3.3 Report of the Central America Tsunami Advisory Center (CATAC)

(established at INETER, Nicaragua)

Dr. Wilfried Strauch
CATAC Coordinator, INETER, Managua, Nicaragua
wilfried.strauch@yahoo.com

CATAC

2015 Creation of CATAC accepted by ICG/PTWS, ICG Caribe EWS and IOC Assembly
2019 Completion of CATAC reinforcement project with Japan
2019 ICG/PTWS and ICG/Caribbean EWS accept experimental CATAC operation
2021 ICG/PTWS accepts full operation starting Jan 2022

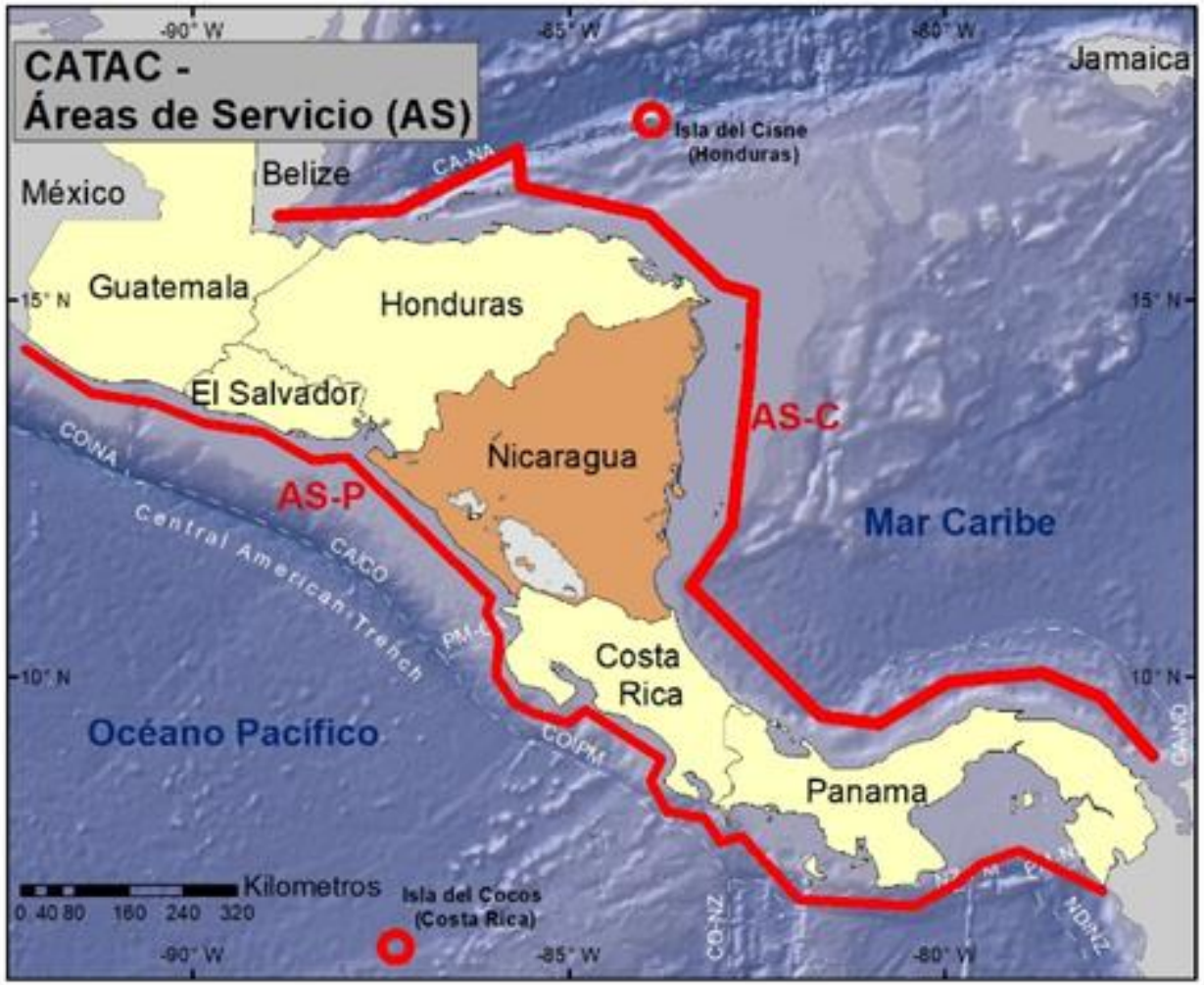
Highlights

- 300 seismic stations in Central America, direct access real time (+ 200 global via IRIS)
- 2 watchstanders 24x7 (group of 16)
- Seismological processing (SeisComP PRO)
- Tsunami Evaluation (Database & SeisComP TOAST real time simulation)
- Initial alert message in 2 minutes after EQ
- Tsunami parameter message in less than 10 minutes after EQ

