Intergovernmental Oceanographic Commission
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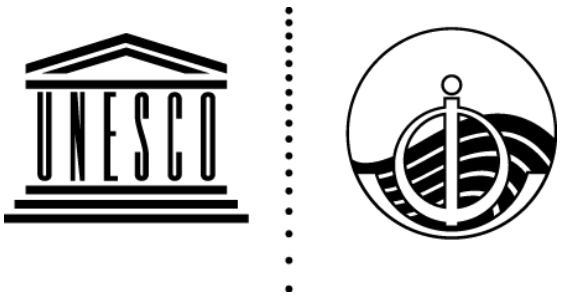

# EXERCISE CARIBE WAVE 19

## A Caribbean and Adjacent Region Tsunami Warning Exercise

## 14 March 2019

## Volume 2 Summary Report

UNESCO

Intergovernmental Oceanographic Commission
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IOC Technical Series, 141 (Volume 2)
Paris, July 2019
English only

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*NOTE: The United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Intergovernmental Oceanographic Commission (IOC) pattern the contents of this handbook after the CARIBE WAVE 2011, 2013, 2014, 2015, 2016, 2017 and 2018 Exercises. Each of these exercises has a handbook published as IOC Technical Series. These CARIBE WAVE exercises followed the Pacific Wave exercises which commenced in 2008 with manual published by the Intergovernmental Oceanographic Commission (Exercise Pacific Wave 08: A Pacific-wide Tsunami Warning and Communication Exercise, 28-30 October 2008, IOC Technical Series, 82, Paris, UNESCO 2008). The UNESCO How to Plan, Conduct and Evaluate Tsunami Wave Exercises, IOC Manuals and Guides, 58 rev., Paris, UNESCO 2013 (English and Spanish) is another important reference.*

**For bibliographic purposes, this document should be cited as follows:**

UNESCO/IOC. 2019. *Exercise Caribe Wave 2019. A Caribbean and Adjacent Region Tsunami Warning Exercise, 14 March 2019. Volume 2: Summary Report.* Paris, UNESCO, IOC Technical Series No 141, Vol. 2. (English only)

Report prepared by: The Intergovernmental Coordination Group for the Tsunami and the other Coastal Hazard Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE-EWS)

Published in 2019
by United Nations Educational, Scientific and Cultural Organization
7, Place de Fontenoy, 75352 Paris 07 SP

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(IOC/2018/TS/141 Vol.2)

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***Summary***

According to preliminary information, almost 800,000 people from Bermuda thru Brazil and across the entire Caribbean basin participated in the Caribe Wave 19 tsunami exercise held on 14 March 2019 (IOC/2018/TS/141 Vol.1). The exercise was conducted within the framework of the UNESCO Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE-EWS) with a participation of forty-seven of its forty-eight Member States (MS) and Territories[1]. The high participation rate reflects the importance the countries are giving to tsunami preparedness. This exercise was also used to test for the first time PTWC tsunami products for volcanic activity.

Participants included all officially designated CARIBE-EWS Tsunami Warning Focal Points (TWFPs), National Tsunami Warning Centres (NTWCs), international, state, territorial and local emergency management organizations (EMO), schools, universities, governmental agencies, private organizations, health facilities, members of the media, businesses and tourism industry as well as communities, individuals and families. The highest participation from the grand total corresponds to the education sector (K-12 Schools and Districts); these represent over 40% of the participants this year.

Each country participated with one of two Caribe Wave 2019 scenarios: Kick 'em Jenny Volcano (KEJ) or Panama. The Pacific Tsunami Warning Center (PTWC) issued eighteen (18) simulated international messages. Additionally, PTWC as the NTWC for Puerto Rico and US Virgin Islands (USVI) and British Virgin Islands (BVI), issued six (6) domestic products for the KEJ scenario. It was the decision of each Member States (MS) and Territory to decide their level of participation and issue and disseminate national and local products. Sirens, emails, emergency alert systems, text messages, media outlets, and social media were reported to be used by various countries as the means of dissemination. In addition to the communication tests, exercises were conducted at various levels of magnitude and sophistication including seminars, tabletop exercises and drills.

Planning for Caribe Wave 19 took over 12 months and was coordinated by a task team led by Dr Elizabeth Vanacore of the Puerto Rico Seismic Network (PRSN) and facilitated by the US NWS Caribbean Tsunami Warning Program (CTWP). TsunamiZone.org was used for the registration of the participants.

[1] Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Brazil, Colombia, Costa Rica, Cuba, Curacao, Dominica, Dominican Republic, France (Martinique, Guadeloupe, St. Barthelemy, St. Martin), Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Netherlands (Bonaire, Saba and Sint Eustatius), Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sint Maarten, Trinidad and Tobago, United Kingdom (Anguilla, British Virgin Islands, Bermuda, Cayman Islands, Montserrat and Turks and Caicos), United States (Puerto Rico and the US Virgin Islands) and Venezuela (Bolivarian Republic of).

## 1. BACKGROUND

The UNESCO/IOC Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions at its Eighth session (ICG/CARIBE-EWS-VIII, Port of Spain, Trinidad and Tobago, 29 April–1 May 2013) decided to conduct exercises named Caribe Wave on an annual basis leaving each Member State to define its level of participation. At its Thirteenth session (ICG/CARIBE-EWS-XIII, Willemstad, Curacao, 24–27 April 2018), the ICG/CARIBE-EWS recommended that Exercise Caribe Wave 19 take place on 14 March 2019, with two hypothetical tsunami scenarios. The first scenario generated by a 6.0 magnitude earthquake causing flank collapse of the Kick 'em Jenny submarine volcano and the second scenario generated by an 8.5 magnitude earthquake located along the Northern Panama Deformed Belt (NPDB).

Historical tsunami records from sources such as the National Oceanic and Atmospheric Administration's (NOAA) Centers for Environmental Information (NCEI) show that from 1530 to 2018 tsunamis from earthquake, landslide, and volcanic sources have affected the region. According to NCEI, in the past 500 years, over 105 tsunamis have been observed and approximately 4,500 people have lost their lives from tsunamis in the Caribbean and adjacent regions. Since the most recent devastating tsunami of 1946, there has been an explosive population growth and influx of tourists along the Caribbean and Western Atlantic coasts increasing the tsunami vulnerability of the region (von Hillebrandt-Andrade, 2013).

Recognizing the need for an early warning system, especially after the lessons learned from the 2004 Indian Ocean tsunami, the Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE-EWS) was established in 2005 as a subsidiary body of the IOC/UNESCO with the purpose of providing assistance to all Member States of the region to establish their own early warning system. The main objective of the ICG/CARIBE-EWS is to identify and mitigate the hazards posed by local, regional and distant tsunamis. The ultimate goal is to create a fully integrated end-to-end warning system comprising four key components: monitoring and detection systems; hazard assessment, tsunami related services (dissemination); and community preparedness, readiness and resilience.

The Caribe Wave 19 exercise provided simulated threat tsunami messages from the PTWC triggered by two hypothetical earthquakes: A 8.5 Mw with an epicentre at 10.00o, -78.50°, located offshore north of Panama (Figure 1), and a 6.0 Mw with an epicentre at 12.34°, -61.65°, at the underwater volcano Kick 'em Jenny located approximately 8 km north of Grenada.

At the national level, each Member State was responsible for defining its level of participation, which could include issuing simulated warnings or other alerts to its own citizens. These alerts could be based either on the TWFP's own analysis of the situation or the messages and/or graphical products received from the PTWC for the Panama scenario.

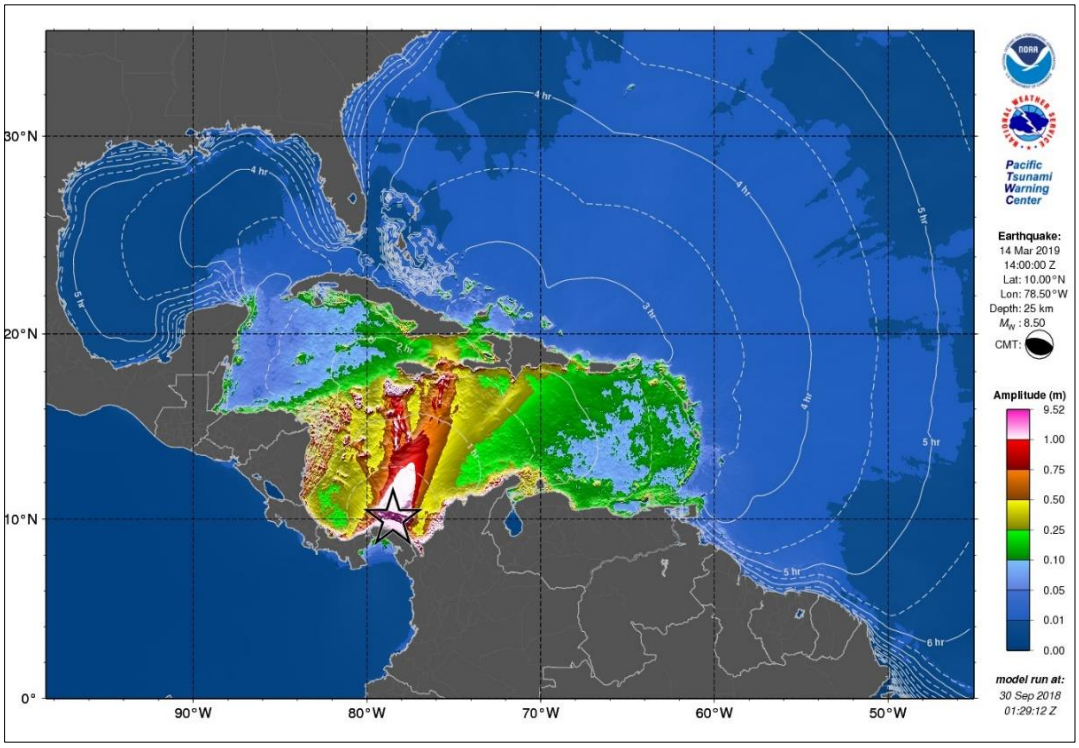



Figure 1. PTWC maximum deep-ocean amplitude map generated using RIFT for Panama scenario.

## 2. EXERCISE CONCEPT

### 2.1 PURPOSE

The purpose of the exercise was to improve tsunami warning system effectiveness in the Caribbean and adjacent regions. The exercise provided an opportunity for emergency management organizations throughout the region to exercise their operational lines of communications, review their tsunami response procedures, and promote tsunami preparedness. Regular exercising of response plans is critical to maintain readiness in case of an emergency. This is particularly true for the Caribbean and adjacent regions, where tsunamis are infrequent but can be of very high impact. Every emergency management organization (EMO) was encouraged to participate.

### 2.2 OBJECTIVES AND GOALS

Each organization developed its objectives for the exercise depending on its level of involvement in the scenario. There were three principal overarching objectives for the exercise.

**1. Exercise and evaluate communications between Regional Tsunami Service Provider and Members States/Territories.**

a. Validate the issuance of tsunami products from the PTWC.

b. Validate receipts of tsunami products by CARIBE-EWS Tsunami Warning Focal Points (TWFPs) and/or National Tsunami Warning Centres (NTWCs).

**2. Evaluate the tsunami procedures and programmes within Members States/Territories.**

a. Validate readiness to respond to a tsunami.

b. Validate the operational readiness of the TWFPs/NTWCs and/or the National Disaster Management Office (NDMO).

c. Improve operational readiness.

d. Validate that the dissemination of warnings and information/advice by TWFPs and NTWCs, to relevant in-country agencies and the public is accurate and timely.

e. Evaluate the status of the implementation of the pilot CARIBE-EWS Tsunami Ready recognition program.

**3. Evaluate volcanic products.**

a. Evaluate proposed PTWC CARIBE-EWS products for volcanic events.

b. Evaluate input from Seismic Research Centre.

c. Evaluate Member States and Territories response plans for tsunamis from volcanoes.

