	Geosphere-biosphere coupling: Carbonate Mud Mounds and Cold Water Reefs; Gent, Belgium, 7–11 February 1998.	E
144	IOC-SOPAC Workshop Report on Pacific Regional Global Ocean Observing Systems; Suva, Fiji, 13-17 February 1998.	E
145	IOC-Black Sea Regional Committee Workshop: 'Black Sea Fluxes' Istanbul, Turkey, 10-12 June 1997.	E
146	Taller Internacional sobre Formacíon de Capacidades para el Manejo de las Costas y los Óeanos en le Gran Caribe, La Habana, – Cuba, 7–10 de Julio de 1998 / International Workshop on Management Capacity-Building for Coasts and Oceans in the Wider Caribbean, Havana, Cuba, 7–10 July 1998	S/E
147	IOC-SOA International Training Workshop on the Intregration of Marine Sciences into the Process of Integrated Coastal Management, Dalian, China, 19-24 May 1997.	E
148	IOC/WESTPAC International Scientific Symposium – Role of Ocean Sciences for Sustainable Development Okinawa, Japan, 2-7 February 1998.	E
149	Workshops on Marine Debris & Waste Management in the Gulf of Guinea, 1995-97.	E
150	Primera Sesión del Grupo de Trabajo COI sobre Algas Nocivas en el Caribe y Regiones Adyacentes (IOCARIBE-ANCA)/First Meeting of the IOC Working Group on Harmful Algae in the Caribbean and Adjacent Region (IOCARIBE-ANCA), 29 June – 1 July 1998, Havana, Cuba.	S/E ***(electronic copy only)***
151	Taller Pluridisciplinario TEMA sobre Redes del Gran Caribe en Gestión Integrada de Áreas Costeras Cartagena de Indias, Colombia, 7-12 de septiembre de 1998.	S
152	Workshop on Data for Sustainable Integrated Coastal Management (SICOM) Maputo, Mozambique, 18-22 July 1998	E
153	IOC/WESTPAC-Sida (SAREC) Workshop on Atmospheric Inputs of Pollutants to the Marine Environment Qingdao, China, 24-26 June 1998	E
154	IOC-Sida-Flanders-SFRI Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA project) Capetown, South Africa, 30 November-11 December 1998.	E
155	Science of the Mediterranean Sea and its applications UNESCO, Paris 29-31 July 1997	E
156	IOC-LUC-KMFRI Workshop on RECOSCIX-WIO in the Year 2000 and Beyond, Mombasa, Kenya, 12-16 April 1999	E
157	'98 IOC-KMI International Workshop on Integrated Coastal Management (ICM), Seoul, Republic of Korea 16-18 April 1998	E
158	The IOCARIBE Users and the Global Ocean Observing System (GOOS) Capacity Building Workshop, San José, Costa Rica, 22-24 April 1999	E
159	Oceanic Fronts and Related Phenomena (Konstantin Fedorov Memorial Symposium) – Proceedings, Pushkin, Russian Federation, 18-22 May 1998	E
160	Under preparation	
161	Under preparation	
162	Workshop report on the Transports and Linkages of the Intra-americas Sea (IAS), Cozumel, Mexico, 1-5 November 1997	E
163	Under preparation	
164	IOC-Sida-Flanders-MCM Third Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA Project), Cape Town, South Africa, 29 November – 11 December 1999	E
165	An African Conference on Sustainable Integrated Management; Proceedings of the Workshops. An Integrated Approach, (PACSICOM), Maputo, Mozambique, 18 –25 July 1998	E, F
166	IOC-SOA International Workshop on Coastal Megacities: Challenges of Growing Urbanization of the World's Coastal Areas; Hangzhou, P.R. China, 27 –30 September 1999	E
167	IOC-Flanders First ODINAFRICA-II Planning Workshop, Dakar, Senegal, 2-4 May 2000	E
168	Geological Processes on European Continental Margins; International Conference and Eight Post-cruise Meeting of the Training-Through-Research Programme, Granada, Spain, 31 January – 3 February 2000	E
169	International Conference on the International Oceanographic Data & Information Exchange in the Western Pacific (IODE-WESTPAC) 1999, ICIWP '99, Langkawi, Malaysia, 1-4 November 1999	E ***(electronic copy only)***
170	IOCARIBE-GODAR-I Cartagenas, Colombia, February 2000	***under preparation***