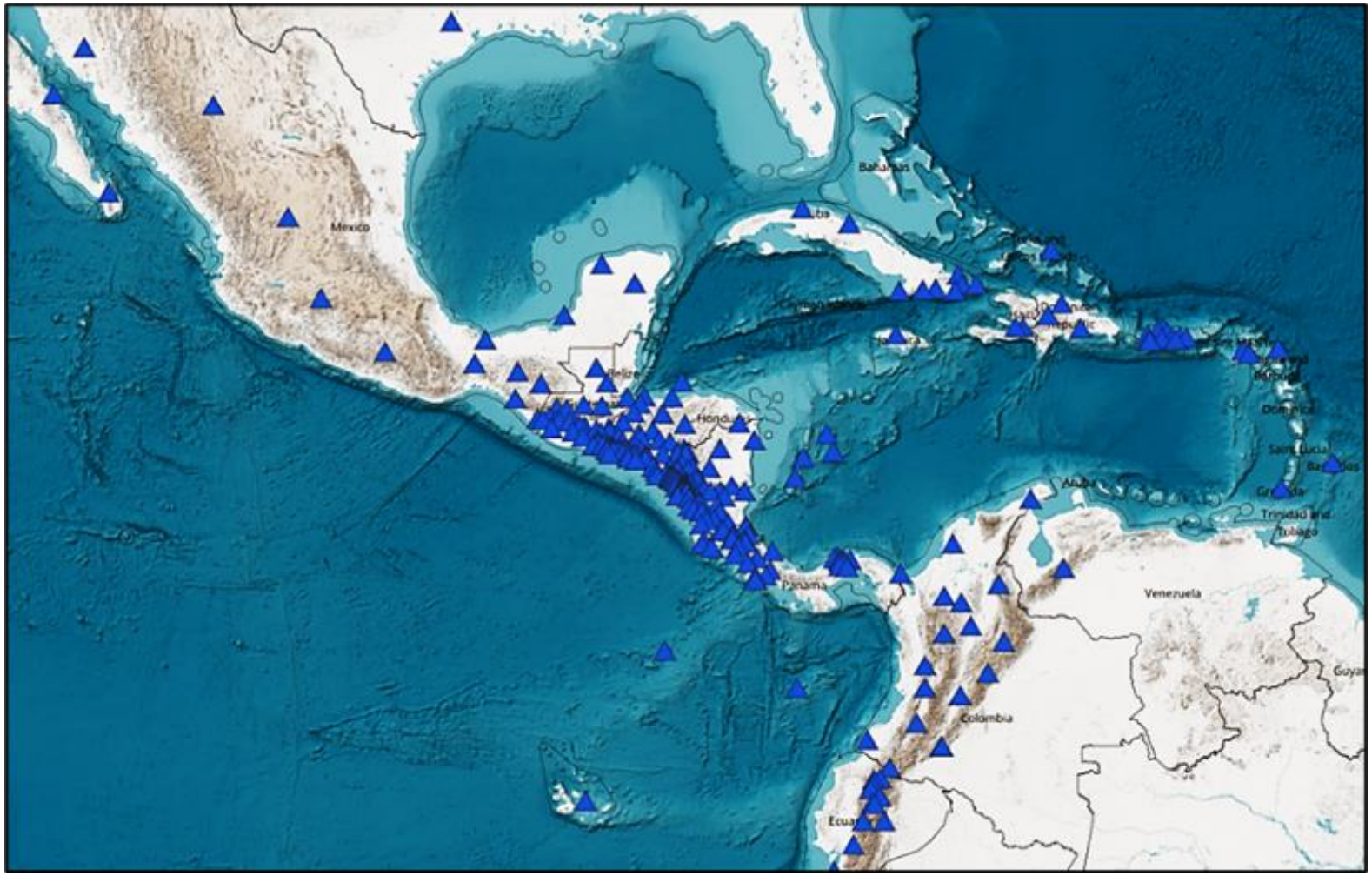
<u>Addressees</u>

- 11 monitoring/scientific institutions in Central America,
- 9 civil protection agencies & 1 regional coordinating body (CEPREDENAC)
- PTWC, NTWC

CATAC service areas and monitoring zones



Location of seismic stations in and around Central American countries used by CATAC, June 2022