ICG/CARIBE-EWS has established metrics to evaluate the goals of the exercise (Table 1). Only 79% of MS and Territories submitted the Post-Exercise Survey on or before the due date, 29 March 2019. With 82% of these being satisfied with the exercise.

| Goals | 2013 Results | 2014 Results | 2015 Results | 2016 Results | 2017 Results | 2018 Metric | 2018 Results | 2019 Metric | 2019 Results |
|---|---|---|---|---|---|---|---|---|---|
| **TWFP receive the dummy message** | 98% | 94% | 90% | 84% | 95% | 100% | 100% | 100% | 89% |
| **Participation of Member States of ICG CARIBE EWS with designated focal warning point** | 94% | 98% (including two MS/Territory unofficial) | 100% | 100% | 100% | 100% | 97% | 100% | 100% |
| **Community involvement (beyond TWFP)** | 75% | 75% | 66% | 73% | 82% | 95% | 77% | 95% | 66% |
| **Number of participants** | 44,000 | 191,000 | 191,420 | 332,812 | 679,985 | +10% | 643,403 | +10% | 793,353 |
| **Countries who participate submit exercise questionnaire** | 90% | 100% | 91% | 100% | 100% | 100% | 91% | 100% | 82% |
| **Members State and territories are satisfied with exercise** | | | | | | | | | 82% |

Table 1. Goals and Metrics

## 2.3 TYPE OF EXERCISES

Exercises were carried out such that communications and decision making at various organizational levels and were exercised and conducted without disrupting or alarming the general public. A majority of National and local Offices of Emergency Management (OEM)

extended the exercise down to the level of testing local notification systems such as the Emergency Alert System (EAS), sirens and loudspeakers.

According to the Member States, the number of participants in the exercise was 793,353 people throughout the Caribbean and adjacent regions. The participants in the eighth annual regional tsunami exercise hailed from 32 Member States and 16 territories. It represented a participation rate of 100% of all the Member States of the UNESCO Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE-EWS) which provided the framework. This level of participation from the past exercises, including this year, represents the highly enthusiasm from the CARIBE-EWS Members States to participate and makes this tsunami exercise as one of the largest simulation exercises of its kind in the world.

Exercises were conducted at various scales of magnitude and sophistication. Exercises simulated the development, training, testing, and evaluation of Disaster Plans and Standard Operating Procedures (SOPs). The reported exercises included different activities as test on communication systems, tabletop, seminars and drills (Figure 2).


Figure 2. Examples of exercises as part of the Caribe Wave 19: Colombia (a), Puerto Rico (b), Mexico (c), Honduras (d), Dominican Republic (e), Puerto Rico (f), Venezuela (g), Honduras (h), Costa Rica (i), Martinique (j), Venezuela (k), Guadeloupe (l).

## 3. EXERCISE OUTLINE

### 3.1 GENERAL

Tsunami messages for this exercise were issued by the Pacific Tsunami Warning Center (PTWC) based on two hypothetical earthquakes (Figure 3) with the following hypocentre parameters:

Kick 'em Jenny Earthquake Scenario:

| | |
|---|---|
| Origin Time | 14:00:00 UTC March 14, 2019 |
| Latitude | 12.342° |
| Longitude | -61.658° |
| Magnitude | 6.0 – $M_w$ |
| Depth | 12.34 km |

Panama Earthquake Scenario:

| | |
|---|---|
| Origin Time | 14:00:00 UTC March 14, 2019 |
| Latitude | 10.00000°N |
| Longitude | 78.50000°W |
| Magnitude | 8.47 – $M_w$ |
| Depth | 25.1 km |

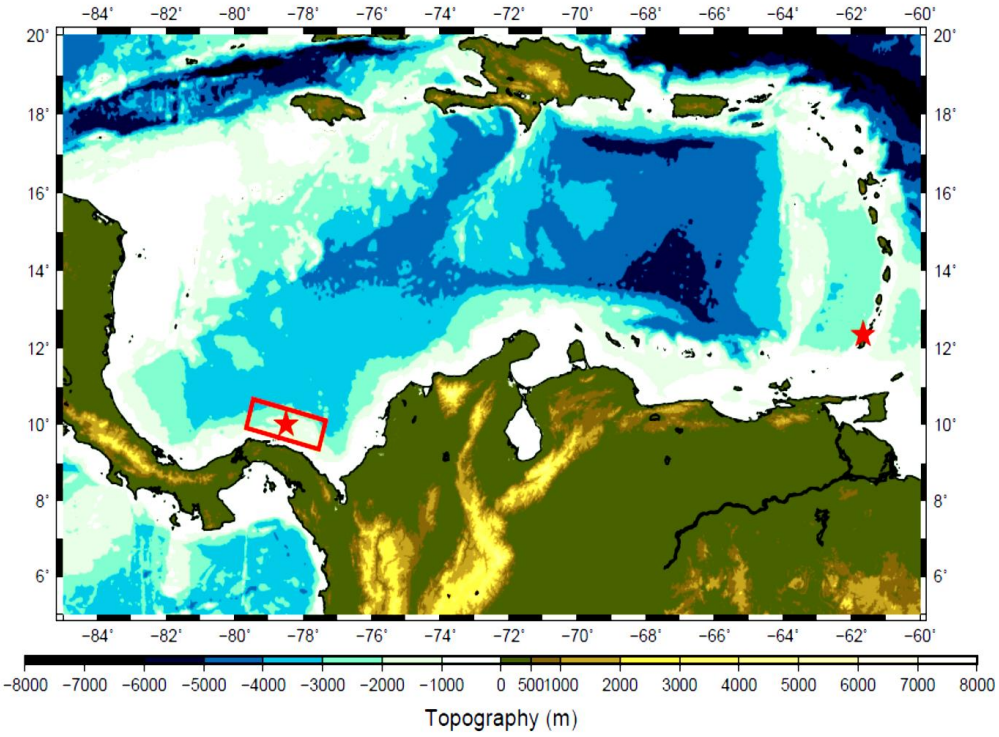



Figure 3. Map of the Caribe Wave 19 scenarios. Stars indicate epicenteral locations and the red boxes indicate the map view of the ruptured fault segments. The figure is underlain by etopo1 model of Amante and Eakins (2009). This figure was generated using The Generic Mapping Tool (GMT) (Wessel et al., 2013).

Messages Issued by the Pacific Tsunami Warning Center (PTWC)

The PTWC issued eighteen (18) international simulated messages, and six (6) domestic products for the Kick 'em Jenny scenario for Caribe Wave 19. The first tsunami information statement for the Kick 'em Jenny scenario and tsunami threat message for the Panama scenario was based on the earthquake magnitude and location, and the tsunami travel times. While as of the second messages were based on simulated tsunami wave forecasts, rather than upon seismic information. Tsunami threat forecasts indicated the levels of threat that have been forecast and to which countries or places they apply. The levels are tsunami heights of 0.3-1 meter, 1-3 meters, and greater than 3 meters above the normal tide level are determined. The threats were updated usually within an hour.

For the 2019 exercise, Member States were required to select one scenario by 28 February. Those who did not select any scenario, the organizers decided for which scenario the PTWC sends products. All simulated products (text and graphical) were disseminated through email to the corresponding TWFPs and NTWCs. Further dissemination was the responsibility of the corresponding national and local authorities.

The PTWC also issued live over all standard broadcast channels (WMO/AWIPS IDs WECA41 PHEB/TSUCAX) the initial dummy message to start the exercise at 1400 UTC on 14 March 2019.

## 3.2 MASTER SCHEDULE (EXERCISE SCRIPT)

CARIBE-EWS Tsunami Service Provider (PTWC) issued the initial dummy message for the two scenarios on 14 March 2019 at 1400 UTC. This was to test communications with TWFPs and NTWCs, and to start the exercise. The transmission methods used to send the dummy message were GTS - WIS (WMO Information System), EMWIN, AISR, NWWS, email, fax and AWIPS (Advanced Weather Interactive Processing System), using header IDs WECA41 PHEB/TSUCAX. All simulated products (text and graphical) were disseminated only thru email to TWFPs and NTWCs. Six (6) threat messages were issued for the Kick 'em Jenny scenario, and twelve (12) threat messages for the Panama scenario. The graphic enhanced products were included in the second threat message for the Panama scenario. As in past years, the most common methods to receive the Dummy message were email from PTWC and fax (Figure 4).

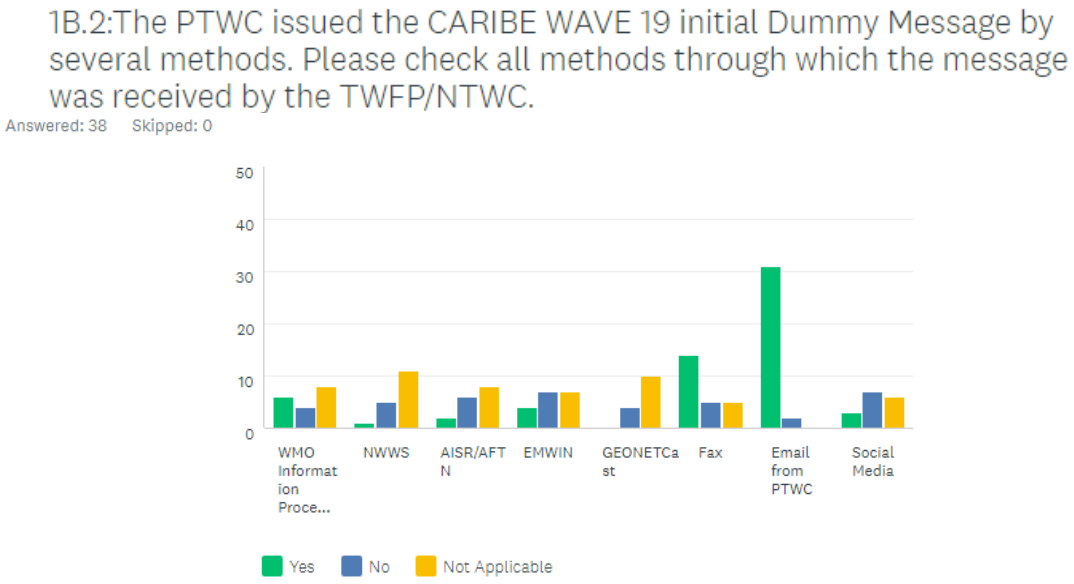



Figure 4. Methods that the CARIBE-EWS TWFPs/NTWCs used to receive the Dummy message by the PTWC.

## 3.3 ACTIONS IN THE CASE OF A REAL EVENT, AND FALSE ALARMS

No significant real events and false alarms were reported by the Member States and Territories during the exercise. No actions were thus required.

## 3.4 REGISTRATION PROCEDURE

As for past exercises, the ICG/CARIBE-EWS teamed up with TsunamiZone.org for online registration. The link used for the registration was http://www.tsunamizone.org/register/. Under the “Register Here” tab, participants were able to sign up and choose among the three major categories:

1. Myself and/or my family,

2. My school, district, college/university, or childcare center, and

3. My organization, department, or agency (including TNCs. TWFPs and NTWCs) (Figure 5). EMOs were encouraged to promote this registration system.

Most people registered directly on the TsunamiZone.org, which is an open registration system available during the whole year. As of 16 April 2019, 500,872 participants were counted (Table 2). Also based on own statistics, some Member States provided in the post-exercise survey the estimates of people participating (total number 785,734). Table 3 shows a comparison between registered, reported, and the consolidated number of participants.

