



---

**IOC/JCOMM/GLOSS/PRSN**  
**Caribbean Training Course**  
**for Operators of Sea Level Stations**

---

23–27 June 2008  
Mayagüez, Puerto Rico

**Electronic copy only**

---

**IOC/JCOMM/GLOSS/PRSN**  
**Caribbean Training Course**  
**for Operators of Sea Level Stations**

---

23–27 June 2008  
Mayagüez, Puerto Rico

IOC Training Course Report N° 91  
Paris, 30 June 2008  
English only

***Abstract***

This report provides a summary of the IOC-GLOSS-PRSN Caribbean Training Course for Operators of Sea Level Stations, which took place from June 23-27, 2008 in Mayagüez, Puerto Rico. The purpose of the course was to provide the sea level station operators in the region lectures and hands on training on the science and operations of sea level stations for tsunami and other coastal hazards warning purposes. It also considered the proposed IOCARIBE-GOOS partnership that promotes development and sustainability of the Caribbean Sea level array and its integration into the Caribbean Tsunami and Other Coastal Hazards Warning System. The report also provides an overview of methods and materials used for sea level observations, reports of national and regional sea level initiatives, and a set of recommendations concerning sea level activities in the region.

## TABLE OF CONTENTS

|           |  |           |
|-----------|--|-----------|
| <b>1.</b> | <b>INTRODUCTION.....</b>                           | <b>1</b>  |
| <b>2.</b> | <b>LECTURES.....</b>                               | <b>1</b>  |
| <b>3.</b> | <b>COUNTRY REPORT PRESENTATIONS.....</b>           | <b>5</b>  |
| <b>4.</b> | <b>FIELD VISITS.....</b>                           | <b>8</b>  |
| <b>5.</b> | <b>REVIEW, CONCLUSION AND RECOMMENDATIONS.....</b> | <b>8</b>  |
| <b>6.</b> | <b>CLOSURE.....</b>                                | <b>10</b> |
| <b>7.</b> | <b>ACKNOWLEDGMENTS.....</b>                        | <b>11</b> |

## ANNEXES

|             |   |
|-------------|---|
| <b>I.</b>   | <b>COURSE SCHEDULE</b>                      |
| <b>II.</b>  | <b>COURSE MATERIAL</b>                      |
| <b>III.</b> | <b>BACKGROUND REPORTS AND PRESENTATIONS</b> |
| <b>IV.</b>  | <b>LIST OF PARTICIPANTS</b>                 |
| <b>V.</b>   | <b>CERTIFICATE</b>                          |
| <b>VI.</b>  | <b>GROUP PHOTO</b>                          |
| <b>VII.</b> | <b>ACRONYMS</b>                             |

## 1. INTRODUCTION

The UNESCO IOC Intergovernmental Coordinating Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE EWS) is responsible for coordinating the implementation of the CARIBE EWS. One of the four components of the system is Monitoring and Warning Guidance. The need for sea level data in the Caribbean to suit operational and research needs was identified as a priority at the second and third session of the ICG/CARIBE EWS. Two of the mechanisms that have been recommended are: (i) holding a training course for the operators of the sea level gauges in the region; and (ii) supporting the IOCARIBE GOOS-GCOS Partnership for a Multi-Use Sea Level Observation Network for the Caribbean Region.

An important component of the Global Sea Level Observing System (GLOSS) is to provide training in sea level observation and data analysis for tide gauge operators. Since 1993 GLOSS has convened a course about once a year at different locations around the world. The core elements of these courses are: sea level observations, benchmark leveling, quality control, tidal prediction and underlining the requirements for long term high accuracy sea level measurements.

The Puerto Rico Seismic Network has expanded its roles and responsibilities since 2003 to include tsunami monitoring and warning guidance. As part of these expanded responsibilities the PRSN installed in 2008 six tsunami ready tide gauges in Puerto Rico to complement the ten sea level stations NOAA, currently operating in Puerto Rico and the US Virgin Islands. Nevertheless, the PRSN recognizes the need for a greater number of stations in the region providing timely and accurate sea level data. In recognition of this need the PRSN requested funding from NOAA to organize and conduct a sea level operator's workshop for the region.

## 2. LECTURES

The workshop programme is provided in Annex I.

### Opening and introduction to course

The workshop commenced at 8:30 am and the participants were welcomed by the following people:

Prof. Christa von Hillebrandt-Andrade, Director, Puerto Rico Seismic Network, UPRM. Prof. von Hillebrandt-Andrade welcomed the lecturers and participants of the course. She recognized the need for more sea level data for an effective warning system and how through this course the participants could contribute in closing this gap. She appreciated the support from United States, through NOAA and other institutions which contributed to the funding of the course, UPRM and Government of Puerto Rico, thru PRSN, the Caribbean Regional Association for Coastal Observations (CARA), and GLOSS. The guidance of Mr. Bernardo Aliaga from the IOC Tsunami Unit and Dr Thorkild Aarup, Technical Secretary of the Global Sea Level Observing System (GLOSS) was also recognized. She thanked Ms Jeanette Lopez and Ms Dalixza Irizarry for all the administrative arrangements.

Dr Jorge Corredor, Co-PI ARCA, UPRM. Dr Corredor expressed the honour it was for the Caribbean Regional Association for Coastal Observations (ARCA) to help support the Sea Level Course by funding Mr Juan Fierro as a main lecturer. ARCA recognizes sea-level observations as an important component of the system and although the area of responsibility of the Association is US Caribbean, they acknowledge and welcome opportunities to work and support other efforts in the Caribbean.

Mr Bernard Kilonsky welcomed participants on behalf of GLOSS.

Mr Thomas Landon, NOAA. He expressed NOAA's support for the workshop and hoped the course would lead to improved sea level observations in the Caribbean and adjoining regions.

Dr Thomas Miller, Associate Director of the Geology Dept. In addition to welcoming the lecturers and participants, he recognized the importance of the data for providing timely warnings for tsunamis and coastal hazards, and its usefulness and applications in scientific research.

Mr Israel Matos, Co-Chair, ICG/CARIBE EWS, UNESCO. He thanked the organizers, lecturers and attendees and also recognized the importance of improving sea-level observations to achieve an effective Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions.

Dr Moisés Orengo, Dean of the Faculty of Arts & Science. He welcomed the participants, wished them success and effective learning, and also an enjoyable stay in the Western region of Puerto Rico.

### **Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE EWS) (Mr Israel Matos, Co-Chair, ICG/CARIBE EWS, UNESCO)**

An overview was given on the history of the ICG/CARIBE EWS and the previous meetings which have been held in 2006, 2007, and 2008. He highlighted the recommendations on the establishment of a Regional Tsunami Warning Centre, the Caribbean Tsunami Information Centre, Hazards Assessment, Warning Dissemination and Communications and the budget for 2008–2009. The next ICG7CARIBE EWS meeting will be held in Martinique in March 2008.

### **Overview of GLOSS (Mr Bernie Kilonsky, University of Hawaii Sea Level Center)**

An overview was given on the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC), the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), the Global Ocean Observing System (GOOS) and the Global Sea Level Observing System (GLOSS). He highlighted regional developments, national activities and the training courses offered by GLOSS. One of the general recommendations of GLOSS is to establish regional projects to develop networks of modern sea-level gauges linked to appropriate geodetic benchmarks. For further questions on GLOSS he directed the participants to contact the GLOSS Technical Secretary, Dr Thorkild Aarup and the Chairman of the GLOSS Group of Experts, Dr Mark Merrifield.

### **IOCARIBE GOOS-GCOS Partnership for a Multi-Use Sea Level Observation Network for the Caribbean Region (Mrs Christa G. von Hillebrandt, Puerto Rico Seismic Network)**

For the Caribbean Region the only sea-level stations reporting sea-level measurements in near real time are all located in Puerto Rico and the Virgin Islands, in addition to the NOAA DART buoys, four of which are in the Caribbean and adjoining regions. In order to be able to confirm whether a tsunami has been generated with potential impact, it has been recognized by ICG/CARIBE EWS that more real-time sea-level observations are required. The high priority sites recommended by ICG are Barbuda, Punta Manzanillo in Costa Rica, N, S and E coast of the Dominican Republic, Portobelo in Panama. The IOCARIBE GOOS-GCOS Partnership was explained as a mechanism for the operation of a Multi-Use Sea Level Observation Network for the Caribbean region

### **Introduction to Sea Level and Its Variations (Mr Bernie Kilonsky, University of Hawaii Sea Level Center)**

For this course the definition of sea level that would be used is the height of the sea measured relative to a mark on the nearby land called the tide gauge benchmark. The timescales for studying sea level changes vary from years to minutes. He presented seasonal and inter-annual changes for sea level due to water density. Tidal characteristics can be determined well from a year of good tide gauge data. The non tidal component of sea level was discussed. Sea-level data are critical for the tsunami warning centres in issuing alerts or cancellations. He stressed the importance of having multi-purpose (as opposed to single purpose or "all hazards") coastal sea level stations and data communications and the free and open exchange of real-time operational data. One of the proposed standards is that a sampling of 15 seconds averages and a continuous, or 1 minute transmission cycle for sites within 100 km of the tsunamigenic zones with immediate retransmission to the appropriate warning centres. The role of thermal expansion as one the contributors to rising sea level was discussed. Altimeters are also useful for observing sea level change but need to be validated with sea level stations.