Honduras, Panama and Costa Rica should contribute more seismic stations for the optimal functioning of CATAC.

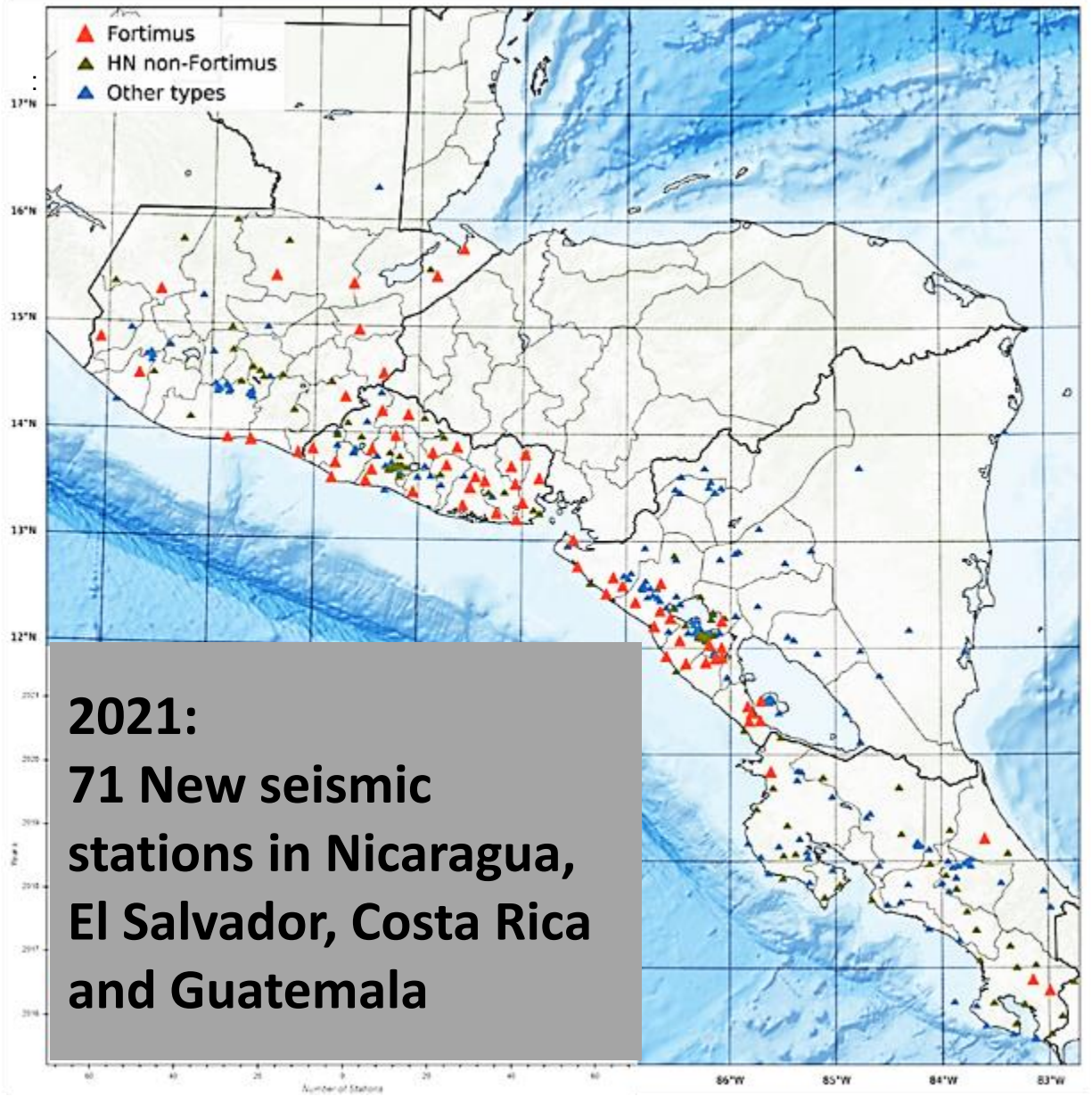
Country		Remarks
Guatemala INSIVUMEH	18	In development
Salvador/MARN	40	
Honduras COPECO	14	Only 3 are in operation (COVID)
Nicaragua INETER	140	
Costa Rica OVSICORI	4	
Costa Rica UCR	22	Only 10 are working (COVID ?)
Panama A Rodriguez	1	
Panama Canal	10	