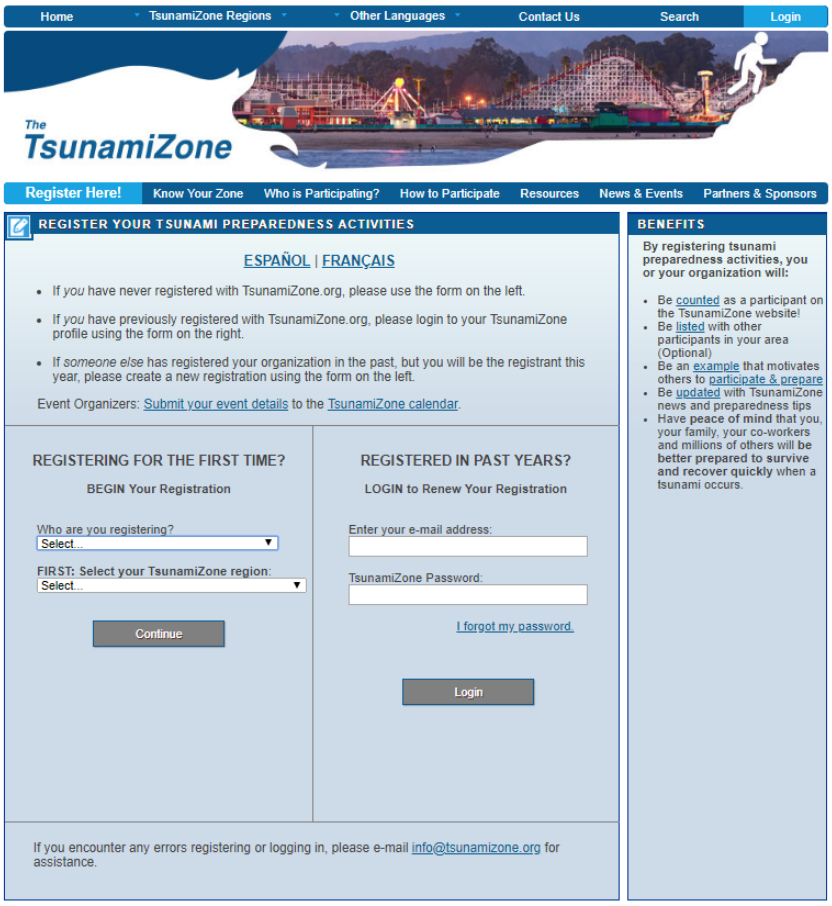



Figure 5. Registration by categories and Country for the Caribe Wave 19 Regional Tsunami Exercise.

| Category | Number of Participants |
|---|---|
| Individuals/Families | 2,404 |
| Childcare and Pre-Schools | 19,543 |
| K-12 Schools and Districts | 202,250 |
| Colleges and Universities | 50,850 |
| Government* | 157,121 |
| Businesses | 2,199 |
| Hotels and Other Lodgings | 724 |
| Healthcare | 9,064 |
| Senior Facilities/Communities | 537 |
| Disability/AFN Organizations | 219 |
| Non-Profit Organizations | 1,596 |
| Neighbourhood Groups | 1,268 |
| Preparedness Organizations | 30,576 |
| Faith-based Organizations | 21 |
| Museums, Libraries, Parks, etc. | 60 |
| Volunteer/Service Clubs | 84 |
| Youth Organizations | 90 |
| Agriculture/Livestock | 475 |
| Volunteer Radio Groups | 298 |
| Science/Engineering Organizations | 7,742 |
| Media Organizations | 15 |
| Other | 13,736 |
| **Total** | **500,872** |

Table 2. List of registrants and participants by Categories on TsunamiZone.org in the Caribbean (as of 4/16/2019)

*This includes TWFPs and TNCs

| Country | Number of Participants who directly registered on TsunamiZone.org | Number of Participants according to Member States | Consolidated Number of Participants |
|---|---|---|---|
| **Anguilla** | 1,250 | 1,200 | 1,250 |
| **Antigua and Barbuda** | 25 | 34 | 34 |
| **Aruba** | 9,755 | 12,000 | 12,000 |
| **Bahamas** | 90 | 90* | 90 |
| **Barbados** | 1,016 | 1,000 | 1,016 |
| **Belize** | 25 | 8 | 25 |
| **Bermuda** | 368 | 368 | 368 |
| **Brazil** | 2 | 2[2]* | 2 |
| **British Virgin Islands** | 2,088 | 2,088* | 2,088 |
| | **Cayman Islands** - 50 | 90 | 90 |
| | **Turks and Caicos** - 13 | 13* | 13 |
| **Colombia** | 521 | 521 | 521 |
| **Costa Rica** | 257 | 200 | 257 |
| **Cuba** | 145 | 5,700 | 5,700 |
| **Curaçao** | 66 | 200 | 200 |
| **Dominica** | 7 | 55 | 55 |
| **Dominican Republic** | 8,399 | 8,399 | 8,399 |
| **France** | **France**- 2,151 | 41 | 2,151 |
| | **Guadeloupe** - 93, 039 | 93,039 | 93,039 |
| | **Guyane** - 0 | 0 | 0 |
| | **Saint Barthélemy** - 1 | 1 | 1 |

[2] Numbers taken from TsunamiZone.org for cases where countries did not report number of participants in survey

| Country | Number of Participants who directly registered on TsunamiZone.org | Number of Participants according to Member States | Consolidated Number of Participants |
|---|---|---|---|
| | **Saint Martin** - 110 | 110 | 110 |
| | **Martinique**- 29,697 | 31,848 | 31,848 |
| **Grenada** | 10,976 | 1,000 estimated, 80,000 text messaging, 10,000 plus registration, plus private sector | 10,976 |
| **Guatemala** | 29 | 60 | 60 |
| **Guyana** | 30 | 10 | 30 |
| **Haiti** | 817 | 817 | 817 |
| **Honduras** | 3,000 | 4,000 | 4,000 |
| **Jamaica** | 115 | 115* | 115 |
| **Mexico** | 2,694 | 1,500 | 2,694 |
| **Montserrat** | 7 | 7* | 7 |
| **Netherlands** | **Netherlands**- 4 | 40 Including TWFPs, NDWOs, and local authorities | 4 |
| | **Bonaire** - 34 | | 34 |
| | **Saba** - 2 | | 2 |
| | **Sint Eustaius** - 4 | | 4 |
| | **Sint Maarten** - 25 | 25 | 25 |
| **Nicaragua** | 7,267 | 21,014 | 21,014 |
| **Panama** | 36 | 100 | 100 |
| **Puerto Rico** | 159,539 | 159,536 | 159,539 |
| **Saint Kitts and Nevis** | 5,500 | 5,500* | 5,500 |
| **Saint Lucia** | 6,656 | 3,500 | 6,656 |

| Country | Number of Participants who directly registered on TsunamiZone.org | Number of Participants according to Member States | Consolidated Number of Participants |
|---|---|---|---|
| **Saint Vincent and the Grenadines** | 300 | 350 | 350 |
| **Suriname** | 3 | 3* | 3 |
| **Trinidad and Tobago** | 46 | 30 | 46 |
| **U.S. Virgin Islands** | 2,021 | 2,021 | 2,021 |
| **Venezuela** | 152,692 | 420,099 | 420,099 |
| **TOTAL** | **500,872** | **785,734** | **793,353** |

Table 3. List of participants by Country/Territory (as of 04/16/2019)

## 3.5 STATUS OF SEA LEVEL STATIONS DURING EXERCISE

An analysis of sea level stations status was carried out by the CTWP as part of the Caribe Wave 19 Regional Tsunami Exercise. This allowed the CTWP to analyze the availability of sea level data retrieved from the sea level stations in the case of a real event occurring at the time of the exercise on March 14, 2019. The PTWC provided forecasted maximum wave heights for a number of stations in the simulated bulletins, 30 for the Kick 'em Jenny (Figure 6), and 62 for the Panama scenarios (Figure 7). Only about 70% of the sea level stations were online on the IOC Sea Level facility during the exercise period (Figure 8). Several stations reported in the simulated products have not been in operation for many years and/or were recently impacted by the hurricanes. The Tide Tool had around 67% of stations available to display estimated times of arrival (ETAs) (Figures 9 and 10). DART had 4 of 7 stations streaming data in the Caribbean/Gulf and Atlantic thru the National Buoy Center (Figure 11)

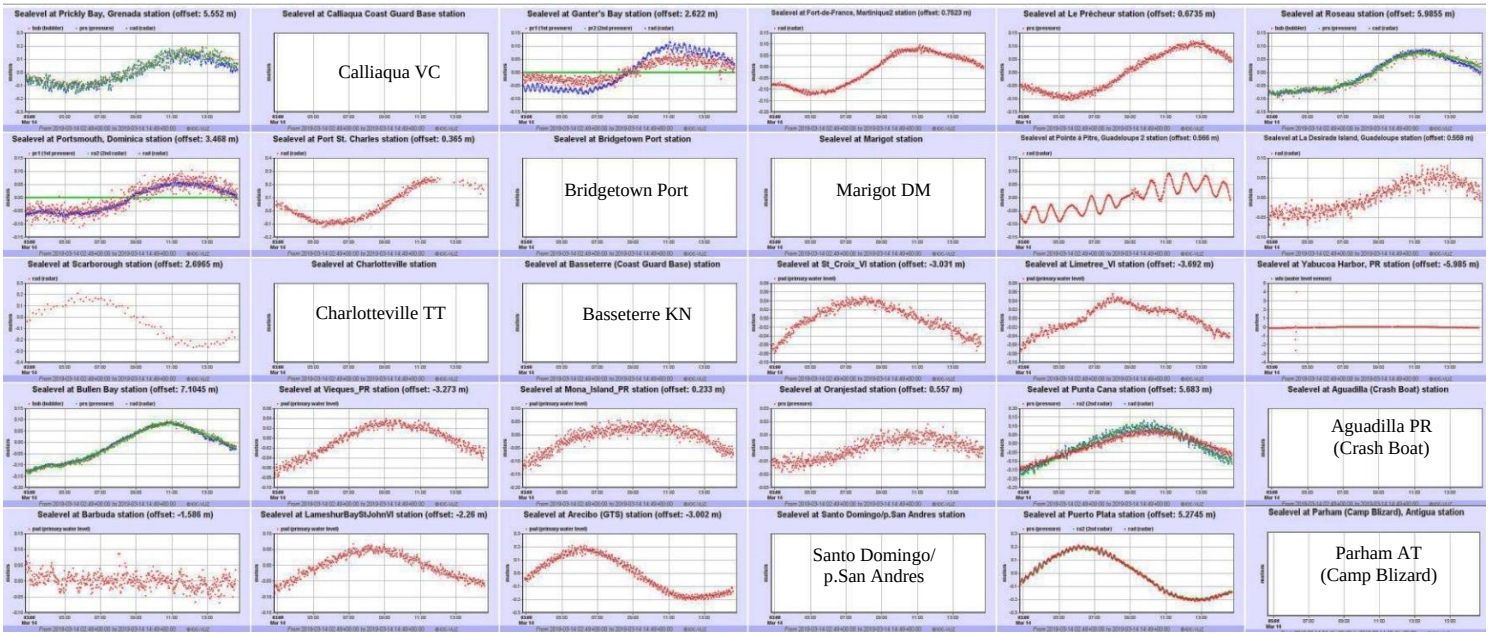



Figure 6. Forecasts of maximum wave heights for the Kick 'em Jenny scenario from 30 stations.

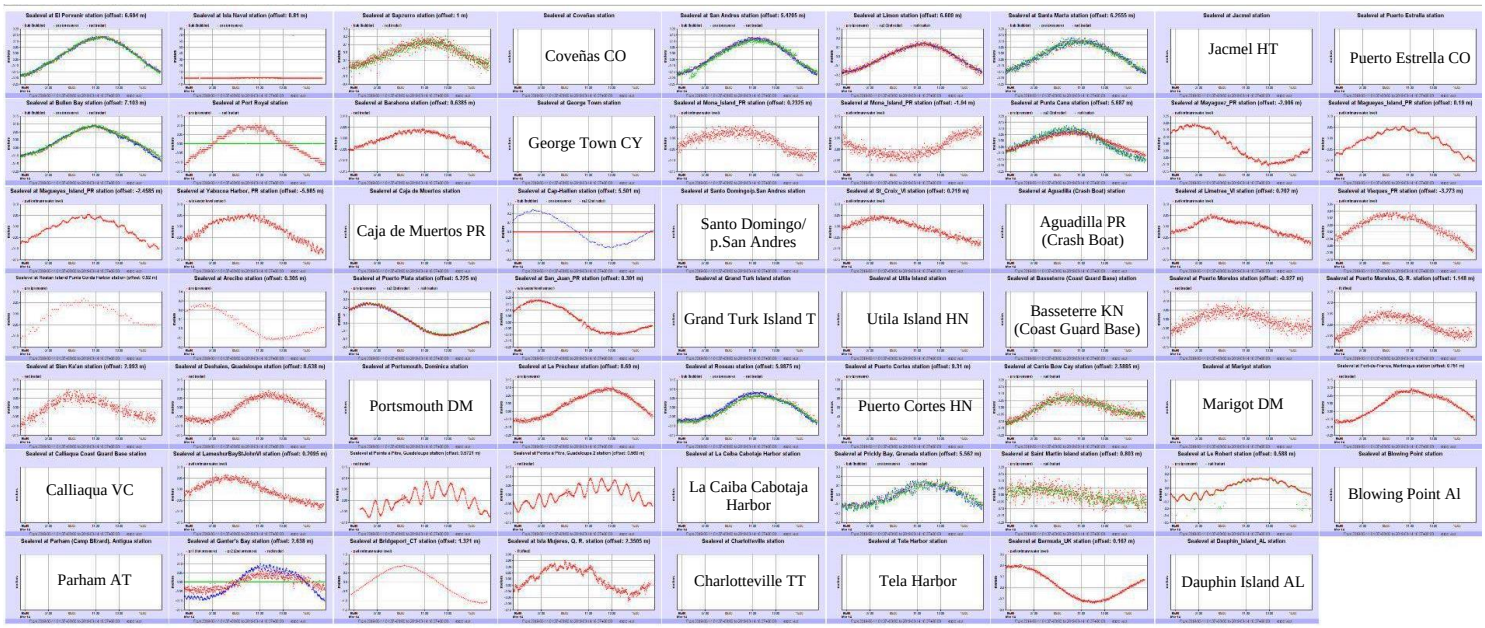



Figure 7. Forecasts of maximum wave heights for the Panama scenario from 62 stations.