### **Caribbean Oceanography (Dr Jorge E. Corredor, University of Puerto Rico)**

Dr Jorge Corredor gave an overview on the Caribbean circulation pattern, inter-annual and seasonal variability of river inflows, the temperature and salinity fields, eddies, tide patterns within the Caribbean (diurnal vs semi diurnal), density and internal waves. It is important to understand these phenomena and characteristics in evaluating variations in sea level in the region.

### **Instruments Used for Measurements of Sea Level (Mr Bernie Kilonsky, University of Hawaii Sea Level Center)**

The pros and cons for the following practices for observing sea level were presented: tide pole gauges, float gauges, acoustic gauges, pressure gauges, radar gauges. GLOSS requires that at least five benchmarks be installed near the gauge, one of which is the Tide Gauge Benchmark (TGBM) that should be leveled annually. There are many types of equipment, although the important issue is that the gauge be capable of measuring to at least a-centimeter accuracy in all weather and wave conditions. He stressed the importance of a daily inspection of the data. The selection of tide gauge sites was also discussed.

### **Real-Time Data Transmission-GOES, Internet (Mr Juan Fierro, Hydrographic and Oceanographic Service of the Chilean Navy)**

Telemetry options include radio links, public switched telephone lines, mobile phone links and mobile satellite links. An overview of the traditional satellite systems available for real-time transmissions were summarized: ARGOS, GOES E and W, POES, METEOSAT, MTSAT. Alternatives to satellite communications were discussed. More recent developments in telemetry include IRIDIUM, INMARSAT/BGAN, GLOBALSTAR, ORBCOMM. The service used depends on availability of channels, slots and costs. Developing an interface to GTS is important so that the data can be more accessible to the operational centres.

### **Hints for Optimum Installation and Operation of Tide Gauges (Mr Bernie Kilonsky, University of Hawaii Sea Level Center)**

Reference was made to the IOC Manual on Sea Level Measurement and Interpretation, Volume IV (IOC Manuals and Guides 14). Not all sites are suitable for meteorological purposes due to obstructions, but if they are appropriate, it is highly encouraged to add these types of sensors. He suggested that stations will have a tide pole

gauge, even though they are not a primary source of sea-level data. Float gauges, although tried and tested, have problems with stilling wells, density and require engineering of the site. Metadata needs to be provided for each of the stations. There is lots of expertise, especially large network, with acoustic gages with sounding tubes, which do require yearly calibration and some associated met sensors. He did not recommend open air acoustic gauges due to calibration issues. Pressure sensors can be used to create a solid data set, although it can be difficult to establish the datum. Pressure transducers are very survivable in high wave and storm conditions, but not as good for studies of long term sea-level changes, unless datum control is exercised. Radar gauges are easily installed and economic. He reviewed recommendations for sensors, station and site selection.

### **Datum Control and Leveling (Mr Juan Fierro, Hydrographic and Oceanographic Service of the Chilean Navy)**

Mr Juan Fierro addressed high precision GPS observations. GPS measurements can be corrected to obtain the absolute sea-level variations. It is necessary to decouple sea-level and land-level datums. At each station datum needs to be established. Guidelines for benchmarks include taking into consideration its permanency and identification. Need to identify the gauge contact point. All the marks must be connected by leveling at least annually. Equipment includes automatic and digital levels, tripod, staff pole, change plate, pole staff bubble and survey markers. Need to take back sights, fore sights and intermediate sights. The acceptable disclosure error is established by the country for different classes. Most significant errors are from effect of earth curvature, refraction and collimation. Sea leveling measurements can be compared with altimetry measurements. If GPS is used, he recommended dual frequency with choke ring, better permanent, if not yearly observations would also be useful.

### **Sea Level Visualization Programs (Mr Juan Fierro, Hydrographic and Oceanographic Service of the Chilean Navy)**

Tide Tool program was presented. This software is managed by the Pacific Tsunami Warning Center available at [ftp:ioc.unesco.org/ITIC/PTWC/Tide Tool](ftp:ioc.unesco.org/ITIC/PTWC/Tide%20Tool). This tool display prints, creates error log and activates an alarm when PTWC or JMA issue a product which is automatically updated. Visualization tools permit the determination of arrival times of tsunamis and the amplitudes and periods. Vaisala software was also presented. Web tools from NOAA and IOC were also illustrated ([www.vliz.be/gauges](http://www.vliz.be/gauges)).

### **Tideview (Mr Guy Urban, WCATWC)**

An overview was given on how to get and display water level and DART data at the WCATWC. The main ways to obtain sea level data are thru GTS and via a browser. Additional pathways at WCATWC include NOAA net (only US), private internet provider, satellite and VSAT. Guy Urban emphasized the need to define for GTS and the local communications platform GTS message, GOES ID and WMO headers. He described the typical water-level formats transmitted over GTS. Many different formats of data are transmitted on the GTS. He welcomed efforts to standardize data, like the CREX format. The data can be viewed on a web page or with graphic interface software such as TideTool (PTWC), Tide View (WCATWC) or the station monitoring ([www.vliz.be/gauges](http://www.vliz.be/gauges)). Disadvantage of the browser sites is that you cannot take a measurement. He presented SOCKETPORT for decoding data and Tide View for displaying the data. It is a windows only programme and there are plans for creating a Java script so it is platform independent.



### **Tide Monitoring Data System (Dr Víctor Huérfano, Puerto Rico Seismic Network)**

The web tools and decoders that have been developed and/or implemented at PRSN were presented.

### **Quality Control of Data (Mr Bernie Kilonsky, University of Hawaii Sea Level Center)**

Mr Kilonsky first gave an overview of the four volumes of IOC Manuals on Sea Level Measurement and Interpretation 14 (1985, 1994, 2000 and 2006). The need to have copies of the original data files was emphasized. He focused on processing and quality control aimed at producing hourly data. Be consistent with the use of tide gauge prediction programmes. Convert the data to monthly data files and create yearly files.

### **DART II Buoys (Mr Guy Urban, WCATWC)**

An overview was given on the Deep Ocean Assessment for Reporting Tsunamis. There are five US NOAA DART II installed in the Caribbean and Adjoining Regions. The configuration, data availability and formats were discussed. There is a DART II set up in Mississippi to be used for training of tsunami warning centre personnel. An overview was given on the data format and data types. Data can be accessed through the RUDICS web page. The maintenance is usually given every two years. The batteries have enough power for 20 dial up events.

## **3. COUNTRY REPORT PRESENTATIONS**

### **USA NOAA NOS [Thomas Landon and Allison Allen]**

Maintenance and standards is the cornerstone of any programme. Programme description, end-to-end system of data collection, and national standard for legal certification explains the rigour of their operations such as NWLON attributes and NWLON Operations, NWLP support TWX, Storm Surge Program and long-term sea-level studies, among others. NOAA is the lead agency for the US Tsunami Program, including warnings, research and observations. NOAA recognizes the need for tsunami hazard warning in the Caribbean. NOAA has hardened station installation in case of hurricanes. USA has a primary and backup system at every station. All stations transmit in 1 hour or 6 minute time slots via GOES and some sites are also using the IRIDIUM satellite system. Also perform short-term water level measurements. They operate an ocean systems test and evaluation programme (OSTEP). Each station has a minimum of 10 benchmarks. Every year 2<sup>nd</sup> Order and Class 1 leveling is performed, and at least every two years all benchmarks are leveled. Some GPS stations observations are done annually or every five years depending on the rate of change, higher frequency is used when abnormal sea level change is observed. NOS and NGS have located CORS to establish whether the sea-level change is associated with absolute sea level and subsidence. 24 x 7 quality assurance and control is conducted.

### **WCATWC [Guy Urban]**

An overview was given on the operations of the West Coast Alaska Tsunami Warning Center. Access seismic and sea level data for decision process. In the case of an event more time is spent dedicated to analysis of sea-level data than seismic data. WCATWC operates 9 tide gauge stations using VSAT for communications.

### **PUERTO RICO [Christa von Hillebrandt]**

The Puerto Rico Seismic Network operates 24 seismic stations in the northeastern Caribbean monitoring 24 x 7 along with seismic data from another 50 seismic stations in the

Caribbean and adjoining regions. The goal is to be able to detect earthquakes with Magnitude 4.5 or greater in the region within 1 minute in order to issue the corresponding earthquake/tsunami product within 5 minutes. Each station has an acoustic and pressure sensor. All data is transmitted in 6 minute slots through GOES. A GOES ground station is located at the PRSN to access the data. XCONNECT and TideTool (WCATWC) are used to display the data. To complement the monitoring task, hazard and risk studies are conducted, as well as an education, preparedness and awareness program. Funding is provided mainly by the UPRM, Government of Puerto Rico and NOAA.

#### **COSTA RICA [Fernando Urena]**

RONMAC Program started in 2000 with NOAA funding after Hurricane Mitch. Currently, Red Observación Nivel del Mar de América Central, is only for Costa Rica. Costa Rica has installed stations on the Pacific and Caribbean coasts. The Limon station is operational but is not transmitting. The sample rate is every 6 minutes and it has a 3-hour time slot. The equipment consists of an Aquatrack logger/transmitter and a pressure sensor.