Expansion of seismic networks for earthquake and tsunami warning in 2021

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service

ETH zürich



2021:
71 New seismic stations in Nicaragua, El Salvador, Costa Rica and Guatemala

New accelerographs digital Fortimus installed, in cooperation with:

- Nicaragua (25)
- El Salvador (25),
- Guatemala (17),
- Costa Rica (4)

- **Reduction of the detection and localization time of earthquakes,**
- Improved quality of results,
- Possibility to calculate very fast Moment Tensor (and magnitude Mw) of strong earthquakes with local stations (not saturated).
- Creation of Shakemaps (Shakemaps)
- Seismic impact recording in major installations

CATAC - Fulfillment of capacity requirements for ICG-TSP*

- ✓ Access to real time data sources and capability to produce standardized seismic/sea level parameters
- ✓ Appropriate historical database of earthquakes and tsunamis
- ✓ Maintain or have access to benchmark, pre-calculated numerical model scenarios
- ✓ Revise advisories in light of additional seismic and sea level data
- ✓ Provide timely and effective tsunami advisories to respective NTWCs/TWFPs – **in CA**
- Provide products in globally standard formats - **Regional Formats in Spanish**
- ✓ Disseminate tsunami forecast information freely and timely to NTWCs/TWFPs on the GTS and Internet and all other possible means of communication – **GTS/English in prep.**
- ✓ Adequate trained and experienced staff, utilities, and resources to operate functionally 24 hours per day, seven days per week (24/7)
- ✓ Adequate infrastructure and back-up facilities to continue operating during power cuts and national emergencies such as all critical equipment on 30-min UPS, generator or alternative power backup (with 1 day of back-up capability), all critical equipment operating in duplicate and all critical communications circuits with backup
- Staff should be able to communicate in English - **Fluency in English for 16 from 19 staff**

***IOC technical series 130 TSUNAMI WATCH OPERATIONS Global Service Definition Document UNESCO 2016**

CATAC - TSP Performance*

No.	Key Performance Indicator	Target Value	CATAC
	Earthquake Detection		
1	Elapsed time of 1st (EQ) Bulletin for TSP Area of Service	10 minutes (when no coordination required between TSPs)	**2 minutes**
2	Probability of Detection of EQ with basin-defined minimum magnitude threshold, in comparison with final estimate from USGS after one month	100%	**100%**
3	Accuracy of EQ parameters In comparison with final estimate from USGS after one month:	Magnitude: 0.3 Depth: 30 km Location: 30 km	**Magnitude: 0.3** **Depth: 30 km** **Location: 20 km**
	Threat Assessment		
4	Elapsed time of Issuing first threat assessment bulletin after EQ	20 minutes (when no coordination required between TSPs)	**10 minutes**
5	Probability of detection of tsunamis above basin specific threat threshold	100%	**100%**
6	Accuracy of tsunami amplitude forecasts	factor of 2	**factor of 2**
**Figures to be verified and adjusted according to basin and nature of threat by each ICG*			