171	Ocean Circulation Science derived from the Atlantic, Indian and Arctic Sea Level Networks, Toulouse, France, 10-11 May 1999	E
172	(*Under preparation*)	
173	The Benefits of the Implementation of the GOOS in the Mediterranean Region, Rabat, Morocco, 1-3 November 1999	E, F
174	IOC-SOPAC Regional Workshop on Coastal Global Ocean Observing System (GOOS) for the Pacific Region, Apia, Samoa, 16-17 August 2000	E
175	Geological Processes on Deep-water European Margins, Moscow-Mozhenka, 28 Jan.-2 Feb. 2001	E
176	MedGLOSS Workshop and Coordination Meeting for the Pilot Monitoring Network System of Systematic Sea Level Measurements in the Mediterranean and Black Seas, Haifa, Israel, 15-17 May 2000	E
177	*(Under preparation)*	
178	*(Under preparation)*	
179	*(Under preparation)*	
180	Abstracts of Presentations at Workshops during the 7th session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, USA, 23-27 April 2001	E
181	*(Under preparation)*	
182	*(Under preparation)*	
183	Geosphere/Biosphere/Hydrosphere Coupling Process, Fluid Escape Structures and Tectonics at Continental Margins and Ocean Ridges, International Conference & Tenth Post-cruise Meeting of the Training-through-Research Programme, Aveiro, Portugal, 30 January-2 February 2002	E
184	*(Under preparation)*	
185	*(Under preparation)*	
186	*(Under preparation)*	
186	*(Under preparation)*	
187	Geological and Biological Processes at deep-sea European Margins and Oceanic Basins, Bologna, Italy, 2–6 February 2003	E
188	Proceedings of 'The Ocean Colour Data' Symposium, Brussels, Belgium, 25-27 November 2002	E
189	Workshop for the Formulation of a Draft Project on Integrated Coastal Management (ICM) in Latin America and the Caribbean (LAC), Cartagena, Colombia, 23–25 October 2003 Taller de Formulación de un Anteproyecto de Manejo Costero Integrado (MCI) en América Latina y el Caribe (ALC), Cartagena, Colombia, 23–25 de Octubre de 2003	E F ***(electronic copy only)***
190	First ODINCARSA Planning Workshop for Caribbean Islands, Christchurch, Barbados, 15–18 December 2003	E ***(electronic copy only)***
191	North Atlantic and Labrador Sea Margin Architecture and Sedimentary Processes — International Conference and Twelfth Post-cruise Meeting of the Training-through-research Programme, Copenhagen, Denmark, 29–31 January 2004	E
192	Regional Workshop on Coral Reefs Monitoring and Management in the ROPME Sea Area, Iran I.R., 14–17 December 2003	E ***(under preparation)***
193	Workshop on New Technical Developments in Sea and Land Level Observing Systems, Paris, France, 14–16 October 2003	E ***(electronic copy only)***
194	IOC/ROPME Planning Meeting for the Ocean Data and Information Network for the Central Indian Ocean Region	***(under preparation)***
195	Workshop on Indicators of Stress in the Marine Benthos, Torregrande-Oristano, Italy, 8–9 October 2004	E
196	International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework, Paris, France, 3–8 March 2005	E
197	Geosphere-Biosphere Coupling Processes: The TTR Interdisciplinary Approach Towards Studies of the European and North African Margins; International Conference and Post-cruise Meeting of the Training-Through-Research Programme, Morocco, 2-5 February 2005	E
198	Second International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean, Grand Baie, Mauritius, 14–16 April 2005	E
199	International Conference for the Establishment of a Tsunami and Coastal Hazards Warning System for the Caribbean and Adjacent Regions, Mexico, 1–3 June 2005	E
200	Lagoons and Coastal Wetlands in the Global Change Context: Impacts and Management Issues — Proceedings of the International Conference, Venice, 26–28 April 2004 (*ICAM Dossier N° 3)*	E