#### **COLOMBIA [Leonardo Marriaga]**

The Institute of Hydrology, Meteorology and Environmental studies directs and coordinates the environmental information system. The Oceanographic and Hydrographic Research Center from the General Maritime Directorate has been participating in the ICG and has the technical capability for observing, monitoring, prediction and alerts. It operates a network of wave buoys with meteorological capabilities, but none of the seven sea level stations transmit data in real time. Stations in the Caribbean are Cartagena, Capurgana, San Andres (in front of the coast of Nicaragua) and del Rosario. Funding exists at present to acquire two stations for Tumaco and Gorgona Island in the Pacific. There are plans for four stations in the Caribbean.

#### **SEISMIC RESEARCH CENTER [Nish Nath]**

The efforts of SRC to monitor sea level have been focused on Kick "em Jenny. A tide gauge sensor was installed in 2001, but it was destroyed by wave action. SRC will be deploying two new instruments in Grenada by September, 2008.

#### **TRINIDAD [Clinton Stewart]**

Three stations were installed in Port of Spain and Point Fortin on Trinidad and Scarborough in Tobago. Due to timing the data were not received at UWI. Tide tables are compiled by the Proudman Oceanographic Laboratory. T & T has purchased six new gauges, four will be installed in Trinidad and two in Tobago and all gauges should be installed by 2008. These will be integrated into the current CPAC project and archived at CIMH in Barbados.

#### **CCCCC (CIMH, BARBADOS) [Marvin Forde]**

Eighteen original stations installed throughout the Caribbean. Two stations were operational up to 2005, but not transmitting. In 2006 World Bank funding was obtained for 11 stations. CIMH will assist with the station installation, Regional Centre to be located at CIMH, QA and QC for met data, pending for sea level data, provide technical assistance. Islands included now are Guyana, Barbados, Jamaica, Antin, St. Kitts, Antigua, Dominica, St. Lucia, Grenada, and St. Vincent.

### **BARBADOS [Ian Timothy]**

Lack of local management and archival in Barbados has led to the unsustainability of the stations. Five stations have been installed in Barbados, only the gauge of the Coastal Zone Management Unit Pelican in Bridgetown is active and functioning well. No real-time communications. CZMU operates a CORS. CZMU has another sea-level station to install, in addition to the MAC station.

### **FRANCE [Arnaud Lemarchand]**

Two stations in Martinique and Guadeloupe with radar gauge and air pressure gauges. No real-time transmissions. These are operated by the French Navy. Local authorities in Marnizieu installed on the east and another on the west. Geodetic leveling is always performed. GSM hourly transmission. IGP has funding for five tide gauges in Guadeloupe. He presented sketches for the first station to be installed in La Desirades which will have a radar and air pressure sensors. Require a slot for GOES transmission because the station is GOES capable. Other communication platforms include RF links and VSAT. He requested recommendations on other measurements.

### **ANTIGUA AND BARBUDA [Donald Simon]**

One station is operating in Antigua, Camp Blizzard. Operated by Fisheries Division and transferred to Antigua Meteorological Services. The station is operational, but does not have real time transmission of data. There are three benchmarks.

### **NETHERLAND ANTILLES AND ARUBA [Joeffrey Boekhudt]**

Floating tide gauge and recorder installed in Curacao, access is limited to the Port Authority. Only paper records are available, no real time data. New installation is required to be managed by the National Met Service. Capacity building will be required.

### **BAHAMAS [Gregory Gibson]**

Three stations were installed, two are operational. The operational stations are in Nassau and Lee Stocking Island. The stations transmit every three hours.

### **JAMAICA [Adrian Shaw]**

Two tide gauges in Jamaica, south and north coast. Port Royal, data available from 1954 to 1971. There have been two stations at Discovery Bay, none are functional.

### **BRITISH VIRGIN ISLANDS [Nigel Cines]**

In 1964 the Canadian Hydrographic Survey installed three bench marks and operated a tide gauge station. The location of this station is now inland. A tide gauge station is under installation and will be contributing to the CARIBE EWS.

### **DOMINICAN REPUBLIC (INDRHI) [Irving Baez]**

INDRHI received funding to purchase six tide gauges. Forty-four gauges have been installed and, one was vandalized. The other three have onsite recording. Installation is pending for Santo Domingo and Punta Cana.

## **DOMINICAN REPUBLIC (ONAMET) [Claudio Martínez]**

In the process of installing one tide gauge with the PRSN and ISU in Puerto Caucedo, Dominican Republic, along the southern coast. There is a GOES receiver at ONAMET, but it is not operational.

### **4. FIELD VISITS**

The participants were invited to visit the NOAA Tide Gauge in “La Parguera”, Lajas, Puerto Rico. They were also taken to the Puerto Rico Seismic Network’s Sea Level Stations in Mayagüez and Arecibo and the NOAA’s Sea Level Station in Crash Boat in Aguadilla.

### **5. REVIEW, CONCLUSION AND RECOMMENDATIONS**

In addition to the criteria established by GLOSS and outlined in the IOC Manuals and Guides 14, Vol. I–IV, the SLO discussed and recommended a set of criteria and standards for the siting, sensors, leveling procedures, data processing and other factors for sea-level stations in the Caribbean (Table 1).

SLO recognizes the efforts of many Member States to install, operate and maintain sea-level stations in the region to increase the availability of the sea-level data and the importance of engaging the national and local governments. Nevertheless the SLO recognizes the lack of sea-level stations in the region providing timely and accurate data for tsunamis and other coastal hazards purposes.

Recommend the establishment and maintenance of a digital web-based sea-level station book for the Caribbean and adjacent regions and appreciates the PRSN availability to perform this task.

It is very important for the sustainability of the stations that there be a sense of local ownership of the data and therefore the SLO supports efforts and programmes for the local access and visualization to the sea-level data.

Tsunamis and other coastal hazards do not recognize boundaries therefore the sea-level network operators’ support free and open access of data.

The SLO supports the IOCARIBE/GOOS-GCOS Partnership to Support a Multi-Use Sea-Level Observation Network for the Caribbean Region and urges the appropriate funding to be identified, and the active participation of the sea-level operators. Priority should be given to document the definition of the Caribbean Tsunami hazard and risk. The SLO will engage the corresponding authorities in their countries to support the Partnership in the appropriate form.

SLO are concerned with the lack of time slots on GOES for real-time transmission and request NESDIS for a channel for all the Caribbean Sea-level stations or another appropriate alternative.

The SLO recognizes that a lot of expertise has been developed in the region and globally which should be taken full advantage of. Areas of support can include, but are not limited to, assistance with the determination of the siting and installation of the stations and training for data processing and visualization of sea-level data. The SLO recommends venues to share sea-level expertise, experiences, publications and reports. It was suggested that regional partners be included when installations are being performed and that a database on sea level expertise be created.

The sea-level operators recognize that in addition to the necessity of timely and accurate sea-level data, local emergency preparedness, education, mitigation, mapping and other monitoring efforts are needed to achieve an end-to-end tsunami and other coastal hazards warning system.

**Table 1. Criteria and standards for the siting, sensors, leveling procedures, data processing and other factors for sea-level stations in the Caribbean**

|                                    |  |
|------------------------------------|--|
| <b>Siting Criteria</b>             |  |
| Tectonic/Geological                | Stable. Co-located GPS would help determine the stability of the ground and help discriminate between the sea and land signals motions.  |
| Support structure                  | Stable engineered structures are desirable. Hurricane and earthquake resistant   |
| Wave activity                      | Avoid areas of high wave activity. The waves not only affect the operation of the station, also to the benchmarks.   |
| River discharges                   | To be avoided when possible. Take into consideration when choosing instrumentation, consider using a radar if fresh water discharge is a problem.  |
| Local Knowledge                    | Important to be taken into consideration, also to develop local ownership.   |
| Development plans                  | Discuss future development plans that can affect the station   |
| Tsunami                            | Determine possible travel time of tsunamis to the site.  |
| Volcanic Activity                  | Having a portable station available to detect rapid sea level changes.   |
| Documentation                      | Document the site selection process.   |
| Decision Making process            | Involve all the agencies that are interested and would be accessing the data   |
| References                         | Historical and modeling data should be reviewed and taken into consideration.  |
| <b>Sensors and DCP</b>             |  |
| Accuracy of sea level measurements | 1 cm or less.  |
| Sampling Rate                      | 1 minute or less.  |
| Data Format                        | Well documented, it will depend on the manufacturer. With height in mm, epoch time, check sum and metadata. Support standardization of data format, eg. CREX format for GTS.   |
| Timing                             | GPS timing of data.  |
| Power                              | Will be dependable on the sensors and DCP. Lowest as possible power consumption. Independent. Solar, wind power desirable. Backup power for 20 days for communications. Independent battery supply for communications and data collection. The capacity of the battery should be enough to support the communication requirements. |
| Calibration                        | As required to achieve the desired accuracy.   |
| Reliability                        | Redundant sensors and DCP. On site storage capacity  |
| <b>Communications</b>              |  |
| Transmissions                      | 15 minutes or less. At sites tsunami travel times are less than 1 hour, higher frequency transmissions are required. Support efforts for event triggered communications with restricted access.  |