***IOC technical series 130 TSUNAMI WATCH OPERATIONS Global Service Definition Document UNESCO 2016**

TSP Functional Status*

No.	Key Performance Indicator	Target Value	CATAC
1	Operational 24 hours/day, seven days /week (24/7)	99%	**99%**
2	Notify TWFPs and NTWCs of planned major service chanqes	> 3 months	**> 3 months**
3	Notify TWFPs and NTWCs of planned major interruptions	> 3 months	**> 3 months**
4	Return to service after planned Interruptions	< 1 day	**< 1 day**
5	Return to service after unplanned interruptions in an event	<30 mlns	**<30 mlns**

***IOC technical series 130 TSUNAMI WATCH OPERATIONS Global Service Definition Document UNESCO 2016**

Personnel CATAC

#	First and last name	24x7		Function / experience
1	Dr. Wilfried Strauch	-	PhD	CATAC Coordinator
2	MSc Emilio Talavera	X	MSc	Director Seismology/CATAC
3	Virginia Tenorio	-		Director of the Central Monitoring Station, seismology, tsunami, volcanic seismology
4	Miguel Flores	X		Computer science, digital systems, Seismology, Tsunami
5	Eng. Norwin Acosta	-		Tsunami Modeling, GIS
6	MSc Greyving Argüello	X	MSc	Seismology, Geophysics, Tsunami
7	MSc Amilcar Cabrera	X	MSc	Seismology, Mathematics, Tsunami
8	MSc Petronila Flores	X	MSc	Seismology, Geology, Tsunami,
9	MSc Martha Herrera	X	MSc	Seismology, Electronics, Tsunami, Digital Communication, Seismometry
10	MSc Domingo J. Ñamendi	X	MSc	Seismology, Electronics, Tsunami, Digital Communication, Seismometry
11	MSc Ulbert Grillo	X	MSc	Seismology, Tsunami, Electronics, Digital Communication, Seismometry
12	Fernando García	X		Seismology, Tsunami, Electronics, Digital Communication, Seismometry
13	Jaqueline Sanchez	X		Seismology, Tsunami, Computer Science
14	Juan Carlos Guzmán	X		Seismology, Tsunami, Computer Science
15	Tec. Allan Morales	X		Seismometry, Tsunami, Electronics
16	Tec. Antonio Acosta	X		Seismometry, Tsunami, Electronics
17	Ana Rodriguez	X		Seismology, Tsunami, GIS
18	Milton Espinoza	X		Seismology, Tsunami, GIS
19	Wesly Rodríguez	X		Geophysics, Seismology, Tsunami

CATAC appreciates the Central American scientific cooperation

Institutions responsible for scientific monitoring which cooperate or which provide seismic data to CATAC

1) **Nicaragua INETER, CATAC/Dirección de Sismología**

For Nicaragua, CATAC acts as NTWC issuing messages to the Government of Nicaragua, the Emergency Operations Center (CODE) of the National System for Disaster Prevention, Mitigation and Response (SINAPRED) and Civil Defense of the Nicaraguan Army according to the national SOPs of Nicaragua. It is intended that, starting in 2022, INETER will directly send Earthquake and Tsunami messages to the population.

2) **El Salvador Ministry of Environment and Natural Resources (MARN),**

General Directorate of the Environmental Observatory (MARN-DGOA**)**

(3) **Guatemala National Institute of Seismology, Volcanology, Meteorology and Hydrology (INSIVUMEH)**

4) **Honduras Permanent Contingency Commission (COPECO).**
COPECO has a scientific section and maintains the seismic network of the country.
UNAH University cooperates and has some stations.

(5) **Costa Rica** **a) Tsunami Monitoring Room of the National University (SINAMOT)**
b) OVSICORI-sesimic network
c) UCR-seismic network