201	Geological processes on deep-water European margins - International Conference and 15th Anniversary Post-cruise Meeting of the Training-Through-Research Programme, Moscow/Zvenigorod, Russian Federation, 29 January–4 February 2006	E
202	Proceedings of 'Ocean Biodiversity Informatics': an international conference on marine biodiversity data management Hamburg, Germany, 29 November–1 December 2004	E
203	IOC-Flanders Planning Workshop for the formulation of a regional Pilot Project on Integrated Coastal Area Management in Latin America, Cartagena de Indias, Colombia, 16–18 January 2007	*E* ***(electronic copy only)***
204	Geo-marine Research along European Continental Margins, International Conference and Post-cruise Meeting of the Training-through-research Programme, Bremen, Germany, 29 January–1 February 2007	E
205	IODE/ICAM Workshop on the development of the Caribbean marine atlas (CMA), United Nations House, Bridgetown, Barbados, 8–10 October 2007	E ***(electronic copy only)***
206	IODE/JCOMM Forum on Oceanographic Data Management and Exchange Standards, Ostend, Belgium, 21–25 January 2008	*(Under preparation)*
207	SCOR/IODE Workshop on Data Publishing, Ostend, Belgium, 17–18 June 2008	*(Under preparation)*

No.	Title	Languages
208	JCOMM Technical Workshop on Wave Measurements from Buoys, New York, USA, 2–3 October 2008 (IOC-WMO publication)	*(Under preparation)*
209	Collaboration between IOC and OBIS towards the Long-term Management Archival and Accessibility of Ocean Biogeographic Data, Ostend, Belgium, 24–26 November 2008	*(Under preparation)*
210	Ocean Carbon Observations from Ships of Opportunity and Repeat Hydrographic Sections (IOCCP Reports, 1), Paris, France, 13–15 January 2003	E ***(electronic copy only)***
211	Ocean Surface pCO_2 Data Integration and Database Development (IOCCP Reports, 2), Tsukuba, Japan, 14–17 January 2004	E ***(electronic copy only)***
212	International Ocean Carbon Stakeholders' Meeting, Paris, France, 6–7 December 2004	E ***(electronic copy only)***
213	International Repeat Hydrography and Carbon Workshop (IOCCP Reports, 4), Shonan Village, Japan, 14–16 November 2005	E ***(electronic copy only)***
214	Initial Atlantic Ocean Carbon Synthesis Meeting (IOCCP Reports, 5), Laugavatn, Iceland, 28–30 June 2006	E ***(electronic copy only)***
215	Surface Ocean Variability and Vulnerability Workshop (IOCCP Reports, 7), Paris, France, 11–14 April 2007	E ***(electronic copy only)***
216	Surface Ocean CO2 Atlas Project (SOCAT) 2nd Technical Meeting Report (IOCCP Reports, 9), Paris, France, 16–17 June 2008	E ***(electronic copy only)***
217	Changing Times: An International Ocean Biogeochemical Time-Series Workshop (IOCCP Reports, 11), La Jolla, California, USA, 5–7 November 2008	E ***(electronic copy only)***
218	Second Joint GOSUD/SAMOS Workshop, Seattle, Washington, USA, 10–12 June 2008	E ***(electronic copy only)***
219	International Conference on Marine Data management and Information Systems (IMDIS), Athens, Greece, 31 March–2 April 2008	E
220	Geo-marine Research on the Mediterranean and European-Atlantic Margins. International Conference and TTR-17 Post-cruise Meeting of the Training-through-research Programme, Granada, Spain, 2–5 February 2009	E ***(electronic copy only)***
221	Surface Ocean CO_2 Atlas Project Pacific Regional Workshop, Tsukuba, Japan, 18-20 March, 2009 (IOCCP Report Number 12)	E ***(electronic copy only)***
222	Surface Ocean CO_2 Atlas Project Atlantic and Southern Oceans Regional Meeting, Norwich, UK, 25-26 June, 2009 (IOCCP Report Number 13)	E ***(electronic copy only)***
223	Advisory Workshop on enhancing forecasting capabilities for North Indian Ocean Storm Surges, Indian Institute of Technology (IIT), New Delhi, India, 14–17 July 2009	E ***(electronic copy only)***