|  |  |
|--|--|
| Robust   | Reliable communications.   |
| Accessibility  | Data can be available to the corresponding institutions, warning centers.  |
| Redundancy   | Local and global communication systems. Overlap of data transmitted over satellites should be considered.  |
| Format   | Will be dependable on the communications platform. Needs to be well documented.  |
| Two way communications                               | Desirable and highly recommended   |
| <b>Leveling</b>                                      |  |
| Number of Bench marks                                | Minimum of five set.   |
| GPS bench marks                                      | Stable ground or engineered structures.  |
| Location of benchmarks                               | Integrate existing bench marks.<br>Install in stable areas.<br>Locate in a variety of sites of geological and soil stability and engineered structures.<br>Some perpendicular to the coast, not all parallel to the coast. |
| Leveling standard                                    | Third order required, second order recommended.  |
| Frequency of leveling                                | At least annually, or more often if ground is stable or after significant events that could affect the levels.   |
| Continuous High Rate GPS                             | Recommended. Leveling must be performed between the primary benchmarks and the GPS at least annually.  |
| <b>Data Processing</b>                               |  |
| Inspection of Data                                   | Daily.   |
| Quality Control                                      | Highly recommended.  |
| Agencies   | All the agencies that might require the sea level data should have access to the data, meteorological, navigation, research, seismic   |
| Display of Data                                      | Local real time displays for the sea level operators are required, eg. Tide Tool, Tide View, or IOC Sea Level Station Monitoring Facility.   |
| Format of Data                                       | Well documented. With height in mm, epoch time, check sum and metadata. Support standardization of data format, eg. CREX format for GTS.   |
| <b>Other Factors</b>                                 |  |
| Local operators                                      | Expertise in formatting, leveling, electronics and oceanography.   |
| Funding  | Redundant funding is required for the operation of the stations.<br>Seek reduced special rates for communications in consideration of the emergency applications.  |
| Training   | Necessary. Sharing of publications and reports and training opportunities.   |
| Maintenance Schedule                                 | Yearly visits are required.  |
| Replacement of equipment                             | Overlap of time period sensors are operating.  |
| Communications with Emergency Management authorities | Direct and robust communications between the institutions monitoring sea level data, warning centers and the emergency management institutions.  |

## 6. CLOSURE

On Friday 27 June 2008, the Chancellor of the University of Puerto Rico at Mayagüez delivered a greeting to the attendees of the course. A group picture was taken with the

Chancellor. The Sea-Level training course was officially closed by Christa G. von Hillebrandt-Andrade. Leonardo Marriaga Rocha, Oceanographer of the Oceanographic and Hydrographic Research Centre of Colombia, on behalf of the participants thanked the Puerto Rico Seismic Network for the excellent organization and conduct of the course. Certificates (Appendix V) were distributed by Christa von Hillebrandt, Bernard Kilonsky and Juan Fierro and the workshop was closed at 6:30 on Friday, 27 June 2008.

## **7. ACKNOWLEDGMENTS**

Support for this training course was provided by the US Government, NOAA, the University of Puerto Rico and the Government of the Commonwealth of Puerto Rico through the Puerto Rico Seismic Network. Funding for the lecturers was provided by IOC (Bernard Kilonsky) and the Caribbean Regional Association for Coastal Observations, CARA (Juan Fierro).

ANNEX I

**COURSE SCHEDULE**

| <b>Date/Day</b>   | <b>Time</b>       | <b>Program/Activity</b>   | <b>Lecturer</b>              |
|-------------------|-------------------|---|------------------------------|
| Mon. 23 June 2008 | 8:00am – 8:30am   | Registration  |                              |
|                   | 8:30am – 9:00am   | Official Opening  |                              |
|                   | 9:00am – 9:15am   | Group Photo   |                              |
|                   | 9:30am – 9:40am   | Presentation of Attendees   | Christa von Hillebrandt      |
|                   | 9:40am – 10:30am  | Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE EWS)  | Israel Matos                 |
|                   | 10:30am – 11:15am | GLOSS   | Bernie Kilonsky              |
|                   | 11:15am to 12:00n | IOCARIBE GOOS-GCOS Partnership for a Multi-Use Sea Level Observation Network for the Caribbean Region | Christa von Hillebrandt      |
|                   | 1:00pm – 3:00pm   | Introduction to Sea Level and Its Variations  | Bernie Kilonsky              |
|                   | 3:15pm – 4:00pm   | Caribbean Oceanography  | Jorge Corredor               |
|                   | 4:00pm – 5:30pm   | Instruments Used for Measurement of Sea Level   | Bernie Kilonsky              |
| Tue. 24 June 2008 | 8:00am – 10:00am  | Real-Time Data Transmission-GOES, Internet  | Juan Fierro                  |
|                   | 10:30am – 12:00n  | Hints for Optimum Installation and Operation of Tide Gauges   | Bernie Kilonsky              |
|                   | 1:00pm – 2:30pm   | Datum Control and Leveling  | Juan Fierro                  |
|                   | 2:30pm – 3:15pm   | Sea Level Instrumentation Country Reports   | Attendees                    |
|                   | 3:30pm – 4:00pm   | Sea Level Instrumentation Country Reports   | Attendees                    |
|                   | 4:00pm – 5:00pm   | Visit to the Puerto Rico Seismic Network  | Attendees                    |
| Wed. 25 June 2008 | 8:00am – 10:00am  | Sea Level Visualization Programs  | Juan Fierro                  |
|                   | 10:30am – 12:00n  | Tideview  | Guy Urban<br>Víctor Huérfano |
|                   | 1:00pm – 3:00pm   | Sea Level Instrumentation Country Reports   | Attendees                    |
|                   | 3:15pm – 5:00pm   | Sea Level Instrumentation Country Reports   | Attendees                    |
|                   | 5:00pm            | Visit to NOAA Tide Gauge, Tour of the Phosphorescent Bay, Parguera, Lajas.                            | Juan González Lagoa          |



| <b>Date/Day</b>   | <b>Time</b>       | <b>Program/Activity</b>                | <b>Lecturer</b> |
|-------------------|-------------------|--|-----------------|
| Thu. 26 June 2008 | 8:00am            | Field Trip                             |                 |
| Fri. 27 June 2008 | 8:00am – 10:00am  | Quality Control of Data                | Bernie Kilonsky |
|                   | 10:15am – 11:15am | DART Buoys                             |                 |
|                   | 11:15am – 12:00n  | Review, conclusion and recommendations | Attendees       |
|                   | 1:00pm – 3:15pm   | Review, conclusion and recommendations | Attendees       |
|                   | 3:30pm – 4:00pm   | Closure                                |                 |

## ANNEX II

### COURSE MATERIAL

List of course materials used during the course.

- D. Pugh (2004): Changing Sea Levels.
- IOC Manuals and Guides 14: *Sea Level Measurement and Interpretation: Volume IV: An update to 2006.*
- S. Dopp-Hicks (2006): Understanding Tides. NOAA.
- Tsunami Warning Center Reference Guide Software 2007.

ANNEX III

**BACKGROUND REPORTS AND PRESENTATIONS**

| <b>No.</b> | <b>Title</b>   | <b>Language</b>   |
|------------|--|-------------------|
| 1.         | Report to the IOC-GLOSS-PRSN on the Status of the Tide Gauge/Sea Level Monitoring Station in Antigua.  | English           |
| 2.         | National Report for the Bahamas.   | English           |
| 3.         | Report on the National Tide Gauge Network of Barbados.   | English           |
| 4.         | British Virgin Islands Sea Leveling Status.  | English           |
| 5.         | Colombian Sea Level Network: Current Status.   | English & Spanish |
| 6.         | Costa Rica's Report on the Local Sea Level Monitoring System.  | English           |
| 7.         | Sea Level Data From Cuban Sea Level Stations to Permanent Service for Mean Sea Level (PSMSL).  | English           |
| 8.         | National Report on Sea Level Status in Jamaica.  | English           |
| 9.         | Puerto Rico Tsunami Ready Tide Gauge Network.  | English           |
| 10.        | Estatus Mareógrafos en República Dominicana, Instituto Nacional de Recursos Hidráulicos (INDRHI)   | Spanish           |
| 11.        | National Report of the Republic of Trinidad and Tobago<br>11 <sup>th</sup> Session of the Group of Experts for the Global Sea Level Observing System (GLOSS) | English           |
| 12.        | Sea Level Monitoring at the Seismic Research Unit  | English           |
| 13.        | Caribbean Oceanography, Jorge E. Corredor  | English           |
| 14.        | Global Level of the Sea Surface, The Future of Operational Oceanography, Bernard Kilonsky  | English           |
| 15.        | Global Level of the Sea Surface, Permanent Service for Mean Sea Level, Bernard Kilonsky  | English           |
| 16.        | Methods For Sea Level Measurement, Bernard Kilonsky  | English           |
| 17.        | Sea Level Variations, Bernard Kilonsky   | English           |
| 18.        | Tsunami and Other Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions (IOC/ICG-CARIBE EWS), Israel Matos                               | English           |

| No. | Title   | Language |
|-----|---|----------|
| 19. | Partnership for a Multi-Use Sea Level Observation Coordination Network for the Caribbean Region, Christa G. von Hillebrandt-Andrade | English  |
| 20. | Datum Control and Leveling, Juan J. Fierro  | English  |
| 21. | Real Time Data Transmission, Juan J. Fierro   | English  |
| 22. | Sea Level Data and Its Application at the West Coast/Alaska Tsunami Warning Center, Guy Urban                                       | English  |
| 23. | Sites and operations, Bernard Kilonsky  | English  |
| 24. | NOAA's National Water Level Program Overview, Thomas F. Landon, and Allison Allen   | English  |
| 25. | National Report of Curaçao  | English  |
| 26. | French West Indies Sea Level instrumentations, Arnaud Lemarchand  | English  |
| 27. | Specifications of tide gauge at "La Désirade"   | English  |
| 28. | Getting and Displaying Water Level and DART Data at WCATWC, Guy Urban   | English  |
| 29. | Mareógrafo en Republica Dominicana, ONAMET  | Spanish  |
| 30. | Report on the Re-establishment Of the Sea Level Monitoring For the English-speaking Caribbean                                       | English  |
| 31. | Sea Level Visualization Programs, Juan Fierro   | English  |
| 32. | Tide Monitoring Data System, Víctor Huérfano  | English  |
| 33. | DART II, Guy Urban  | English  |