6) **Panama** **a) Panama Canal,** seismic network

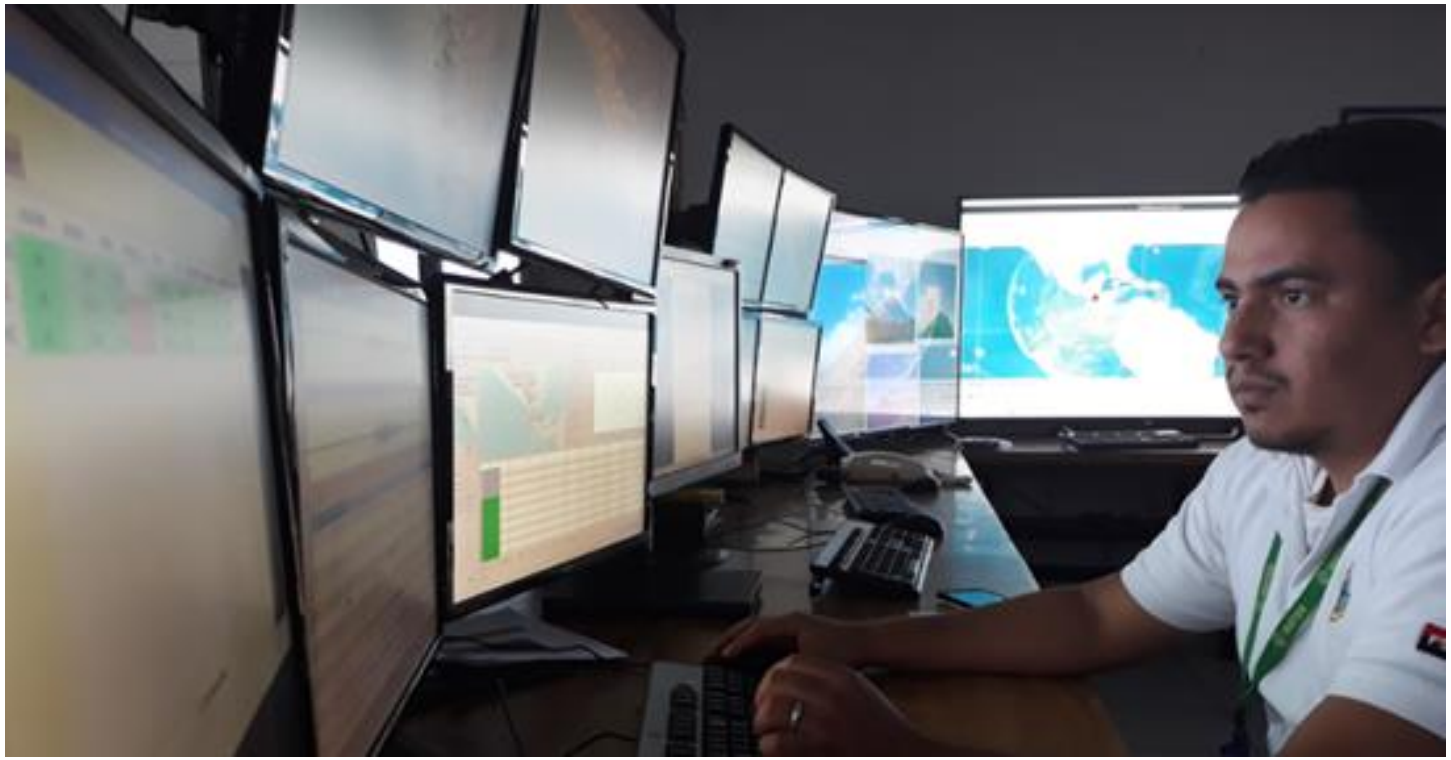
b) Institute of Geosciences of the University of Panama (IGC-UPA), sseismic network

c) Ángel Rodríguez, broad band seismic station

CATAC, Processing and Alert Room

CATAC, Situation and meeting room

Watchstanders



The seismologists of the 24x7 service review the automatic results and perform manual processing. They must publish the initial seismological products within 2 minutes after the earthquake occurs. The tsunami assessment based to be published in less than 10 minutes after the earthquake.