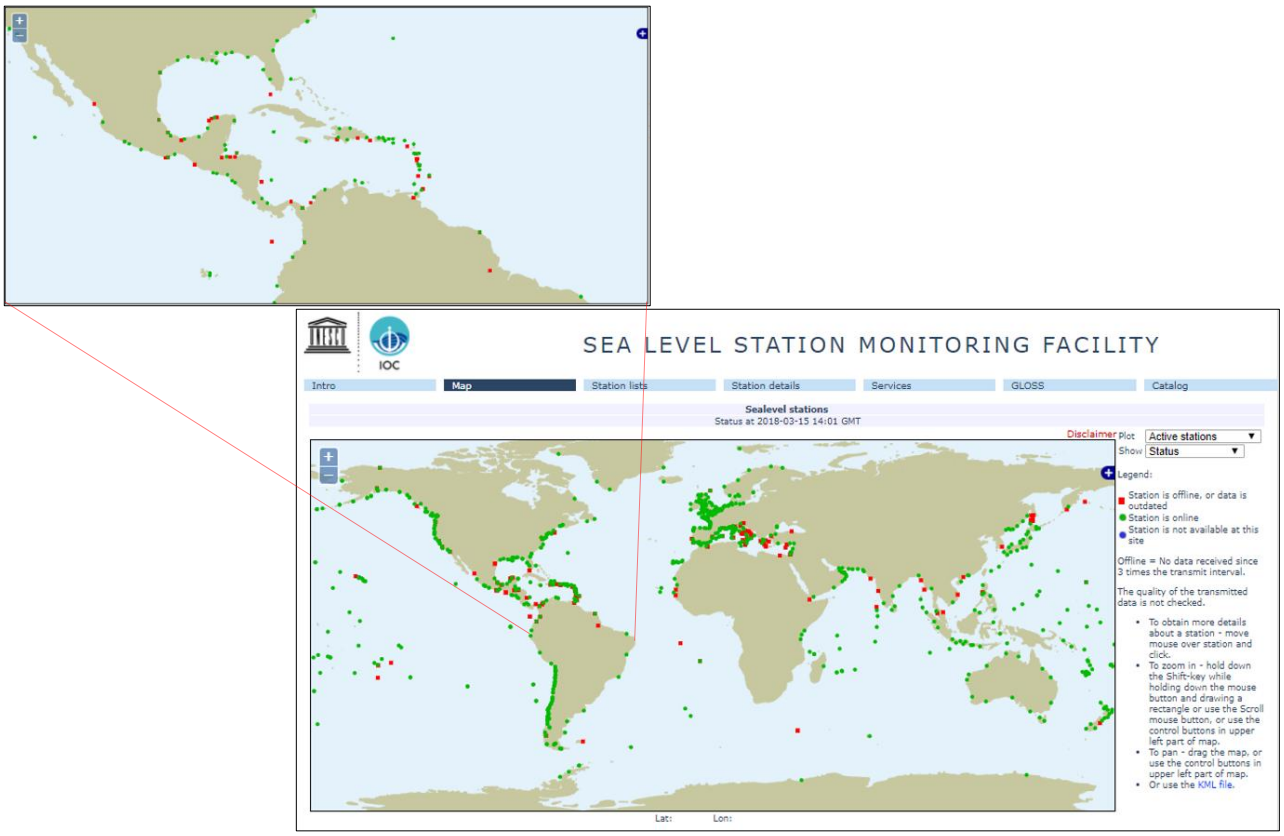



Figure 8. Screenshot showing IOC Sea Level facilities operating during the Caribe Wave 19 exercise

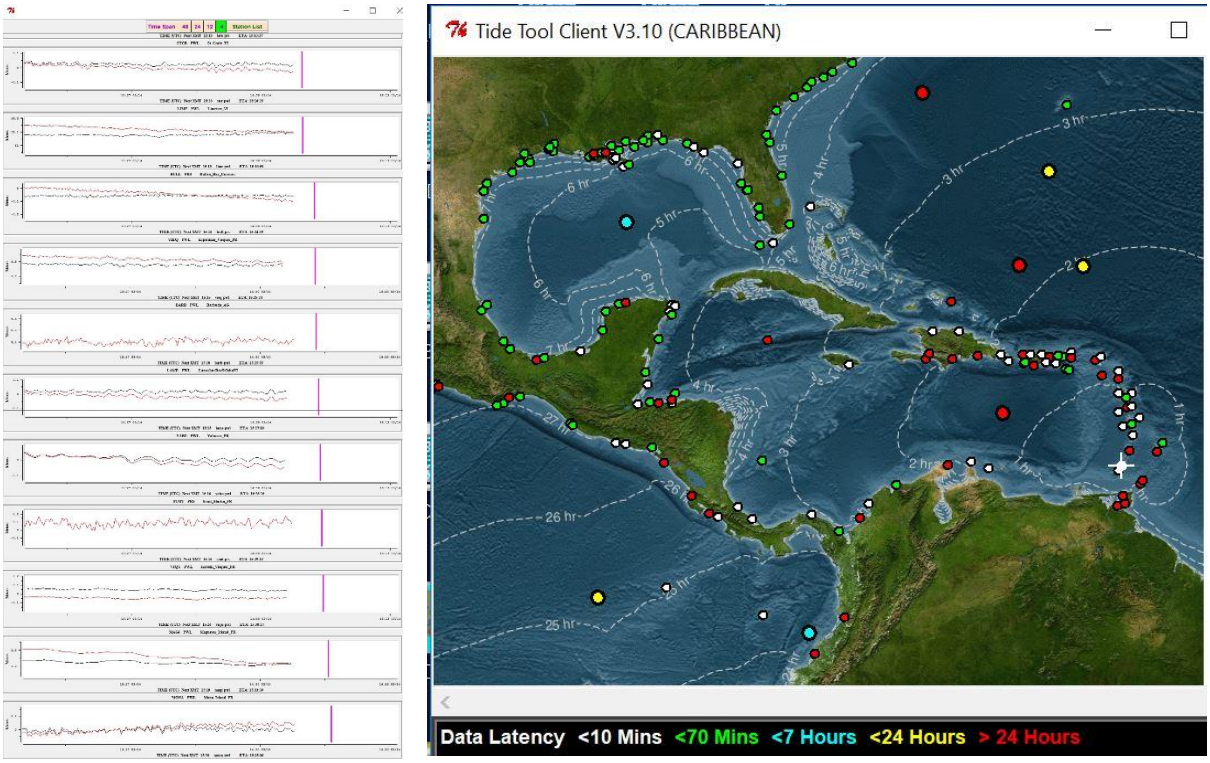
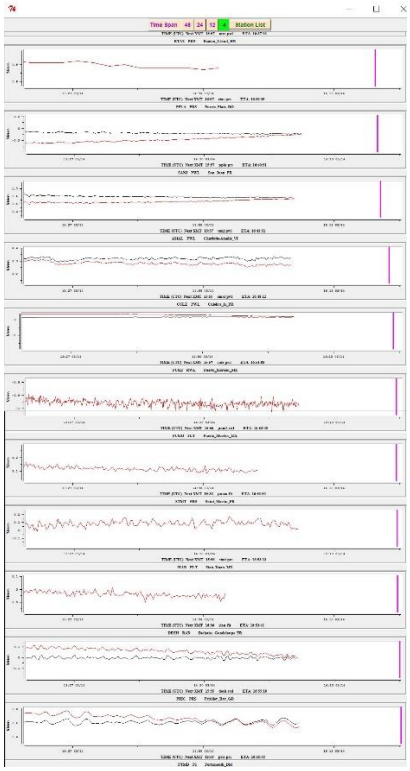



Figure 9. Screenshot showing the Tide Tool data for the Caribe Wave 19 Kick 'em Jenny Scenario



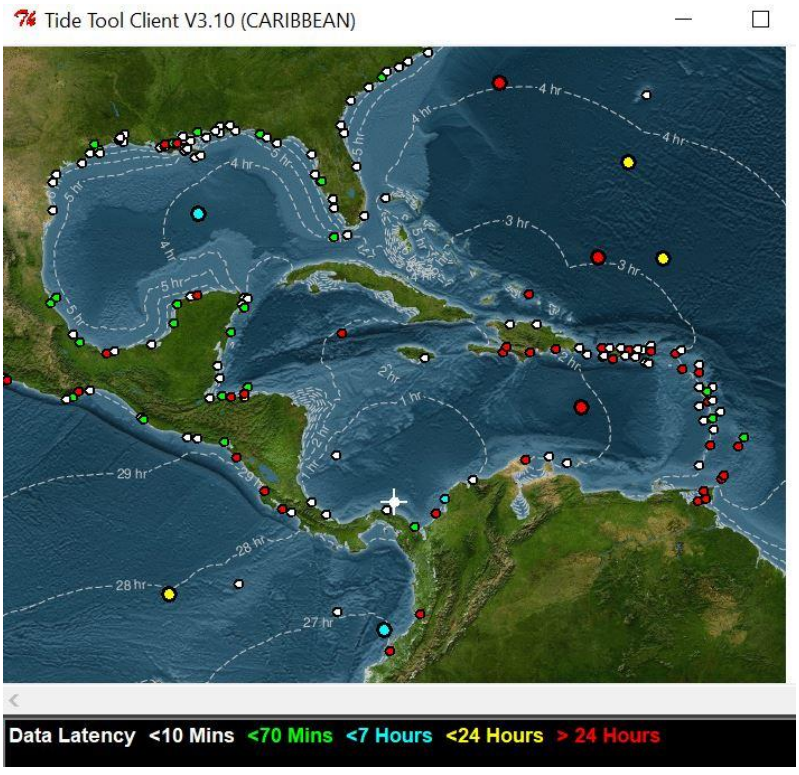



Figure 10. Screenshot showing the Tide Tool data for the Caribe Wave 19 Panama Scenario.

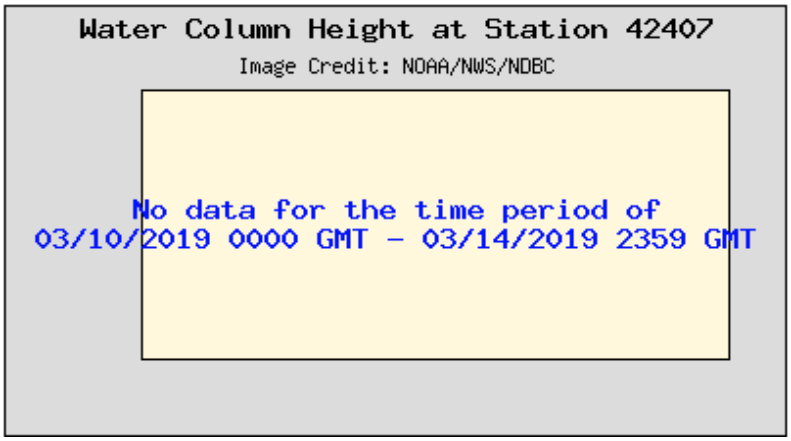



Figure 11. Screenshot of DART42407 located at the south of Puerto Rico. Station 42407 has been declared inoperative as there has not been any water column data since 0015z, 11/02/18. Data will be restored during National Data Buoy Center next service.