## ANNEX IV

### LIST OF PARTICIPANTS

#### **TRAINEES**

**Allen, Allison**

NOAA National Ocean Service  
Oceanographer  
1305 East West Highway, #7234  
Silver Spring, MD 20910  
USA  
Tel (W): 301-713-2890 Ext 166  
Tel (H): 240-638-6882  
Fax: 301-713-4437  
Email: [allison.allen@noaa.gov](mailto:allison.allen@noaa.gov)

**Anselmi-Molina, Carlos M.**

Caribbean Regional Association (CARA)  
University of Puerto Rico  
Graduate Student  
Mayagüez, PR 00681  
Puerto Rico  
Cell: 939-245-1775  
Email: [carlos.anselmi@uprm.edu](mailto:carlos.anselmi@uprm.edu)

**Arnaud, Lemarchand**

Institut de Physique du Globe de Paris  
Chief Engineer of Volcano Observatories  
4 Place Jussieu 75252  
Paris  
France  
Tel: 33 1 44 27 48 13  
Fax: 33 1 44 27 24 01  
Email: [arnaudl@ipgp.jussieu.fr](mailto:arnaudl@ipgp.jussieu.fr)

**Báez Morillo, Irving**

National Institute of Hydraulic Resource  
Chief of Electronic Instrumentation  
Division  
Juan de Dios Ventura Avenue, Apat. 1407  
Santo Domingo  
Dominican Republic  
Tel (W): 809-532-3271, Ext. 3464  
Tel (H): 809-496-5830 and 809-616-9716  
Fax: 809-508-7215  
Email: [irvinmorillo@hotmail.com](mailto:irvinmorillo@hotmail.com)

**Báez Sánchez, Gisela**

Puerto Rico Seismic Network  
University of Puerto Rico  
Coordinator, Geophysical Data Analyses  
P.O. Box 9017, Mayagüez, PR 00681

Puerto Rico

Tel: 787-833-8433  
Cell : 787-464-0341  
Fax: 787-265-1684  
Email: [gbaez@midas.uprm.edu](mailto:gbaez@midas.uprm.edu)

**Boekhoudt, Joffrey**

Meteorological Service of the Netherlands  
Antilles and Aruba  
Climate Research and Development  
Mahuma, Curacao  
Netherlands Antilles  
Tel (W): 05999-839-3368 or 839-3328  
Tel (H): 564-6241  
Email: [joffrey.boekhoudt@gov.an](mailto:joffrey.boekhoudt@gov.an) and  
[boekhoudt@hotmail.com](mailto:boekhoudt@hotmail.com)

**Brown, Kevin**

Center for Marine and Environmental Studies  
University of Virgin Islands  
Research Specialist  
2 John Brewer's Bay, St. Thomas, VI 00802  
USA  
Tel: 340-693-1384  
Fax: 340-639-1385  
Email: [kbrown@uvi.edu](mailto:kbrown@uvi.edu)

**Caines, Nigel**

Survey Department, BVI Government  
CAD Technician  
Road Town, Tortola, BVI  
British Virgin Islands  
Tel (W): 284-494-3459  
Tel (H): 284-494-2942  
Fax: 284-494-3895  
Email: [survey@bvigovernment.org](mailto:survey@bvigovernment.org) and  
[ncainz@hotmail.com](mailto:ncainz@hotmail.com)

**Cano, Leonardo**

Puerto Rico Seismic Network  
University of Puerto Rico  
Graduate Student  
PO Box 9017  
Mayagüez. PR 00681  
Puerto Rico  
Tel: 787-833-8433  
Cell: 787-238-5328  
Fax: 787-265-1684  
Email: [lcano@midas.uprm.edu](mailto:lcano@midas.uprm.edu)

**Cole, George**

Department of Civil Engineering &  
Surveying  
University of Puerto Rico  
Visiting Prof. of Surveying & Topography  
P.O. Box 9041  
Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-265-5405  
Tel (H): 850-544-3806  
Fax: 787-833-8260  
Email: [gcole@uprm.edu](mailto:gcole@uprm.edu)

**Ferrer, Fernando**

Puerto Rico Seismic Network  
University of Puerto Rico  
Chief Data Analyst  
P.O. Box 9017  
Mayagüez, PR 00681  
Puerto Rico  
Tel: 787-833-8433  
Cell: 787-349-0688  
Fax: 787-265-1684  
Email: [fferrer@midas.uprm.edu](mailto:fferrer@midas.uprm.edu)

**Forde, Marvin**

Caribbean Institute for Meteorology &  
Hydrology (CIMH)  
Technical Officer (1)  
Husbands, St. James, BB23006  
Barbados  
Tel (W): 246-425-1362 and 246-425-1365  
Tel (H): 246-435-0745  
Fax: 246-424-4733  
Email: [mforde@cimh.edu.bb](mailto:mforde@cimh.edu.bb)

**Gibson, Gregory G.**

Department of Meteorology  
Trainee Meteorological Officer  
P.O. Box 8330  
Nassau N.P.  
Bahamas  
Tel (W): 242-356-3736 and 242-377-7461  
Tel (H): 242-324-3321  
Cell: 242-456-6524  
Fax: 242-356-3739 and 242-377-1750  
Email: [gregory\\_gibson\\_25@hotmail.com](mailto:gregory_gibson_25@hotmail.com)  
and [gregory\\_gibson\\_1969@yahoo.com](mailto:gregory_gibson_1969@yahoo.com)

**González, Juan O.**

Department of Marine Sciences  
University of Puerto Rico  
Graduate Student – Physical  
Oceanography  
Mayagüez, PR 00681

Puerto Rico

Cell: 787-356-7057

Email: [ocean.gonzalez@gmail.com](mailto:ocean.gonzalez@gmail.com)

**Hernández, Alice**

Puerto Rico Seismic Network  
University of Puerto Rico  
Graduate Student  
P.O. Box 9017  
Mayagüez, PR 00681  
Puerto Rico  
Tel: 787-833-8433  
Cell: 787-640-7194  
Fax: 787-265-1684  
Email: [ahernandez@midas.uprm.edu](mailto:ahernandez@midas.uprm.edu)

**Hincapié Cárdenas, Carolina**

Puerto Rico Seismic Network  
University of Puerto Rico  
Graduate Student  
P.O. Box 9017  
Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-833-8433  
Tel (H): 787-477-5679  
Fax: 787-265-1684  
Email: [chincapie@midas.uprm.edu](mailto:chincapie@midas.uprm.edu)

**Irizarry, Harold J.**

Puerto Rico Seismic Network  
University of Puerto Rico  
Chief Data Analyst  
P.O. Box 9017, Mayagüez, PR 00681  
Puerto Rico  
Tel: 787-833-8433  
Fax: 787-265-1684  
Email: [hirizarry@midas.uprm.edu](mailto:hirizarry@midas.uprm.edu)

**Landon, Thomas**

NOAA National Ocean Service  
National Water Level Program Lead  
1305 East West Highway, SSMC4  
Sta. 6409, Silver Spring, MD 20910  
USA  
Tel (W): 301-713-2897 Ext 191  
Cell: 301-461-8063  
Fax: 301-713-4465

**Marriaga Rocha, Leonardo**

Oceanographic & Hydrographic Research Center  
Operational Oceanography Area  
Cartagena, Colombia  
Tel: 6694104  
Cell: 300-8167379  
Email: [lmariaga@dimar.mil.co](mailto:lmariaga@dimar.mil.co)

**Martínez Jiminian, Claudio**

National Meteorology Office (ONAMET)  
OMMIV Observer and Radar Expert  
Juan Molina #1 St., Los Mameyes  
Santo Domingo  
Dominican Republic  
Tel (W): 809-788-1122  
Tel (H): 829-779-0818  
Fax: 809-597-9842  
Email: [claudiomartin85@hotmail.com](mailto:claudiomartin85@hotmail.com)