224	2009 International Nutrients Scale System (INSS) Workshop Report, Paris, France, 10–12 February 2009	E ***(electronic copy only)***
225	Reunión subregional de planificación de ODINCARSA (Red de Datos e Información Oceanográficos para las Regiones del Caribe y América del Sur)/ ODINCARSA (Ocean Data and Information Network for the Caribbean and South America region) Latin America sub-regional Planning Meeting, Universidad Autónoma de Baja California (UABC), Ensenada (México), 7-10 December 2009. 2010	E/S ***(electronic copy only)***
226	OBIS (Ocean Biogeographic Information System) Strategy and Work plan Meeting, IOC Project Office for IODE, Oostende, Belgium, 18–20 November 2009	E ***(electronic copy only)***
227	ODINAFRICA-IV Project Steering Committee, First Session, Ostend, Belgium, 20–22 January 2010. 2010	E ***(electronic copy only)***
228	First IODE Workshop on Quality Control of Chemical Oceanographic Data Collections, Ostend, Belgium, 8–11 February 2010. 2010	E ***(electronic copy only)***
229	Surface Ocean CO_2 Atlas Project Equatorial Pacific, North Pacific, and Indian Ocean Regional Workshop, Tokyo, Japan, 8–11 February 2010. 2010 (IOCCP Report Number 18)	E ***(electronic copy only)***
230	SCOR/IODE/MBLWHOI Library Workshop on Data Publication, Paris, France, 2 April 2010	E ***(electronic copy only)***
231	First ODINAFRICA Coastal and Marine Atlases Planning Meeting, Ostend, Belgium, 12–14 October 2009	E ***(electronic copy only)***
232	Eleventh International Workshop on Wave Hindcasting and Forecasting and Second Coastal Hazard Symposium, Halifax, Canada, 18–23 October 2009	E ***(electronic copy only)***
233	2010 Meeting of the Joint IODE-JCOMM Steering Group on the Global Temperature-Salinity Profile Programme Ostend, Belgium, 5–7 May 2010	E ***(electronic copy only)***
234	Southern and Indian Surface Ocean CO_2 Atlas (SOCAT) Workshop, CSIRO Marine Laboratories, Hobart, Tasmania 16-18 June 2010	E ***(electronic copy only)***
235	The Caribbean Marine Atlas (CMA) Review and Planning Workshop and Saint Lucia National Coastal Atlas Stakeholder Event, Bay Gardens Inn, Rodney Bay, Saint Lucia, 2–6 August 2010	E ***(electronic copy only)***
236	First Session of the IODE Steering Group for the IODE OceanDataPortal (SG-ODP-I), 20–22 September 2010, Ostend, Belgium	E ***(electronic copy only)***
237.	Ad hoc meeting of the IODE Steering Group for OBIS, Ostend, Belgium 18-19 November 2010	E ***(electronic copy only)***
238.	Implementing Adaptation to Climate Change in Western and Eastern Africa, Nairobi, Kenya, 3-5 November 2010	E ***(electronic copy only)***
239.	2nd Advisory Workshop on enhancing forecasting capabilities for North Indian Ocean Storm Surges, 11-15 February 2011, New Delhi, India	E ***(electronic copy only)***
240.	Ocean Biogeographic Information System (OBIS) Infrastructure Meeting, INCOIS, Hyderabad, India, 2–4 March 2011.	E ***(electronic copy only)***
241.	Best Practice on Tsunami and Coastal Hazards Community Preparedness and Readiness in Central America and the Caribbean, 11–13 August 2008, Panama City, Panama	E ***(electronic copy only)***
242.	Integrated Coastal Area Management (ICAM) Training Workshop for the English Speaking Caribbean States, 16–18 March 2011, Bridgetown, Barbados	E ***(electronic copy only)***
243.	Implementing Adaptation to Climate Change in Western and Eastern Africa: Targeting the Adaptation Fund. Nairobi, Kenya, 3–5 November 2010	*cancelled*
244.	SCOR/IODE/MBLWHOI Library Workshop on Data Publication, 4th Session, British Oceanographic Data Centre, Liverpool, United Kingdom, 3-4 November 2011	E ***(electronic copy only)***
245.	Surface Ocean CO2 Data-to-Flux Workshop, UNESCO, Paris, 12-14 September 2011	*cancelled*