## 3.6 RESOURCES

Although EMOs had advance notice of the exercise and some elected to set up a special dedicated shift to allow normal core business to continue uninterrupted, it was requested that realistic resource levels be deployed in order to reflect some of the issues that are likely to be faced in a real event.

This year the exercise's Chair was Elizabeth Vanacore; while Richard Robertson, Joan L. Latchman, Frederic Dondin and Valerie Clouard were the scientific experts that helped in the determination of the Kick 'em Jenny scenario; Diana Patricia Mendoza and Alberto Lopez were the scientific experts for the Panama scenario. The CTWP coordinated the exercise for CARIBE-EWS.

## 3.7 MEDIA ARRANGEMENTS

One advantage in conducting exercises is that it provides a venue to promote tsunami awareness. The exercise offered an opportunity to collaborate with the media and disseminate more broadly information on the warning system. About 54% of the CARIBE-EWS Member States and Territories indicated that the news media participated and covered the exercise. Exercise messages were disseminated and community participation was also encouraged through social media outlets such as Facebook and Twitter. Hash tracking services indicated that #CaribeWave, #CaribeWave2019, among other hashtags, reached over 4,000 users and had over 500 impressions on social media outlets before, during and after the date of the exercise (Figure 12). During the exercise, text messages and tweets about the start of the exercise were displayed on PTWC and CTWP accounts (Figure 13). News of press releases (Figure 14) and media outputs can be found in the IOC Caribe Wave 19, Volume 3: Media Report, April 2019.

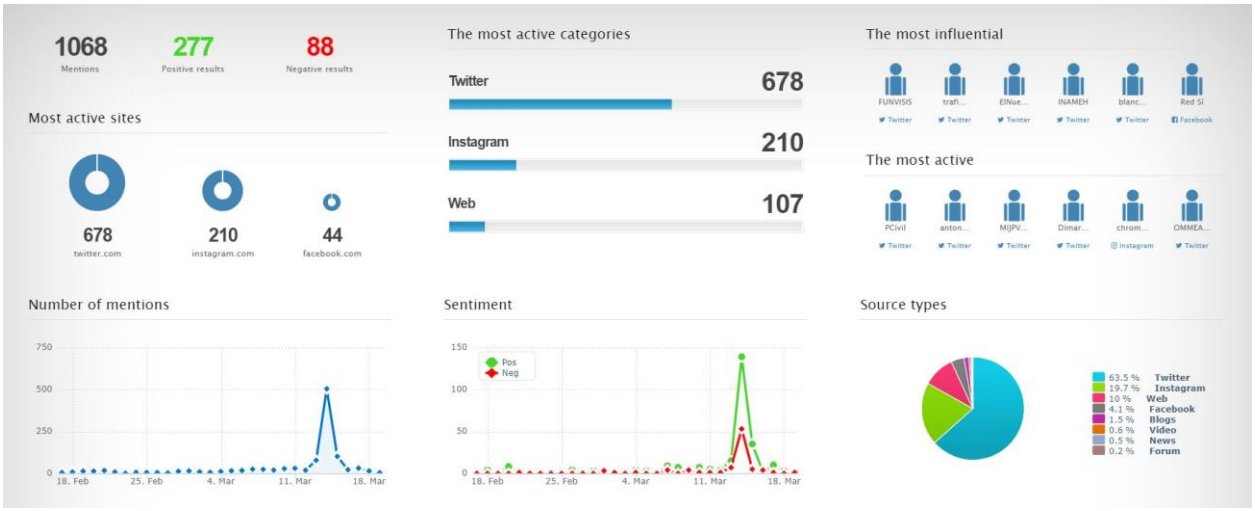



Figure 12. Graphs showing the #CaribeWave and #CaribeWave19 trending between the 18th of February and 18th of March 2019.

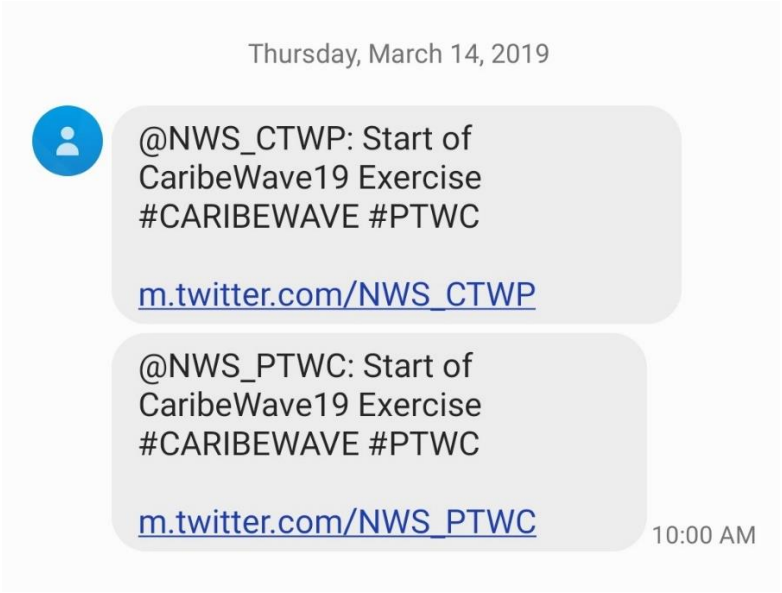



Figure 13. Text Message about the start of Caribe Wave 19 exercise.

Figure 14. Puerto Rico seismic Network (PRSN) and Puerto Rico State Emergency Management (NMEAD) Press conference for the Caribe Wave 19.

## 3.8 POST-EXERCISE EVALUATION

All participating countries were requested to provide feedback on the exercise through a survey. This feedback assists the ICG/CARIBE-EWS in the evaluation of Caribe Wave 19 and the development of subsequent exercises, and helps response agencies document lessons learned. The survey contained 70 questions conducted by the IOC/UNESCO using the Survey Monkey service. This report includes feedback from 38 surveys completed by some MS and Territories*.

The questions as well as the answers and comments are contained in the Supplement. This questionnaire has a wealth of information that is important for the evaluation and planning of tsunami exercises but reflects an improved level of tsunami preparedness in the region. Caribe Wave Task Team and CTWP as coordinator of the exercise, prompts the importance of submitting ONE SURVEY per Member State or Territory as corresponded. This survey is an overall metric for effectiveness of the exercise at a regional level, but intends to offer an opportunity between national agencies to meet and work to compile the information, reviewing the status of their tsunami SOPs and make adjustments for next year exercise or even a real event. This evaluation contains valuable information and gives to the ICG/CARIBE-EWS group insights to address the objectives of the exercise. Regarding to the status of implementation of the pilot CARIBE-EWS Tsunami Ready recognition program, the results indicate that 37% of the countries that answered are interested in implementing the program and 45% of these are already implementing it with 223 as a total number of target communities to be recognized as Tsunami Ready (Table 4). In addition, this evaluation contains a question to take account of the countries feedback and experience with the exercise (Table 5).

| Country | Already Implementing | Interested in Implementing | TsunamiReady® or Tsunami Ready Communities | Target Number |
|---|---|---|---|---|
| **Antigua and Barbuda** | No | Yes | - | - |
| **Bahamas** | No | Yes | - | - |
| **Barbados** | Yes | - | 2 | 10 |
| **Belize** | No | Yes | - | - |
| **Brazil** | No | No | - | - |
| **Colombia** | No | No | - | - |

*Only these countries answered the post- exercise survey: Antigua and Barbuda, Barbados, Belize, Colombia, Costa Rica, Curacao, Dominica, Dominican Republic, France (St. Martin), Grenada, Guatemala, Guyana, Haiti, Mexico, Netherlands (Bonaire, Saba and Saint Eustatius), Nicaragua, Saint Lucia, Trinidad and Tobago, United Kingdom (Anguilla, Bermuda, British Virgin Islands, Cayman Islands), United States (Puerto Rico) and Venezuela.

| Country | Already Implementing | Interested in Implementing | TsunamiReady® or Tsunami Ready Communities | Target Number |
|---|---|---|---|---|
| **Costa Rica** | Yes | - | 2 | 4 |
| **Cuba** | No | Yes | - | - |
| **Dominica** | Yes | - | 0 | 4 |
| **Dominican Republic** | No | Yes | - | - |
| **France (Martinique, Guadeloupe, St. Barthelemy, St. Martin)** | No | Yes | - | - |
| **Grenada** | Yes | - | 2 | 7 |
| **Guatemala** | Yes | - | 0 | 1 |
| **Guyana** | No | Yes | - | - |
| **Haiti** | Yes | - | 2 | 9 |
| **Honduras** | Yes | - | 3 | 10 |
| **Jamaica** | - | - | - | - |
| **Mexico** | No | Yes | - | - |
| **Netherlands (Aruba)** | Yes | - | 0 | 32 |
| **Netherlands (Bonaire, Saba and Sint Eustatius)** | No | - | 0 | - |
| **Netherlands (Curaçao)** | No | Yes | - | - |

| Country | Already Implementing | Interested in Implementing | TsunamiReady® or Tsunami Ready Communities | Target Number |
|---|---|---|---|---|
| **Netherlands (Sint Maarten)** | Yes | - | 0 | 1 |
| **Nicaragua** | Yes | - | 0 | 10 |
| **Panama** | No | Yes | - | - |
| **Saint Kitts and Nevis** | Yes | - | 60 | 60 |
| **Saint Lucia** | No | Yes | - | - |
| **Saint Vincent and the Grenadines** | Yes | - | 0 | 5 |
| **Suriname** | - | - | - | - |
| **Trinidad and Tobago** | Yes | - | 0 | 15 |
| **United Kingdom of Great Britain & Northern Island (Anguilla)** | Yes | - | 4 | 4 |
| **United Kingdom of Great Britain & Northern Island (Bermuda)** | No | Yes | - | - |
| **United Kingdom of Great Britain & Northern Island (British Virgin Islands)** | Yes | - | 0 | 2 |

| Country | Already Implementing | Interested in Implementing | TsunamiReady® or Tsunami Ready Communities | Target Number |
|---|---|---|---|---|
| **United Kingdom of Great Britain & Northern Island (Cayman Islands)** | No | No | - | - |
| **United Kingdom of Great Britain & Northern Island (Montserrat)** | - | - | - | - |
| **United Kingdom of Great Britain & Northern Island (Turks and Caicos)** | No | Yes | - | - |
| **United States (Puerto Rico)** | Yes | - | 45 | 45 |
| **United States (US Virgin Islands)** | Yes | - | 4 | 4 |
| **Venezuela** | No | Yes | - | - |

Table 4. Status of Implementation of the Pilot CARIBE EWS Tsunami Ready Recognition Program

| Country | Exercise Caribe Wave 19<br>General Statements |
|---|---|
| **Antigua & Barbuda** | The 2019 exercise provided a chance for the Government civil society and Private sector to review and re-orientate those whom will have responsibility for coordination of response and continuity of Government. (1.) Review and update warning at the national and community levels. (2.) Complete the installation signs and safe areas. (3.) Complete the disaster plan.<br><br>According to Keithley Meade from the Antigua and Barbuda Met Services (TWFP), at the national level, there was not enough effort put into involving more stakeholders, or making this into a truly national event. Activities at the national level were disjoint at best. Greater collaboration is needed between the TWFP and the NTWC, and other stakeholders, so as to make the best use of these exercises and expand them into national events. There is also the question of the SOPs which were developed a long time ago. Though they are still used by the TWFP, there are many glaring gaps; they were never completed to begin with. They are also not well circulated |