**Nath, Nisha**

The Seismic Research Centre Unit, U.W.I.  
Chief Technician – Seismology  
St. Augustine Campus  
Trinidad and Tobago  
Tel (W): 868-662-4659  
Tel (H): 868-760-0646  
Fax: 868-663-9293  
Email: [seismictech@uwiseismic.com](mailto:seismictech@uwiseismic.com) and  
[nisha\\_nath@yahoo.com](mailto:nisha_nath@yahoo.com)

**Pujols, Rafael**

Puerto Rico Seismic Network  
University of Puerto Rico  
Graduate Student  
P.O. Box 9017  
Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-833-8433  
Fax: 787-265-1684  
Email: [rpujols@midas.uprm.edu](mailto:rpujols@midas.uprm.edu);  
[rafaelpujols@hotmail.com](mailto:rafaelpujols@hotmail.com)

**Shaw, Adrian**

Meteorological Service, Jamaica  
Meteorologist  
65 ¾ Half Way Tree Road, Kingston 10  
Jamaica  
Tel (W): 929-3700 and 929-3706  
Tel (H): 969-6002 and 362-3017  
Fax: 960-8989  
Email: [metservice.cbh@jamweb.net](mailto:metservice.cbh@jamweb.net);  
[balleryouth@hotmail.com](mailto:balleryouth@hotmail.com)

**Santiago, Javier**

Puerto Rico Seismic Network  
University of Puerto Rico  
Scientific Instrumentation Specialist  
P.O. Box 9017, Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-833-8433  
Tel (H): 787-868-2750  
Fax: 787-265-1684  
Email: [santiago@midas.uprm.edu](mailto:santiago@midas.uprm.edu)

**Román, Yomayra**

Puerto Rico Seismic Network  
University of Puerto Rico  
Chief Data Analyst  
P.O. Box 9017, Mayagüez, PR 00681  
Puerto Rico  
Tel: 787-833-8433  
Cell: 787-632-8256  
Fax: 787-265-1684  
Email: [yomroman@midas.uprm.edu](mailto:yomroman@midas.uprm.edu)

**Simon, Donald**

Antigua Meteorological Services  
Information Systems Manager  
V.C. Bird Int'l Airport, Coolidge  
P.O. Box 1051  
Antigua  
Antigua and Barbuda  
Tel (W): 268-462-3229 and 268-462-4606  
Tel (H): 268-460-4503  
Fax: 268-462-4606  
Email: [metoffice@antigua.gov.ag](mailto:metoffice@antigua.gov.ag);  
[don\\_acs@yahoo.com](mailto:don_acs@yahoo.com)

**Soto, Lillian**

Puerto Rico Seismic Network  
University of Puerto Rico  
Chief Data Analyst  
P.O. Box 9017  
Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-833-8433  
Tel (H): 787-877-0341  
Fax: 787-265-1684  
Email: [lsoto@midas.uprm.edu](mailto:lsoto@midas.uprm.edu)

**Stewart, Clinton R.**

Survey & Mapping Division  
Hydrographic Surveying Assistant  
118 Frederick St.  
Port of Spain  
Trinidad and Tobago  
Tel (W): 868-627-9201; 868-627-9204  
Tel (H): 868-674-0235  
Cell: 868-756-7337  
Email: [disd@tstt.net.tt](mailto:disd@tstt.net.tt); [clintons@tstt.net.tt](mailto:clintons@tstt.net.tt)

**Timothy, Ian G.D.**

Coastal Zone Management Unit  
Field Inspector  
Bay Street, St. Michael  
Barbados  
Tel (W): 246-228-5950 and 246-228-5951  
Fax: 246-228-5956  
Email: [itimothy@coastal.gov.bb](mailto:itimothy@coastal.gov.bb)

**Ureña Elizondo, Fernando**

International Ocean Institute  
Ronmac Sea Level Stations Technical  
Coordinator  
National University  
Heredia  
Costa Rica  
Tel (W): 506-2-277-3594  
Tel (H): 506-8-838-9487  
Fax: 506-2-260-2546  
Email: [furenae@gmail.com](mailto:furenae@gmail.com)

**Vélez, Linda**

Department of Civil Engineering &  
Surveying, University of Puerto Rico  
Professor  
P.O. Box 9041  
Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-265-5405  
Tel (H): 787-313-4740  
Fax: 787-833-8260  
Email: [velezl@uprm.edu](mailto:velezl@uprm.edu)

**LECTURERS**

**Corredor, Jorge E.**

Department of Marine Sciences  
University of Puerto Rico  
P.O. Box 9041  
Mayagüez, PR 00681  
Puerto Rico  
Tel: 787-899-2048 Ext. 244  
Email: [jcorredor@uprm.edu](mailto:jcorredor@uprm.edu)

**Fierro, Juan**

Hydrographic & Oceanographic Service of  
the Chilean Navy  
Oceanography Department  
Director, Physical Oceanography Section  
Chile  
Tel: 56 32 2266676  
Fax: 56 32 2266542  
Email: [jfierro@shoa.cl](mailto:jfierro@shoa.cl)

**Huérfano, Víctor A.**

Puerto Rico Seismic Network  
University of Puerto Rico  
Aux. Researcher, PO Box 9017  
Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-833-8433  
Fax: 787-265-1684  
Email: [victor@midas.uprm.edu](mailto:victor@midas.uprm.edu)

**Kilonsky, Bernard**

University of Hawaii  
Sea Level Center, 1000 Pope Rd.  
Honolulu, HI 96822  
USA  
Tel: 808-956-6574  
Email: [kilonsky@hawaii.edu](mailto:kilonsky@hawaii.edu)

**Matos, Israel**

ICG-CARIBE EWS, UNESCO  
Vice-Chair ICG  
Meteorologist in Charge  
NOAA/ National Weather Service  
Forecort Office  
Carretera 190 N°. 4000 Carolina, P.R  
USA  
Tel: (787) 253-4586 Ext. 222  
Fax: (787) 253-7802  
E-mail: [israel.matos@noaa.gov](mailto:israel.matos@noaa.gov)

**Urban, Guy W.**

West Coast/Alaska Tsunami Warning Center  
Geophysicist  
910 South Felton  
Palmer, AK 99645  
USA  
Tel (W): 907-745-4212  
Tel (H): 907-746-1310  
Fax: 907-745-6071  
Email: [guy.urban@noaa.gov](mailto:guy.urban@noaa.gov)

**von Hillebrandt, Christa**

Puerto Rico Seismic Network  
Director  
P.O. Box 9017, Mayagüez, PR 00681  
Puerto Rico  
Tel (W): 787-833-8433  
Tel (H): 787-805-0447  
Cell: 787-608-2577  
Fax: 787-265-1684  
Email: [christa@midas.uprm.edu](mailto:christa@midas.uprm.edu)

**SUPPORT STAFF**

**Feliciano, Angel**

Computer Technician  
Puerto Rico Seismic Network  
P.O. Box 9017  
Mayagüez, PR 00680  
Puerto Rico  
Tel: 787-833-8433  
Fax: 787-265-1684  
Email: [angel@midas.uprm.edu](mailto:angel@midas.uprm.edu)



**Irizarry, Dalixza**

Secretary  
Puerto Rico Seismic Network  
P.O. Box 9017  
Mayagüez, PR 00680  
Puerto Rico  
Tel: 787-833-8433  
Fax: 787-265-1684  
Email: [dalixza@midas.uprm.edu](mailto:dalixza@midas.uprm.edu)

**Lucena, Celestino**

Worker  
Puerto Rico Seismic Network  
P.O. Box 9017  
Mayagüez, PR 00680  
Puerto Rico  
Tel: 787-833-8433  
Fax: 787-265-1684  
Email: [c.lucena@midas.uprm.edu](mailto:c.lucena@midas.uprm.edu)

**López, Jeanette**

Administrative Assistant  
Puerto Rico Seismic Network  
PO Box 9017  
Mayagüez, PR 00680  
Puerto Rico  
Tel (W): 787-833-8433  
Tel (H): 787-832-1094  
Cell: 787-249-8515  
Fax: 787-265-1684  
Email: [jeanette@midas.uprm.edu](mailto:jeanette@midas.uprm.edu)

ANNEX V

CERTIFICATE

|   |   |   |  |   |
|---|---|---|--|---|
| THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION OF UNESCO<br>THE PUERTO RICO SEISMIC NETWORK, DEPARTMENT OF GEOLOGY<br>UNIVERSITY OF PUERTO RICO AT MAYAGÜEZ                             |   |   |  |   |
|    |  |  |  |  |
| Herewith certify that   |   |   |  |   |
| Attended and successfully completed the   |   |   |  |   |
| UNESCO/IOC/ICG CARIBE EWS<br>CARIBBEAN TRAINING COURSE FOR OPERATORS OF SEA LEVEL STATIONS<br>Organized by the Puerto Rico Seismic Network<br>Mayagüez, Puerto Rico<br>June 23-27, 2008 |   |   |  |   |
| Dr. Bernie Kilonsky<br>Sea Level Center University of Hawaii<br>GLOSS   |   | Israel Matos<br>Co-Chair<br>ICG-CARIBE EWS, UNESCO                                |  |   |
| Juan Fierro<br>Navy Hydrographic and Oceanographic Services<br>Chile  |   | Christa von Hillebrandt-Andrade<br>Director<br>Puerto Rico Seismic Network        |  |   |