246.	NEAMTIC/ICAM Workshop on Coastal Management Approaches for Sea-Level Related Hazards, Paris, UNESCO, 5–7 December 2011	E ***(electronic copy only)***
247.	Technical Workshop on the IODE OceanDataPortal, IOC Project Office for IODE, Ostend, Belgium, 27-29 February 2012	E ***(electronic copy only)***
248.	Inter-sessional working group for updating the IOC Strategic Plan for Oceanographic Data and Information Exchange (2012-2015), Ostend, Belgium, 1-2 March 2012	E ***(electronic copy only)***
249.	Operational Oceanography of IOC (for Group II Member States), 20–22 March 2012 Paris, UNESCO (Advisory Workshop)	E ***(electronic copy only)***
250.	Advisory Workshop on The Future of IOC towards next ten years and its Implications for Member States, Varna, Bulgaria, 19 March 2012	E ***(electronic copy only)***
251	Second Technical Meeting of Ocean Biogeographic Information System (OBIS), Ostend, Belgium, 21–22 June 2012	E ***(electronic copy only)***
252.	SCOR/IODE/MBLWHOI Library Workshop on Data Publication, 5th Session, Woods Hole Oceanographic Institution, Woods Hole, USA, 9-10 October 2012	E ***(electronic copy only)***
253.	Second IODE Workshop on Quality Control of Chemical and Biological Oceanographic Data Collections, 22-24 October 2012, IOC Project Office for IODE, Ostend, Belgium	E ***(electronic copy only)***
254.	Consultation on Scientific and Technical Aspects of Sustained Ocean Observations and Services, 5th March, 2013, Rio de Janeiro, Brazil	E ***(electronic copy only)***
255.	Earthquake and tsunami hazard in Northern Haiti: Historical events and potential sources (Meeting of experts)	E ***(electronic copy only)***
256	Sexto Taller Regional de Planificación Científica sobre Floraciones de Algas Nocivas en Sudamérica, Guayaquil, Ecuador, 22-24 Octubre 2003	S ***(electronic copy only)***
257	*(Under preparation)*	
258	*(Under preparation)*	
259	Noveno Taller Regional-COI de Planificación Científica sobre Florecimientos de Algas Nocivas en Sudamérica, 11-13 enero 2011, Puerto Varas, Chile	S ***(electronic copy only)*** *(Summary in E)*
260	*Caribbean Marine Atlas Review and Planning Meeting, Miami, USA, 10-13 December 2013*	
261	Indo-Pacific Ocean Forum on “Charting the Future of Sustained Ocean Observations and Services”, Bangkok, Thailand, 25-28 Nov. 2013	E ***(electronic copy only)***
262	*First Planning Workshop For The Ocean Data And Information Network For The Westpac Region (ODINWESTPAC), Tianjin, China, 4-7 March 2014*	
263	*International Coastal Atlas Network Workshop 6: Expanding Participation in Coastal Web Atlas Development and Use, 16–17 June 2013, University of Victoria, British Columbia, Canada*	
264	9th WESTPAC International Scientific Symposium, Research Directors’ Forum: A Healthy and Safe Ocean for Prosperity in the Indo-Pacific region, Nha Trang, Viet Nam, 22 April 2014	E ***(electronic copy only)***
265	Electoral Group 1 Consultation on the Future of the IOC, Utrecht, The Netherlands, 26–27 May 2014	E ***(electronic copy only)***
266	IOC-UNESCO-ISESCO workshop on Improving Tsunami Warning and Emergency Response in the North-Eastern Atlantic, Mediterranean and connected seas Rabat, 23-24 September 2014	A/E/F ***(electronic copy only)***
267	Proceedings of the First IOCAFRICA Ocean Forecasting workshop for the Western Indian Ocean region, Nairobi, Kenya, 11–15 August 2014	E ***(electronic copy only)***
268	Proceedings of the African Summer School on Application of Ocean Data and Modelling Products, Ghana, Kenya, April–September 2014	E ***(electronic copy only)***
269.	*Forum on Sustained Ocean Observations and Services in IOC Group V (Africa and Arab countries)*	E