| Country | Exercise Caribe Wave 19<br>General Statements |
|---|---|
| | and not well known by the persons who will be called upon to execute them. There is still a lot of work to do. |
| **Bahamas** | During CARIBE WAVE 19 as each message was received by the Bahamas Department of Meteorology (DOM) from the PTWC, DOM would analyze it and from it prepare a Bahamas specific message, which would then be e-mailed to NEMA. |
| **Barbados** | The exercise went well at the Barbados Meteorological Services in reference to the timely dissemination of the messages to the relevant authorities. The downside was that there were issues in sending out the messages via the Common Alert Protocol (CAP) due to circumstances beyond control of the BMS. The BMS felt that the CAP would have been the more effective method of sending tsunami alerts as there are options in the programme including radio interrupts, smartphones and so on. |
| **Belize** | As our fax machine is not working, we needed to have the TNC forward the simulation exercise messages - received via email - to the TWFP which include on-duty forecasters. This might have seemed overwhelming to some, as there was no planning made in sufficient time ahead of the exercise date. The TWFP is also a different entity from the NEMO and there are gaps in relationships among the parties which we have noted that we need to improve upon. So for this year, all the information had to remain mainly within the TWFP and shared with national coordinator of the NEMO as sharing with any others might have caused panic and disruption without the planning ahead. |
| **Brazil** | We are a new country in cuestions of exercises and without problems of Tsunamis. We will be organizing ourselves better in the future. |
| **Colombia** | At International level: The exercise allows you to test the means of communication established with the PTWC, the interpretation of its bulletins and the improved products.<br><br>At National level: The exercise allowed evaluating the capacity of reception and dissemination of information, for such case it was opportune for the sake of the actions that as a country should be generated to guarantee the timely evacuation of risk areas by Tsunami.<br><br>It allowed to evaluate the Communication Protocol of the National System of Tsunami Detection and Alert, being useful to improve the communication channels, the bulletins and the times of issue of bulletins. There is evidence of interest in carrying out more exercises that allow for the evaluation of communications and Tsunami preparedness from the local, regional, and national levels. It is necessary to disseminate more public education material, collapses, videos, and social networks to show the national flaws in relation to inundation, evacuation, and signaling maps present in the municipalities of the Colombian Caribbean, as well as the absence of response plans for the Colombian Caribbean. The importance of the participation of the media and of the schools in the exercise was evidenced. Regarding the evaluation format, it is recommended to include more questions that allows to evaluate the development of the exercise in the communities. |
| **Cuba** | In general, everything could be done according to plan and better than other occasions because it had been prepared since the previous year of |

| Country | Exercise Caribe Wave 19<br>General Statements |
|---|---|
| | 2018 to some coastal towns that, like Baracoa city, could exercise the evacuation through an evacuation map prepared by their local leaders and the population. It also has more technical staff prepared in fields such as mathematical modeling, environmental education and social communication, who were able to do their work in the exercise in better conditions. |
| **Dominica** | The exercise was small but very successful. |
| **Dominican Republic** | We understand that the Caribe Wave exercise was well organized, by the planners. These Caribbean Wave programs have been useful for forecasters and assistants to have greater knowledge about the handling of tsunami warnings and warnings. We have a suggestion to include below the data of the seismic event the type of movement of the sliding plate or of subduction, this to extend the knowledge. |
| **Grenada** | Caribe Wave 2019 was a very successful exercise for Grenada, as the scenario gave us an opportunity to test the SOP created from last year's Tsunami Ready pilot project in St. Patrick's. It also allowed us to test our national response plan. The exercise simultaneously happened in St. Patrick and on the Sister Isle of Carriacou. One of the main challenges observed from the exercise was that of communication from the focal point/ warning center to the national emergency coordinating center/ personnel. Because of that evacuation was delayed and the first alerting system in the SOP (Police siren) was not enabled on time. But we did get to use the newest alerting system; church bells in this exercise. On a positive note, we were able to reach over 80% of the population through media interventions, SMS and house to house interventions. In addition we were able to use employers both in Private and Public sectors to sensitize and engage people. In parishes outside of the exercise area, we tested communication and identifying evacuation routes and muster points. We also had an opportunity to test evacuation time and plans for three vulnerable groups within the hazard zone; elderly, children and pregnant women. Grenada is in need of an electronic siren service for Tsunami's and to complete the inundation mapping for country, including signing and erection of maps. We are extremely grateful for the exercise, as it has awakened a virtual dead hazard for us and the importance of being prepared for its unpredictable occurrence. |
| **Haiti** | For the moment everything is quite good. In Haiti we should have a better exercise. We didn't have a better planification because of the bad political situation, for CARIBE WAVE 2020 we would like to have a better exercise. There is a Tsunami Ready project in Jeremie. We would like a scenario impacting Jeremie. |
| **Honduras** | Estimated the proposed scenario seemed very good but did not take into account that with the event facing the shores of Panama its impacts for Honduras would be almost zero, the waves arrived with a height of less than one meter which is less than one foot, so both of these parameters does not activate the alert protocol nor the minimum or slight green alert, therefore we had to do COPECO bulleting with parameters of up different waves otherwise we would not evacuate people from Omora to Tornabe and it would be a failure to exercise so we can ask in the future to take into account these parameters. It is important that after these events and in the |

| Country | Exercise Caribe Wave 19<br>General Statements |
|---|---|
| | communities that are working the certification of Ready receive the visit of experts who make an evaluation, if we have done the job right now, we have had a response from who corresponds in the certification and this is observed badly by my organization.<br><br>Greetings from Honduras. |
| **Mexico** | The communication between PTWC and CAT was made without mishap, details of distribution of the bulletins issued by the CAT were presented. The time of reception of the bulletins was 51% of the participants received the bulletin between 08:05 and 08:10 hours, and after 08:40 hours 49%. This due to the internet service. Therefore, the response times, ignorance of the actions to be carried out, working hours and lack of satellite communication systems, make response procedures more difficult. |
| **Netherlands– Bonaire, Saba, Sint Eustatius** | Overall the exercise was useful. Communication procedures worked as expected. Main issue is receiving parties not answering the number 1 phone on the list. This delays communications to other concerned parties. Another issue was receiving parties being engaged in other important businesses. Real emergencies never come alone...Based on this exercise we may want to consider SMS messages on top of phone calls to reach all concerned at the same time. |
| **Nicaragua** | Excellent this exercise. We had more participation of the population and coordination with different institutions and local communities. |
| **Panama** | The exercise did not achieve the expected results, due to the low participation of the institutions that make up the Tsunami Committee and the responsible institutions. The reason for this low participation was due to the fact that the institutions involved focused on the visit of Pope Francisco, during and after, which prevented us from preparing, as in previous years, the drill. In addition, the security preparations for the carnival celebration were presented. |
| **Saint Kitts and Nevis** | The exercise was well received;<br><br>Did not work well: higher level of participation from stakeholders.<br><br>Worked well: Engagement of the NDO to support business in Plan development to respond to the threat of a Tsunami and other hazards. |
| **Saint Lucia** | In saint Lucia CARIBEWAVE 19 was tested in three phases. The first phase was the testing of our mobile app, radio broadcast interrupt and activation of multihazard sirens, the second phase saw the evacuation of eight schools in Castries to various assembly points, and the third phase was the evacuation of three schools and parts of the community of Canaries. What didn't go well was (1.) Communication from PTWC was slow and did not arise until 10:30 am, when the estimated time of arrival of the wave for Castries was 10:22am. (2.) No message was received from Seismic Unit on the earthquake and volcanic eruption (3.) One of our sirens did not work, need to reevaluate the maintenance schedule. |
| **Saint Vincent and the Grenadines** | The school evacuation exercise went well. We could have liked to see more involvement of the Seismic Research Centre (SRC) to provide more scientific guidance on the regional activation. |

| Country | Exercise Caribe Wave 19<br>General Statements |
|---|---|
| **UK–Anguilla** | Anguilla has participated in the exercise yearly and finds it to be a timely reminder that although tsunamis do not occur often that the threat is real. The exercise has very real meaning to the school children who have also participated in the exercise since its inception. In Anguilla's case this means that we have an entire generation who were brought up with tsunami education, which is vital to our future preparedness. The Caribe Wave exercise continues to get better and is looked forward to by Disaster Management Anguilla. |
| **UK–Bermuda** | 1. Aside from some miscommunication with the local EMO of the number of warning emails sent to stakeholders, the exercise went according to plan.<br>2. However, Bermuda is well behind when it comes to public education, evacuation zones/mapping and alerting (sirens etc.). As a Tsunami is deemed a high impact but 'low probability' event for Bermuda, the government/EMO buy in to develop any of these items is poor (a very low priority when compared to tropical cyclone resilience/planning etc. which is high impact, high probability).<br>3. As already mentioned, this exercise scenario was somewhat 'weak' (expected wave less than 0.3m, and therefore Bermuda wasn't even mentioned in the tsunami threat section of the PTWC messaging) for Bermuda in terms of impact. However, it was still useful to go through this type of scenario for practice (rather than a larger, more significant impact).<br>4. Bermuda Weather Service's ideal wish list includes: (i.) More Government engagement/buy in for this important hazard mitigation process (ii.) Tsunami inundation mapping/modelling (iii.) Designated tsunami evacuation zones and relevant evacuation signage (iv.) An island wide public alerting system not in place currently - e.g. sirens (v.) Education in schools and beyond including pamphlets etc. |
| **UK–British Virgin Islands** | Despite the passing of the hurricanes people are very aware of the impacts tsunamis can have on the territory. Especially the most recent with the patrons on the beach. We have many functions like this locally and they see where this can possibly happen. |
| **UK–Cayman Islands** | It was a useful exercise for us. We brought together stakeholders to look at a specific area of vulnerability. The tourism sector. On the day of the exercise we had 5 cruise ships and 15 thousand cruise ship passengers in town and thousands of visitors sunning themselves on Seven Mile Beach. First responders were asked to consider what they would do faced with the Caribe Wave Scenario. An informal discussion based format was used and a number of gaps were identified. It was also useful for the various first response agencies to come together to build familiarity with the plan, the tsunami threat and to identify areas for improvement. |
| **USA–Puerto Rico** | As a general statement on CARIBE WAVE 19 we can say the experience went well, more than expected. The planning for our local level was very good in both ways, exercise planning and exercise conduct. We think that we have to improve the community’s participation and also the internal response from the government, give more education in this area so the response will be more efficient and faster than it is now. For the CARIBE WAVE 20 exercise we recommend to keep it simple and keep the same |

| Country | Exercise Caribe Wave 19<br>General Statements |
|---|---|
| | format. It is easy to understand, fast to implement, and not complication. Thanks for the opportunity. |
| **USA–US Virgin Islands** | All information was well written and great help for fulling exercise. We would love to have more community involvement with the private sector with in the tsunami zone. Everyone who participated are looking forward to next year's exercise how well it went for them. Overall it was a great experience and we are ready to take it to greater heights next year. As of right now no improvements need to be done on any level. We just want to advertise more in person throughout the territory. |
| **Venezuela** | The year 2019 for the Bolivarian Republic of Venezuela was a great challenge for the authorities and the population in general, we had previous events that led to change the mode of execution of the exercise, from simulation to simulation; However, that did not prevent during the activity, multiple events associated or not to the tsunami, which helped to increase the resolution of problems and remedy with state resources, emergencies and adverse effects caused by the said threat; communications were put to the test, which leads us to strengthen this area; Likewise, governance was strengthened and timely strategies were fine-tuned through protocols that lead to the least loss of human life possible during a real event. |

Table 5. General statements on Caribe Wave 19 Tsunami Exercise experience from countries that participated.

## 4. REFERENCES

Amante, C and Eakins, B W. 2009. ETOPO1 Global Relief Model converted to PanMap layer format. *NOAA-National Geophysical Data Center, PANGAEA,* (https://doi.org/10.1594/PANGAEA.769615)

von Hillebrandt-Andrade, Christa. 2013. Minimizing Caribbean Tsunami Risk. *Science*, Vol. 341, Issue 6149, pp. 966-968 .