## ANNEX VI

### GROUP PHOTO



## ANNEX VII

### ACRONYMS

|                   |   |
|-------------------|---|
| <b>CARIBE EWS</b> | Caribbean Early Warning Systems   |
| <b>GCOS</b>       | Global Climate Observing System   |
| <b>GLOSS</b>      | Global Sea Level Observing System   |
| <b>GOES</b>       | Geostationary Operational Environmental Satellite   |
| <b>GOOS</b>       | Global Ocean Observing System   |
| <b>ICG</b>        | International Centre for Geohazards   |
| <b>IOC</b>        | Intergovernmental Oceanographic Commission [UNESCO]   |
| <b>IOCARIBE</b>   | Intergovernmental Oceanographic Commission – Sub Commissions for the Caribbean and Adjacent Regions |
| <b>NOAA</b>       | National Oceanic and Atmospheric Administration   |
| <b>PRSN</b>       | Puerto Rico Seismic Network   |
| <b>UNESCO</b>     | United Nations Educational, Scientific and Cultural Organization                                    |

### IOC Training Course Reports

| No. | Title   | Language          |
|-----|---|-------------------|
| 1.  | IOC Indian Ocean Region Training Course in Petroleum Monitoring, Perth, 18 February–1 March 1980  | English           |
| 2.  | IOC Regional Training Course for Marine Science, Technicians Cape Ferguson, Queensland, 1–28 June 1980  | English           |
| 3.  | ROPME-IOC-UNEP Training Workshop on Oceanographic Sampling Analysis, Data handling and Care of Equipment, Doha, Qatar, 3–15 December 1983   | English           |
| 4.  | Stage COI d'initiation à la gestion et au traitement de l'information scientifique et technique pour l'océanologie, Brest, France, 28 novembre–9 décembre 1983                                    | French            |
| 5.  | Curso mixto COI-OMM de formación sobre el Sistema Global Integrado de Servicios Oceánicos (SGISO), Buenos Aires, Argentina, 15–26 de octubre de 1984  | Spanish           |
| 6.  | UNESCO-IOC-NBO Training Course on Tidal Observations and Data Processing, Tianjin, China, 27 August–22 September 1984   | English           |
| 7.  | Stage COI sur la connaissance et la gestion de la zone côtière et du proche plateau continental, Talence, France, 18 septembre–4 octobre 1984   | French            |
| 8.  | IOC Regional Training Course on Marine Living Resources in the Western Indian Ocean, Mombasa, Kenya, 27 August–22 September 1984  | English           |
| 9.  | IOC-UNESCO Summer School on Oceanographic Data, Collection and Management, Erdemli, Icel, Turkey, 21 September–3 October 1987   | English           |
| 10. | IOC-UNESCO Regional Training Workshop on Ocean Engineering and its Interface with Ocean Sciences in the Indian Ocean Region, Madras, India, 17 March–5 April 1986                                 | English           |
| 11. | IOC-UNESCO Training Course on the Use of Microcomputers for Oceanographic Data Management, Bangkok, Thailand, 16 January–3 February 1989  | English           |
| 12. | IOC Advanced Training Course on Continental Shelf Structures Sediments and Mineral Resources, Quezon City, Philippines, 2–13 October 1989   | English           |
| 13. | IOC/IODE Training Course on GF3 Data Formatting System, Obninsk, USSR, 14–24 May 1990   | English           |
| 14. | IOC Training Course on Microcomputers and Management of Marine Data in Oceanographic Data Centres of Spanish-speaking Countries, Bogotá, Colombia, 21–30 October 1991                             | English & Spanish |
| 15. | IOC Advanced Training Course on Nearshore Sedimentation and the Evolution of Coastal Environments, Kuala Lumpur, Malaysia, 17–29 February 1992  | English           |
| 16. | First IOC Training Course on the Applications of Satellite Remote Sensing to Marine Studies, Caracas, Venezuela, 24–28 September 1990   | English           |
| 17. | IOC-KMFRI-RECOSCIX (WIO) Regional Training Course on Microcomputer-based Marine Library Information Management, Mombasa, Kenya, 10–21 August 1992   | English           |
| 18. | ROPME-IOC Regional Training Course on Management of Marine Data and Information on Microcomputers for the ROPME Region, Kuwait, 18–28 October 1992  | English           |
| 19. | IOC-SOA Training Workshop on Environmental Effects on Benthic Communities Xiamen, China, 19–23 October 1992   | English           |
| 20. | IOC Training Course for the Global Sea Level Observing System (GLOSS) directed to the African and South American Portuguese and Spanish-Speaking Countries, São Paulo, Brazil, 1–19 February 1993 | English           |

| No. | Title  | Language          |
|-----|--|-------------------|
| 21. | IOC-SSTC-SOA Training Course on Marine Information Management and ASFA, Tianjin, China, 19–30 October 1992   | English           |
| 22. | First IOC/IOCARIBE-UNEP Training Course on Monitoring and Control of Shoreline Changes in the Caribbean Region, Port-of-Spain, Trinidad and Tobago, 21–30 July 1993  | English & Spanish |
| 23. | IOC/WESTPAC Training Course on Numerical Modelling of the Coastal Ocean Circulation, Matsuyama, Japan, 27 September–1 October 1993   | English           |
| 24. | IOC-JODC Training Course on Oceanographic Data Management, Tokyo, Japan, 28 September–9 October 1992   | English           |
| 25. | IOC-JODC Training Course on Oceanographic Data Management, Tokyo, Japan, 27 September–8 October 1993   | English           |
| 26. | IOC Training Course on Ocean Flux Monitoring in the Indian Ocean. Organized with the support of the Government of Germany, Mombasa, Kenya, 15–27 November 1993   | English           |
| 27. | IOC-UNEP-SPREP Training Course on Coral Reef Monitoring and Assessment, Rarotonga, Cook Islands, 23 February–13 March 1994   | English           |
| 28. | IOC-JODC Training Course on Oceanographic Data Management, Tokyo, Japan, 26 September–7 October 1994   | English           |
| 29. | IOC-UNEP-WHO-FAO Training Course on Qualitative and Quantitative Determination of Algal Toxins, Jena, Germany, 18–28 October 1994  | English           |
| 30. | IOC Training Course on Oceanographic Data Management for Black Sea Countries Obninsk, Russian Federation, 1–12 August 1994   | English           |
| 31. | COI-CEADO Curso Regional de Capacitación en Gestión de Datos e Información Oceanográficos, Buenos Aires, Argentina, 17–28 de octubre de 1994   | Spanish           |
| 32. | IOC-UNEP-FAO Training Course on Nutrient Analysis and Water Quality Monitoring, Zanzibar, Tanzania, 21–26 November 1994  | English           |
| 33. | IOC-IOMAC Advanced Training Course on Marine Geology and Geophysics off Pakistan, Karachi, Pakistan, 12–26 November 1994   | English           |
| 34. | Training Course on Management of Marine Data and Information for the Mediterranean Region, Valletta, Malta, 10–21 April 1995   | English           |
| 35. | IOC-UNEP-WHO-FAO Training Course on Toxin Chemistry and Toxicology related to Harmful Algal Blooms, Trieste, Italy, 3–12 September 1995  | English           |
| 36. | MAST-IOC Advanced Phytoplankton Course on Taxonomy and Systematics Naples, Italy, 24 September–14 October 1995   | English           |
| 37. | IOC-JODC Training Course on Oceanographic Data Management Tokyo, Japan, 16–27 October 1995   | English           |
| 38. | IOC/IODE Training Course on Marine Geological and Geophysical Data Management, Gelendzhik, Russian Federation, 13–29 September 1995  | English           |
| 39. | IOC/GLOSS-GOOS Training Workshop on Sea-Level Data Analysis, Geodetic & Research Branch Survey of India, Dehra Dun, India, 21 November–1 December 1995   | English           |
| 40. | IOC-DANIDA Training Course on the Taxonomy and Biology of Harmful Marine Microalgæ; University of Copenhagen, Denmark, 31 July–11 August 1995; IOC-SAREC-DANIDA Training Course on the Taxonomy and Biology of Harmful Marine Microalgæ; University of Mauritius, Republic of Mauritius, 5–14 February 1996; and Annual Report 1995, IOC Science and Communication Centre on Harmful Algæ, DANIDA, University of Copenhagen, Danish Fisheries Research Institute, Danish National Environmental Research Institute | English           |
| 41. | IOC-Germany Advanced Training Course on Bathymetric Charting in the Western Indian Ocean METEOR, 15–29 December 1995   | English           |