270.	*Second China-Africa Forum on Marine Science and Technology, 9-10 April 2015, Nairobi, Kenya*	*Under preparation*
271.	WESTPAC Workshop on Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems. Phuket, Thailand, 19–21 January 2015	E ***(electronic copy only)***
272.	Second IOCAFRICA Planning Meeting for the Second International Indian Ocean Expedition (IIOE-2), 6-8 October 2015, Catembe, Mozambique	E ***(electronic copy only)***
273.	Initiative de LOANGO : Atelier de la sous-région sur l’érosion côtière en Afrique centrale, Loango, République du Congo, 6–10 octobre 2008	F
274.	First Session of the Advisory Group for the Ocean Data and Information Network for the WESTPAC Region (ODINWESTPAC), Tianjin, China, 27-28 January 2016	E
275.	Scientific meeting of experts for coordinated scenario analysis of future tsunami events and hazard mitigation schemes for the South China Sea region, Xiamen, China, 16–18 November 2015	E
276.	Sources of Tsunamis in the Caribbean with Possibility to Impact the Southern Coast of the Dominican Republic, Santo Domingo, Dominican Republic, 6–7 May 2016	E & S
277.	VI IOC Regional Science Planning Workshop on Harmful Algae in the Caribbean and Adjacent Regions, Santo Domingo, Dominican Republic, 26-30 October 2015 / COI – VI Taller Regional de Planificación Científica sobre Algas Nocivas en el Caribe y Regiones Adyacentes, Santo Domingo, República Dominicana, 26-30 Octubre 2015	E/S
278.	Tsunami Hazard in Central America: Historical Events and Potential Sources. Meeting of Experts, San José, Costa Rica, 23-24 June 2016	E
279.	2nd International Conference on Marine/Maritime Spatial Planning, 15-17 March 2017, UNESCO, Paris	E
280.	Information Meeting on North-Eastern Atlantic, the Mediterranean and Connected Seas Tsunami Early Warning and Mitigation System (NEAMTWS) and NEAMWave 17 Tsunami Exercise: Summary Recommendations, Tunis, Tunisia, 13-14 September 2017	E/F/Ar
281.	Workshop on Sea-Level Measurements in Hostile Conditions, Moscow, Russian Federation, 13–15 March 2018	E/R
282.	IODE/OBIS-Event-Data workshop on animal tagging and tracking, Ostend, Belgium, 23–26 April 2018	E
283.	Sixth International XBT Science Workshop, Ostend, Belgium, 18–20 April 2018	E
284.	Sargassum and Oil Spills Monitoring Pilot Project for the Caribbean and Adjacent Regions Workshop, Mexico DF, Mexico, 2–4 May 2018	E
285	Drafting Workshop for the development of a training and Repository Portal for the Caribbean Large Marine Ecosystem	E

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286.	Preparing for the Next Tsunami: Reducing Losses and Damages in the Coastal Western Mediterranean Areas: Summary Recommendations, Rabat, Morocco, 15-16 November 2018	E/F/Ar
287	Workshop on Sea level Data Archaeology, UNESCO, Paris, 10–12 March 2020	E
288	Workshop on data sharing between UN agencies as a contribution to the UN decade of ocean science for sustainable development, Online meeting, 20 April 2020, 14:00-16:30	E
289	Expert meeting on Tsunami sources, hazards, risk and uncertainties associated with the Tonga-Kermadec Subduction Zone. Wellington, New Zealand. 29 October – 3 November 2018.	E
290	International data sharing workshop for non-UN IGOs, Global and Regional organizations and projects, NGOs and private sector, Online meeting, 12 October 2020.	E
291	Experts Meeting on Sources of Tsunamis in the Lesser Antilles. Fort-de-France, Martinique (France), 18–20 March 2019	E
292	Italian Digital Mobilization Event for the United Nations Decade of Ocean Science for Sustainable Development: “Towards the Generation Ocean”, 22 October 2020, Milan, Italy	E/I
295	Expert Meeting on Tsunami Sources, Hazards, Risk and Uncertainties Associated with the Colombia-Ecuador Subduction Zone. Guayaquil, Ecuador, 27–29 January 2020	E