Wessel, P. et al. 2013. Generic Mapping Tools: Improved Version Released. *EOS Transactions, American Geophysical Union,* Vol. 94, No.45, pp.409-420. (https://doi.org/10.1002/2013EO450001

ANNEX I

## LIST OF ACRONYMS

| | |
|---|---|
| **AWIPS** | Advanced Weather Interactive Processing System |
| **BVI** | British Virgin Islands |
| **CTWP** | Caribbean Tsunami Warning Program |
| **EAS** | Emergency Alert System |
| **EMO** | Emergency Management Organization |
| **EMWIN** | Emergency Managers Weather Information Network |
| **GMT** | Generic Mapping Tool |
| **ICG/CARIBE-EWS** | Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions |
| **IOC** | Intergovernmental Oceanographic Commission |
| **KEJ** | Kick ‘em Jenny Volcano |
| **MS** | Member States |
| **NCEI** | National Centers for Environmental Information |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NPDB** | Northern Panama Deformed Belt |
| **NTWC** | National Tsunami Warning Centre |
| **NWWS** | NOAA Weather Wire Service |
| **OEM** | Office of Emergency Management |
| **PRSN** | Puerto Rico Seismic Network |
| **PTWC** | Pacific Tsunami Warning Center |
| **SOP** | Standard Operating Procedure |
| **TNC** | Tsunami National Centre |
| **TWFP** | Tsunami Warning Focal Point |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organization |
| **USVI** | Puerto Rico and US Virgin Islands |
| **WIS** | WMO Information System |

**IOC Technical Series**

| No. | Title | Languages |
|---|---|---|
| 1 | Manual on International Oceanographic Data Exchange. 1965 | (out of stock) |
| 2 | Intergovernmental Oceanographic Commission (Five years of work). 1966 | (out of stock) |
| 3 | Radio Communication Requirements of Oceanography. 1967 | (out of stock) |
| 4 | Manual on International Oceanographic Data Exchange - Second revised edition. 1967 | (out of stock) |
| 5 | Legal Problems Associated with Ocean Data Acquisition Systems (ODAS). 1969 | (out of stock) |
| 6 | Perspectives in Oceanography, 1968 | (out of stock) |
| 7 | Comprehensive Outline of the Scope of the Long-term and Expanded Programme of Oceanic Exploration and Research. 1970 | (out of stock) |
| 8 | IGOSS (Integrated Global Ocean Station System) - General Plan Implementation Programme for Phase I. 1971 | (out of stock) |
| 9 | Manual on International Oceanographic Data Exchange - Third Revised Edition. 1973 | (out of stock) |
| 10 | Bruun Memorial Lectures, 1971 | E, F, S, R |
| 11 | Bruun Memorial Lectures, 1973 | (out of stock) |
| 12 | Oceanographic Products and Methods of Analysis and Prediction. 1977 | E only |
| 13 | International Decade of Ocean Exploration (IDOE), 1971-1980. 1974 | (out of stock) |
| 14 | A Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment and Baseline Study Guidelines. 1976 | E, F, S, R |
| 15 | Bruun Memorial Lectures, 1975 - Co-operative Study of the Kuroshio and Adjacent Regions. 1976 | (out of stock) |
| 16 | Integrated Ocean Global Station System (IGOSS) General Plan and Implementation Programme 1977-1982. 1977 | E, F, S, R |
| 17 | Oceanographic Components of the Global Atmospheric Research Programme (GARP) . 1977 | (out of stock) |
| 18 | Global Ocean Pollution: An Overview. 1977 | (out of stock) |
| 19 | Bruun Memorial Lectures - The Importance and Application of Satellite and Remotely Sensed Data to Oceanography. 1977 | (out of stock) |
| 20 | A Focus for Ocean Research: The Intergovernmental Oceanographic Commission - History, Functions, Achievements. 1979 | (out of stock) |
| 21 | Bruun Memorial Lectures, 1979: Marine Environment and Ocean Resources. 1986 | E, F, S, R |
| 22 | Scientific Report of the Interealibration Exercise of the IOC-WMO-UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open Ocean Waters. 1982 | (out of stock) |
| 23 | Operational Sea-Level Stations. 1983 | E, F, S, R |
| 24 | Time-Series of Ocean Measurements. Vol.1. 1983 | E, F, S, R |
| 25 | A Framework for the Implementation of the Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment. 1984 | (out of stock) |
| 26 | The Determination of Polychlorinated Biphenyls in Open-ocean Waters. 1984 | E only |
| 27 | Ocean Observing System Development Programme. 1984 | E, F, S, R |
| 28 | Bruun Memorial Lectures, 1982: Ocean Science for the Year 2000. 1984 | E, F, S, R |
| 29 | Catalogue of Tide Gauges in the Pacific. 1985 | E only |
| 30 | Time-Series of Ocean Measurements. Vol. 2. 1984 | E only |
| 31 | Time-Series of Ocean Measurements. Vol. 3. 1986 | E only |
| 32 | Summary of Radiometric Ages from the Pacific. 1987 | E only |
| 33 | Time-Series of Ocean Measurements. Vol. 4. 1988 | E only |
| 34 | Bruun Memorial Lectures, 1987: Recent Advances in Selected Areas of Ocean Sciences in the Regions of the Caribbean, Indian Ocean and the Western Pacific. 1988 | Composite E, F, S |
| 35 | Global Sea-Level Observing System (GLOSS) Implementation Plan. 1990 | E only |

*(continued)*

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|---|---|---|
| 36 | Bruun Memorial Lectures 1989: Impact of New Technology on Marine Scientific Research. 1991 | Composite E, F, S |
| 37 | Tsunami Glossary - A Glossary of Terms and Acronyms Used in the Tsunami Literature. 1991 | E only |
| 38 | The Oceans and Climate: A Guide to Present Needs. 1991 | E only |
| 39 | Bruun Memorial Lectures, 1991: Modelling and Prediction in Marine Science. 1992 | E only |
| 40 | Oceanic Interdecadal Climate Variability. 1992 | E only |
| 41 | Marine Debris: Solid Waste Management Action for the Wider Caribbean. 1994 | E only |
| 42 | Calculation of New Depth Equations for Expendable Bathymerographs Using a Temperature-Error-Free Method (Application to Sippican/TSK T-7, T-6 and T-4 XBTS. 1994 | E only |
| 43 | IGOSS Plan and Implementation Programme 1996-2003. 1996 | E, F, S, R |
| 44 | Design and Implementation of some Harmful Algal Monitoring Systems. 1996 | E only |
| 45 | Use of Standards and Reference Materials in the Measurement of Chlorinated Hydrocarbon Residues. 1996 | E only |
| 46 | Equatorial Segment of the Mid-Atlantic Ridge. 1996 | E only |
| 47 | Peace in the Oceans: Ocean Governance and the Agenda for Peace; the Proceedings of *Pacem in Maribus* XXIII, Costa Rica, 1995. 1997 | E only |
| 48 | Neotectonics and fluid flow through seafloor sediments in the Eastern Mediterranean and Black Seas - Parts I and II. 1997 | E only |
| 49 | Global Temperature Salinity Profile Programme: Overview and Future. 1998 | E only |
| 50 | Global Sea-Level Observing System (GLOSS) Implementation Plan-1997. 1997 | E only |
| 51 | L'état actuel de 1'exploitation des pêcheries maritimes au Cameroun et leur gestion intégrée dans la sous-région du Golfe de Guinée *(cancelled)* | F only |
| 52 | Cold water carbonate mounds and sediment transport on the Northeast Atlantic Margin. 1998 | E only |
| 53 | The Baltic Floating University: Training Through Research in the Baltic, Barents and White Seas - 1997. 1998 | E only |
| 54 | Geological Processes on the Northeast Atlantic Margin (8$^{th}$ training-through-research cruise, June-August 1998). 1999 | E only |
| 55 | Bruun Memorial Lectures, 1999: Ocean Predictability. 2000 | E only |
| 56 | Multidisciplinary Study of Geological Processes on the North East Atlantic and Western Mediterranean Margins (9$^{th}$ training-through-research cruise, June-July 1999). 2000 | E only |
| 57 | Ad hoc Benthic Indicator Group - Results of Initial Planning Meeting, Paris, France, 6-9 December 1999. 2000 | E only |
| 58 | Bruun Memorial Lectures, 2001: Operational Oceanography – a perspective from the private sector. 2001 | E only |
| 59 | Monitoring and Management Strategies for Harmful Algal Blooms in Coastal Waters. 2001 | E only |
| 60 | Interdisciplinary Approaches to Geoscience on the North East Atlantic Margin and Mid-Atlantic Ridge (10$^{th}$ training-through-research cruise, July-August 2000). 2001 | E only |
| 61 | Forecasting Ocean Science? Pros and Cons, Potsdam Lecture, 1999. 2002 | E only |
| 62 | Geological Processes in the Mediterranean and Black Seas and North East Atlantic (11$^{th}$ training-through-research cruise, July- September 2001). 2002 | E only |
| 63 | Improved Global Bathymetry – Final Report of SCOR Working Group 107. 2002 | E only |
| 64 | R. Revelle Memorial Lecture, 2006: Global Sea Levels, Past, Present and Future. 2007 | E only |
| 65 | Bruun Memorial Lectures, 2003: Gas Hydrates – a potential source of energy from the oceans. 2003 | E only |
| 66 | Bruun Memorial Lectures, 2003: Energy from the Sea: the potential and realities of Ocean Thermal Energy Conversion (OTEC). 2003 | E only |

| | | |
|---|---|---|
| 67 | Interdisciplinary Geoscience Research on the North East Atlantic Margin, Mediterranean Sea and Mid-Atlantic Ridge (12th training-through-research cruise, June-August 2002). 2003 | E only |
| 68 | Interdisciplinary Studies of North Atlantic and Labrador Sea Margin Architecture and Sedimentary Processes (13th training-through-research cruise, July-September 2003). 2004 | E only |
| 69 | Biodiversity and Distribution of the Megafauna / Biodiversité et distribution de la mégafaune. 2006<br>Vol.1 The polymetallic nodule ecosystem of the Eastern Equatorial Pacific Ocean / Ecosystème de nodules polymétalliques de l'océan Pacifique Est équatorial<br>Vol.2 Annotated photographic Atlas of the echinoderms of the Clarion-Clipperton fracture zone / Atlas photographique annoté des échinodermes de la zone de fractures de Clarion et de Clipperton<br>Vol.3 Options for the management and conservation of the biodiversity — The nodule ecosystem in the Clarion Clipperton fracture zone: scientific, legal and institutional aspects | E F |
| 70 | Interdisciplinary geoscience studies of the Gulf of Cadiz and Western Mediterranean Basin (14th training-through-research cruise, July-September 2004). 2006 | E only |
| 71 | Indian Ocean Tsunami Warning and Mitigation System, IOTWS. Implementation Plan, 7–9 April 2009 (2nd Revision). 2009 | E only |
| 72 | Deep-water Cold Seeps, Sedimentary Environments and Ecosystems of the Black and Tyrrhenian Seas and the Gulf of Cadiz (15th training-through-research cruise, June–August 2005). 2007 | E only |
| 73 | Implementation Plan for the Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas (NEAMTWS), 2007–2011. 2007 *(electronic only)* | E only |
| 74 | Bruun Memorial Lectures, 2005: The Ecology and Oceanography of Harmful Algal Blooms – Multidisciplinary approaches to research and management. 2007 | E only |
| 75 | National Ocean Policy. The Basic Texts from: Australia, Brazil, Canada, China, Colombia, Japan, Norway, Portugal, Russian Federation, United States of America. (Also Law of Sea Dossier 1). 2008 | E only |
| 76 | Deep-water Depositional Systems and Cold Seeps of the Western Mediterranean, Gulf of Cadiz and Norwegian Continental margins (16th training-through-research cruise, May–July 2006). 2008 | E only |
| 77 | Indian Ocean Tsunami Warning and Mitigation System (IOTWS) – 12 September 2007 Indian Ocean Tsunami Event. Post-Event Assessment of IOTWS Performance. 2008 | E only |
| 78 | Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE EWS) – Implementation Plan 2013–2017 (Version 2.0). 2013 | E only |
| 79 | Filling Gaps in Large Marine Ecosystem Nitrogen Loadings Forecast for 64 LMEs – GEF/LME global project Promoting Ecosystem-based Approaches to Fisheries Conservation and Large Marine Ecosystems. 2008 | E only |
| 80 | Models of the World's Large Marine Ecosystems. GEF/LME Global Project Promoting Ecosystem-based Approaches to Fisheries Conservation and Large Marine Ecosystems. 2008 | E only |
| 81 | Indian Ocean Tsunami Warning and Mitigation System (IOTWS) – Implementation Plan for Regional Tsunami Watch Providers (RTWP). 2008 | E only |
| 82 | Exercise Pacific Wave 08 – A Pacific-wide Tsunami Warning and Communication Exercise, 28–30 October 2008. 2008 | E only |
| *83.* | *Cancelled* | |
| 84. | Global Open Oceans and Deep Seabed (GOODS) Bio-geographic Classification. 2009 | E only |
| 85. | Tsunami Glossary | E, F, S |
| 86 | Pacific Tsunami Warning System (PTWS) Implementation Plan | *Electronic publication* |