| No. | Title   | Language        |
|-----|---|-----------------|
| 42. | COI-SHOA-CICESE Curso Sobre Modelación Numérica de Tsunamis, Valparaíso, Chile, 11 de Marzo–11 de Mayo de 1996  | Spanish         |
| 43. | Seminario/Taller de la COI/GLOSS-SHN sobre Observación y Análisis del Nivel del Mar para países de habla hispano-portuguesa de Latinoamérica<br>Servicio de Hidrografía Naval (SHN), Buenos Aires, Argentina, 19–27 de noviembre de 1996  | Spanish         |
| 44. | IOC-INCO-ROPME Training Course on Oceanographic Data and Information Management, Tehran, Iran, 19–30 October 1997   | English         |
| 44. | IOC-ICSU-IAEA-EU Training Course on Marine Geological and Geophysical Data Management for the Countries of the Black and Caspian Seas Regions, Gelendzhik, Russian Federation, 8–19 September 1997  | English         |
| 45. | IOC-ICSU-IAEA-EU Training Course on Marine Geological and Geophysical Data Management for the Countries of the Black and Caspian Seas Regions Gelendzhik, Russian Federation, 8–19 September 1997   | English         |
| 46. | Training Course on Management of Marine Data and Information for the IOC/INCWIO Region, Mombasa, Kenya, 1–11 December 1997  | English         |
| 47. | IOC/WESTPAC-SIDA-SAREC-SEAPOL Training Workshop on Operational Data and Information System for the Gulf of Thailand, Bangkok, Thailand, 18–21 November 1997   | English         |
| 48. | SZN-IOC Advanced Phytoplankton Course on Taxonomy and Systematics Vico Equense, Naples, Italy, 10–30 May 1998   | English         |
| 49. | First IOC/WESTPAC Training Course on Monitoring of PSP Plankton and Shellfish Toxicity, Japan, July 1995<br>Second IOC/WESTPAC Training Course on Species Identification of Harmful Microalgæ, Japan, February 1997<br>Third IOC/WESTPAC Training Course on Species Identification of Harmful Microalgæ, Japan, August 1997   | English         |
| 50. | IOC/IODE-NIO Training Course on Oceanographic Data and Information Management, Goa, India, 17–27 October 1998   | English         |
| 51. | IOC/GLOSS-GOOS Training Workshop on Sea-Level Data Analysis, Cape Town, South Africa, 16–27 November 1998   | English         |
| 52. | IOC-UNEP Germany Training Course on Qualitative and Quantitative Determination of Algal Toxins, Jena, Germany, 2–12 March 1999  | English         |
| 53. | <i>Cancelled</i>  |                 |
| 54. | IOC/GLOSS-GOOS Training Workshop on Sea-Level Measurements, Tidal Analysis, GPS and Gravity Measurements, Satellite Altimetry and Numerical Modelling, Sao Paulo, Brazil, 30 August–25 September 1999   | English         |
| 55. | IODE Training on Oceanographic Data and Information Management for the Spanish-Speaking Countries of Central and South America / Curso de Formación del Iode sobre la gestión de datos e información oceanográficos para los países de habla hispana de América Central y del Sur<br>Rio Grande, Brazil, 20–29 September 1999 | English/Spanish |
| 56. | <i>Cancelled</i>  |                 |
| 57. | PERSGA/ALECSO-IOC/GLOSS-GOOS Training Workshop on Sea-level Data Analysis for the Red Sea and Gulf of Aden Region, Jeddah, Kingdom of Saudi Arabia, 15–19 April 2000  | English         |
| 58. | Third IOC/WESTPAC Training Course on NEAR-GOOS Data Management, Tokyo, Japan, 24 January–4 February 2000  | English         |
| 59. | Fourth IOC/WESTPAC Training Course on NEAR-GOOS Data Management; Tokyo, Japan, 27 November–8 December 2000 ( <i>electronic copy only</i> )  | English         |
| 60. | First IOC-Flanders ODINAFRICA Training Course on Marine Data Management, Casablanca, Morocco, 2–13 April 2001 ( <i>electronic copy only</i> )   | English         |



| No. | Title  | Language          |
|-----|--|-------------------|
| 61. | First ODINAFRICA Training Course on Marine Information Management, Cape Town, South Africa, 29 October–9 November 2001<br>( <i>electronic copy only</i> )  | English           |
| 62. | First ODINCARSA Training Course on Marine Data Management, Guayaquil, Ecuador, 20-31 May 2002 ( <i>electronic copy only</i> )  | English           |
| 63. | Remedial Training Course in Marine Data Management for Côte d'Ivoire, Abidjan, Côte d'Ivoire, 21-29 March 2002 ( <i>electronic copy only</i> )   | English           |
| 64. | Second ODINAFRICA-II Training Course in Marine Data Management, Tunis, Tunisia, 29 April–10 May 2002 ( <i>electronic copy only</i> )   | English           |
| 65. | <i>under preparation</i>   |                   |
| 66. | First ODINCARSA Training Course in Marine Information Management, Mazatlan, Mexico, 29 September – 4 October 2002 ( <i>electronic copy only</i> )  | English & Spanish |
| 67. | IODE Training Course in Ocean Data Management for the Caspian and Black Sea Regions, Tehran, I.R. Iran, 20–30 October 2002 ( <i>electronic copy only</i> )   | English           |
| 68. | Fifth IOC/WESTPAC Training Course on NEAR-GOOS Data Management, Tokyo, Japan, 5–16 November 2001 ( <i>electronic copy only</i> )   | English           |
| 69. | ODINAFRICA II Remedial Training Course in Marine Data Management (Data Short Course), Accra, Ghana, 14–18 April 2003 ( <i>electronic copy only</i> )   | English           |
| 70. | Sixth IOC/WESTPAC Training Course on NEAR-GOOS Data Management, Tokyo, Japan, 21 October–1 November 2002 ( <i>electronic copy only</i> )   | English           |
| 71. | Taller de Entrenamiento en Observación y análisis del Nivel del Mar, Valparaíso, 7-17 de abril de 2003<br>( <i>disponible solamente en formato electrónico</i> )                                     | Spanish           |
| 72. | ODINAFRICA II Combined Madagascar Marine Atlas Workshop and Remedial Training Course in Marine Data Management for Comoros, Tulear, Madagascar, 30 June–11 July 2003 ( <i>electronic copy only</i> ) | English           |
| 73. | ODINAFRICA II Training Course in Marine Data Management for Mozambique, Maputo, Mozambique, 11–22 August 2003<br>( <i>electronic copy only</i> )   | English           |
| 74. | Final ODINAFRICA II Training Course in Marine Data Management, Brussels, Belgium, 1–5 September 2003 ( <i>electronic copy only</i> )   | English           |
| 75. | Second ODINCARSA Training Course in Marine Data Management, Cartagena, Colombia, 13–17 October 2003 ( <i>electronic copy only</i> )  | English           |
| 76. | <i>under preparation</i>   |                   |
| 77. | IOC/JCOMM Training Course for the Global Sea Level Observing System (GLOSS) on Sea Level Observation and Analysis, 9–20 February 2004, Kuala Lumpur, Malaysia ( <i>electronic copy only</i> )        | English           |
| 78. | First ODINCINDIO Training Course in Ocean Data Management, 10–21 October 2005, Ostend, Belgium ( <i>electronic copy only</i> )   | English           |
| 79. | First ODINAFRICA-III Training Course in Marine Data Management, , 11–29 April 2005, Ostend, Belgium ( <i>electronic copy only</i> )  | English           |
| 80. | HELCOM/BSRP/ICES and IOC/IODE Training Workshop: Baltic Sea Data Collection— Management, Analysis & Synthesis, 24–28 October 2005, Vilnius, Lithuania ( <i>electronic copy only</i> )                | English           |
| 81. | First ODINCARSA-II Data Management Training Workshop, 7–18 November 2005, Ostend, Belgium ( <i>electronic copy only</i> )  | English           |
| 82. | Second ODINCARSA Training Course in Marine Information Management, 9 November – 19 November 2005, Ostend, Belgium ( <i>electronic copy only</i> )  | English           |
| 83. | Web service development training for ODINAFRICA, 5–9 December 2005, Ostend, Belgium ( <i>electronic copy only</i> )  | English           |
| 84. | ODINAFRICA Training course on development of electronic repositories on marine related publications from Africa, 5–9 December 2005, Ostend, Belgium ( <i>electronic copy only</i> )                  | English           |



| No. | Title   | Language |
|-----|---|----------|
| 85. | Third ODINCARSA-I Marine Data Management Training Workshop, 21–26 November, 2005, Ostend, Belgium ( <i>electronic copy only</i> )   | English  |
| 86. | IODE/GOOS/JCOMM Combined Modelling and Data Management Training Workshop ("Jamboree"), 5–10 September 2005, Ostend, Belgium ( <i>electronic copy only</i> )                 | English  |
| 87. | IOC/JCOMM Training Course for the Global Sea Level Observing System (GLOSS) on Sea Level Observation Analysis, 15–26 May 2006, Tokyo, Japan ( <i>electronic copy only</i> ) | English  |
| 88. | IOC/JCOMM/GLOSS/ODINAFRICA Training Workshop on Sea-Level Measurement and Interpretation, 13–24 November 2006, Ostend, Belgium ( <i>electronic copy only</i> )              | English  |
| 89. | ODINAFRICA Marine Biodiversity Data Mobilization Workshop on Sponges, 4–18 November 2006, Ostend, Belgium ( <i>electronic copy only</i> )                                   | English  |
| 90. | ODINAFRICA Marine Biodiversity Data Mobilisation Workshop on Decapoda, 4–15 June 2007, Ostend, Belgium ( <i>electronic copy only</i> )                                      | English  |
| 91. | IOC/JCOMM/GLOSS/PRSN Caribbean Training Course for Operators of Sea Level Stations, 23–27 June 2008, Mayagüez, Puerto Rico ( <i>electronic copy only</i> )                  | English  |