*(continued)*

| | | |
|---|---|---|
| 87. | Operational Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS) – Second Edition. 2011 | E only |
| 88. | Exercise Indian Ocean Wave 2009 (IOWave09) – An Indian Ocean-wide Tsunami Warning and Communication Exercise – 14 October 2009. 2009 | E only |
| 89. | Ship-based Repeat Hydrography: A Strategy for a Sustained Global Programme. 2009 | E only |
| 90. | 12 January 2010 Haiti Earthquake and Tsunami Event Post-Event Assessment of CARIBE EWS Performance. 2010 | E only |
| 91. | Compendium of Definitions and Terminology on Hazards, Disasters, Vulnerability and Risks in a coastal context | *Under preparation* |
| 92. | 27 February 2010 Chile Earthquake and Tsunami Event – Post-Event Assessment of PTWS Performance (Pacific Tsunami Warning System). 2010 | E only |
| 93. | Exercise CARIBE WAVE 11 / LANTEX 11—A Caribbean Tsunami Warning Exercise, 23 March 2011 | |
| | Vol. 1 Participant Handbook / Exercise CARIBE WAVE 11 —Exercice d'alerte au tsunami dans les Caraïbes, 23 mars 2011. Manuel du participant / Ejercicio Caribe Wave 11. Un ejercicio de alerta de tsunami en el Caribe, 23 de marzo de 2011. Manual del participante. 2010 | E/F/S |
| | Vol. 2 Report. 2011 | E only |
| | Vol. 3 Supplement: Media Reports. 2011 | E/F/S |
| 94. | Cold seeps, coral mounds and deep-water depositional systems of the Alboran Sea, Gulf of Cadiz and Norwegian continental margin (17th training-through-research cruise, June–July 2008) | E only |
| 95. | International Post-Tsunami Survey for the 25 October 2010 Mentawai, Indonesia Tsunami | E only |
| 96. | Pacific Tsunami Warning System (PTWS) 11 March 2011 Off Pacific coast of Tohoku, Japan, Earthquake and Tsunami Event. Post-Event Assessment of PTWS Performance | E only |
| 97. | Exercise PACIFIC WAVE 11: A Pacific-wide Tsunami Warning and Communication Exercise, 9–10 November 2011 | |
| | Vol. 1 Exercise Manual. 2011 | E only |
| | Vol. 2 Report. 2013 | E only |
| 98. | Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and connected seas. First Enlarged Communication Test Exercise (ECTE1). Exercise Manual and Evaluation Report. 2011 | E only |
| 99. | Exercise INDIAN OCEAN WAVE 2011 – An Indian Ocean-wide Tsunami Warning and Communication Exercise, 12 October 2011 | E only |
| | Vol. 1 Exercise Manual. 2011<br>Supplement: Bulletins from the Regional Tsunami Service Providers | |
| | Vol. 2 Exercise Report. 2013 | |
| 100. | Global Sea Level Observing System (GLOSS) Implementation Plan – 2012. 2012 | E only |
| 101. | Exercise Caribe Wave/Lantex 13. A Caribbean Tsunami Warning Exercise, 20 March 2013. Volume 1: Participant Handbook. 2012 | E only |
| 102. | Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas — Second Enlarged Communication Test Exercise (CTE2), 22 May 2012. | E only |
| | Vol. 1 Exercise Manual. 2012 | |
| | Vol. 2 Evaluation Report. 2014 | |
| 103. | Exercise NEAMWAVE 12. A Tsunami Warning and Communication Exercise for the North-eastern Atlantic, the Mediterranean, and Connected Seas Region, 27–28 November 2012. | E only |
| | Vol. 1: Exercise Manual. 2012 | |
| | Vol. 2: Evaluation Report. 2013 | |
| 104. | Seísmo y tsunami del 27 de agosto de 2012 en la costa del Pacífico frente a El Salvador, y seísmo del 5 de septiembre de 2012 en la costa del Pacífico frente a Costa Rica. Evaluación subsiguiente sobre el funcionamiento del Sistema de Alerta contra los Tsunamis y Atenuación de sus Efectos en el Pacífico. 2012 | Español solamente (resumen en inglés y francés) |
| 105. | Users Guide for the Pacific Tsunami Warning Center Enhanced Products for the Pacific Tsunami Warning System, August 2014. Revised Edition. 2014 | E, S |

| | | |
|---|---|---|
| 106. | Exercise Pacific Wave 13. A Pacific-wide Tsunami Warning and Enhanced Products Exercise, 1–14 May 2013.<br>Vol. 1 Exercise Manual. 2013<br>Vol. 2 Summary Report. 2013 | E only |
| 107. | Tsunami Public Awareness and Educations Strategy for the Caribbean and Adjacent Regions. 2013 | E only |
| 108. | Pacific Tsunami Warning and Mitigation System (PTWS) Medium-Term Strategy, 2014−2021. 2013 | E only |
| 109. | Exercise Caribe Wave/Lantex 14. A Caribbean and Northwestern Atlantic Tsunami Warning Exercise, 26 March 2014.<br>Vol. 1 Participant Handbook. 2014 | E/S |
| 110. | Directory of atmospheric, hydrographic and biological datasets for the Canary Current Large Marine Ecosystem, 3rd edition: revised and expanded. 2017 | E only |
| 111. | Integrated Regional Assessments in support of ICZM in the Mediterranean and Black Sea Basins. 2014 | E only |
| 112. | 11 April 2012 West of North Sumatra Earthquake and Tsunami Event - Post-event Assessment of IOTWS Performance | E only |
| 113. | Exercise Indian Ocean Wave 2014: An Indian Ocean-wide Tsunami Warning and Communication Exercise.<br>Vol.1 Manual<br>Vol. 2 Exercise Report. 2015 | E only |
| 114. | Exercise NEAMWAVE 14. A Tsunami Warning and Communication Exercise for the North-Eastern Atlantic, the Mediterranean, and Connected Seas Region, 28–30 October 2014<br>Vol. 1 Manual<br>Vol. 2 Evaluation Report – Supplement: Evaluation by Message Providers and Civil Protection Authorities | E only |
| 115. | Oceanographic and Biological Features in the Canary Current Large Marine Ecosystem. 2015 *(revised in 2016)* | E only |
| 116. | Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas. Third Enlarged Communication Test Exercise (CTE3), 1st October 2013.<br>Vol. 1 Exercise Manual<br>Vol. 2 Evaluation Report | E only |
| 117. | Exercise Pacific Wave 15. A Pacific-wide Tsunami Warning and Enhanced Products Exercise, 2–6 February 2015<br>Vol. 1: Exercise Manual; Vol. 2: Summary Report | E only |
| 118. | Exercise Caribe Wave/Lantex 15. A Caribbean and Northwestern Atlantic Tsunami Warning Exercise, 25 March 2015 (SW Caribbean Scenario)<br>Vol. 1: Participant Handbook | E only |
| 119. | Transboundary Waters Assessment Programme (TWAP) Assessment of Governance Arrangements for the Ocean<br>Vol 1: Transboundary Large Marine Ecosystems; Supplement: Individual Governance Architecture Assessment for Fifty Transboundary Large Marine Ecosystems<br>Vol 2: Areas Beyond National Jurisdiction | E only |
| 120. | Transboundary Waters Assessment Programme (TWAP) – Status and Trends in Primary Productivity and Chlorophyll from 1996 to 2014 in Large Marine Ecosystems and the Western Pacific Warm Pool, Based on Data from Satellite Ocean Colour Sensors. 2017 | E only |
| 121. | Exercise Indian Ocean Wave 14, an Indian Ocean wide Tsunami Warning and Communications Exercise, 9–10 September 2014 | *In preparation* |
| 122. | Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas. Sixth Communication Test Exercise (CTE6), 29 July 2015.<br>Vol. 1: Exercise Manual<br>Vol. 2: Evaluation Report | E only |
| *123* | Preparing for the next tsunami in the North-Eastern Atlantic, the Mediterranean and Connected Seas – Ten years of the Tsunami Warning System (NEAMTWS). 2017 —*Cancelled*— | *(IOC/INF-1340)* |

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| | | |
|---|---|---|
| 124 | Indicadores Marino Costeros del Pacífico Sudeste / Coastal and Marine Indicators of the Southeast Pacific (SPINCAM) | E/S |
| 125 | Exercise CARIBE WAVE 2016: A Caribbean and Adjacent Regions Tsunami Warning Exercise, 17 March 2016 (Venezuela and Northern Hispaniola Scenarios)<br>Volume 1: Participant Handbook | E only |
| 126 | Exercise Pacific Wave 16. A Pacific-wide Tsunami Warning and Enhanced Products Exercise, 1-5 February 2016.<br>Volume 1: Exercise Manual.<br>Volume 2: Summary Report | E only |
| 127 | How to reduce coastal hazard risk in your community – A step by step approach | E only |
| 128. | Exercise Indian Ocean Wave 2016: An Indian Ocean-wide Tsunami Warning and Communications Exercise, 7–8 September 2016<br>Vol 1: Participant Manual<br>Vol. 2: Exercise Report | E only |
| 129 | What are Marine Ecological Time Series telling us about the Ocean – A status report | E only |
| 130 | Tsunami Watch Operations – Global Service Definition Document | E only |
| 131 | Exercise Pacific Wave 2017. A Pacific-wide Tsunami Warning and Enhanced Products Exercise, 15-17 February 2017.<br>Volume 1: Exercise Manual<br>Volume 2: Exercise Report | E only |
| 132. | 2nd March 2016 Southwest of Sumatra Earthquake and Tsunami Event Post-Event Assessment of the Performance of the Indian Ocean Tsunami Warning and Mitigation System; Supplement: Tsunami Service Provider Bulletins and Maps | E only |
| 133. | Exercise CARIBE WAVE 17. A Caribbean and Adjacent Regions Tsunami Warning Exercise, 21 March 2017 (Costa Rica, Cuba and Northeastern Antilles Scenarios).<br>Volume 1: Participant Handbook<br>Volume 2: Final Report | E only |
| 134. | Tsunami Exercise NEAMWave17 – A Tsunami Warning and Communication Exercise for the North-eastern Atlantic, the Mediterranean, and Connected Seas Region, 31 October – 3 November 2017<br>Volume 1: Exercise Instructions. 2017<br>Volume 2: Evaluation Report. 2018<br>Supplement: Evaluation by Message Providers and Civil Protection Authorities | E only |
| 135. | User's Guide for the Pacific Tsunami Warning Center Enhanced Products for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE-EWS), October 2017 | E only |
| 136. | Exercise CARIBE WAVE 18. Tsunami Warning Exercise, 15 March 2018 (Barbados, Colombia and Puerto Rico Scenarios).<br>Volume 1: Participant Handbook. 2017<br>Volume 2: Final Report | E only |
| 137. | The Ocean is losing its breath: declining oxygen in the world's ocean and coastal waters | (under preparation) |
| 138. | Exercise Indian Ocean Wave 2018: An Indian Ocean-wide Tsunami Warning and Communication Exercise, 4–5 September 2018<br>Volume 1: Exercise Manual & Supplements<br>Volume 2: Exercise Report. 2019 | E only |
| 139. | Exercise Pacific Wave 2018. A Pacific-wide Tsunami Warning and Enhanced Products Exercise, September to November 2018.<br>Volume 1: Exercise Manual.<br>Volume 2: Summary Report | E only |
| 140 | Analysis of transboundary Water Ecosystems and Green and Blue Infrastructures: Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco | E F S |
| 141 | Exercise Caribe Wave 2019. A Caribbean and Adjacent Region Tsunami Warning Exercise, 14 March 2019. Volume 1: Participant handbook.<br>Volume 2: Summary Report | E only |

| | | |
|---|---|---|
| 142 | Users' Guide for the Northwest Pacific Tsunami Advisory Center (NWPTAC) – Enhanced Products for the Pacific Tsunami Warning System. 2019 | E only |
| 143 | Status of the Indian Ocean Tsunami Warning and Mitigation System 2019 | (under preparation) |
| 144 | IOTWMS Medium Term Strategy: 2019–2024 | (under preparation) |
| 145 | IOTWMS Users Guide for National Tsunami Warning Centres | (under preparation) |
| 146 | Definition of Services provided by the Tsunami Service Providers of the IOTWMS | (under preparation) |
| 147 | The Global Ocean Observing System 2030 Strategy | (under preparation) |
| 148 | Ejercicio TSUNAMI-CA 19. Un simulacro de tsunami para Centroamérica, 19 de agosto de 2019. Volumen 1, Manual para participantes. | S only |

*(continued)*