Main Systems for CATAC operations

- **SeisComP** (GFZ, GEMPA – Germany)
  - Automatic seismic processing
  - Interactive seismic processing
  - Calculation of the Momentum Tensor from which the Magnitude Mw is derived
  - Sending seismological and tsunami messages (on seismological basis)

- **Tsunami database** with pre-calculated solutions

- **TOAST**
  - Numerical tsunami simulation
  - Sending of simulation product messages, arrival times and amplitudes
  - Processing of tide gauge records

TsunamiGenic Potential adopted by CATAC

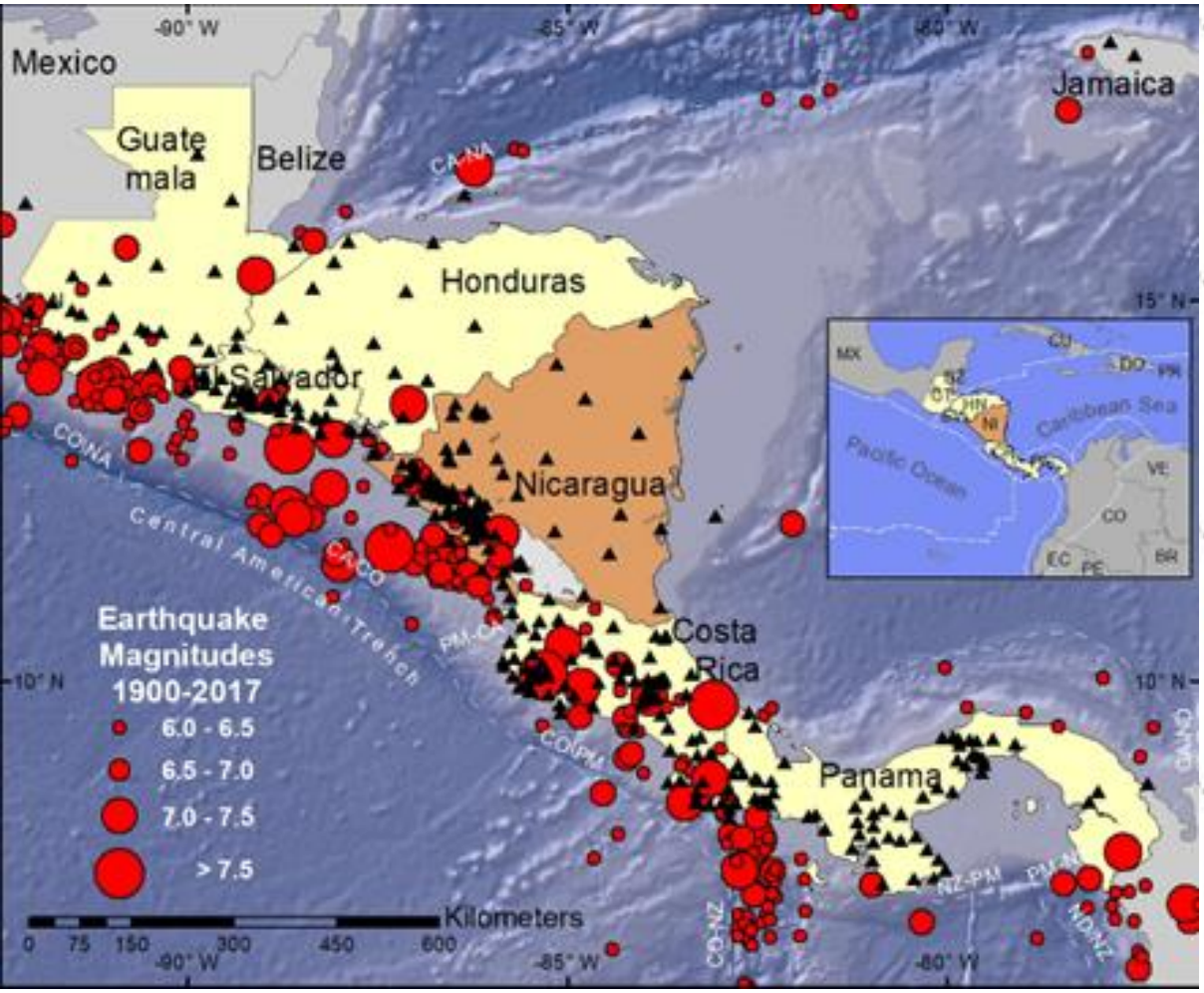
based on seismological parameters

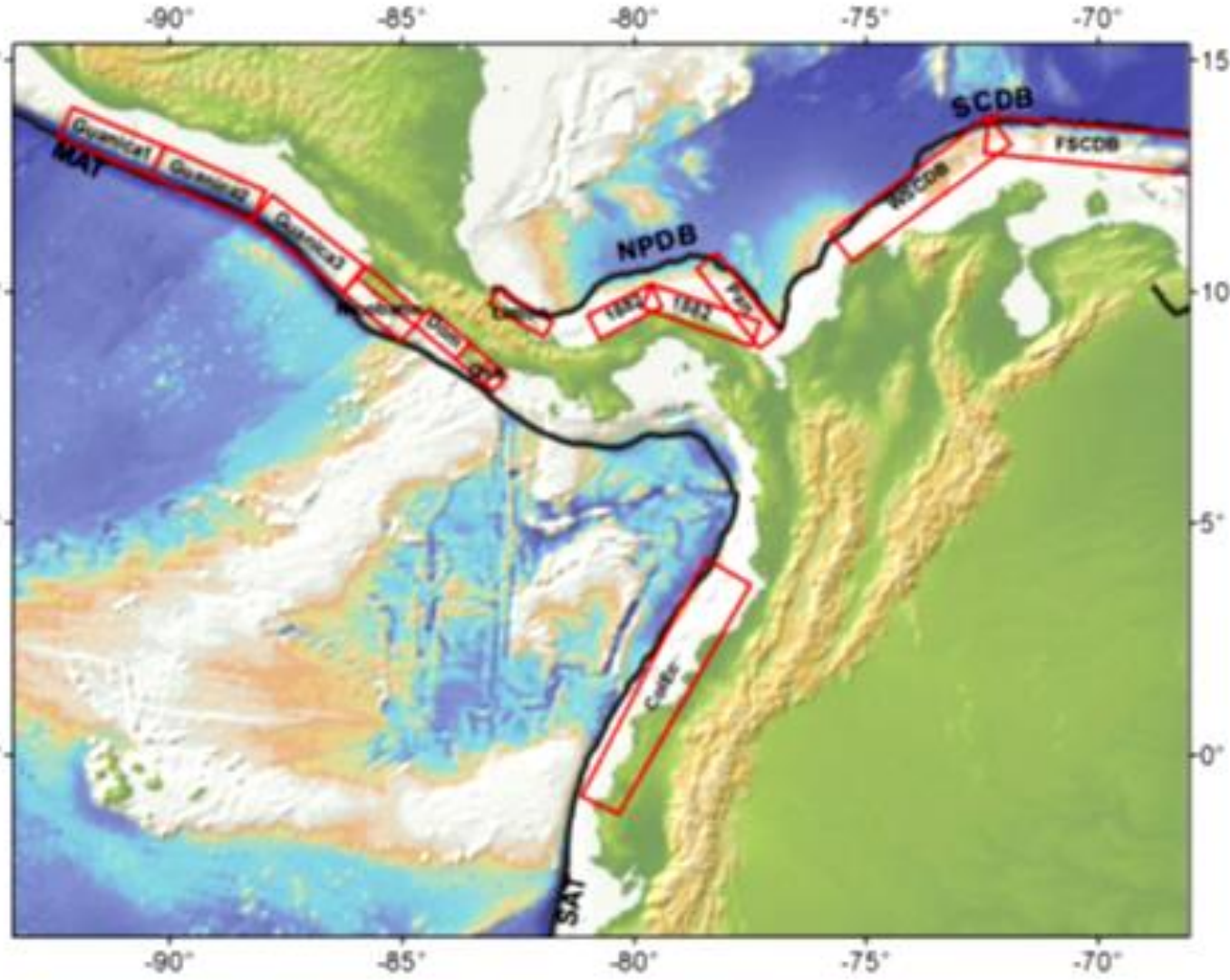
Magnitude (Mw)	Tsunami Potential Description
$4.5 \leq M_w \leq 7.0$	There is no tsunami threat from this earthquake.
$7.1 \leq M_w \leq 7.5$ **and under the sea;** **and depth less than 100km**	Possibility of a destructive local tsunami confined to distances of 100-300 km from the epicenter.
$M \geq 7.6_w$ **and under the sea;** **and depth less than 100km**	Possibility of a destructive tsunami all along the coast

Criteria adopted by CATAC

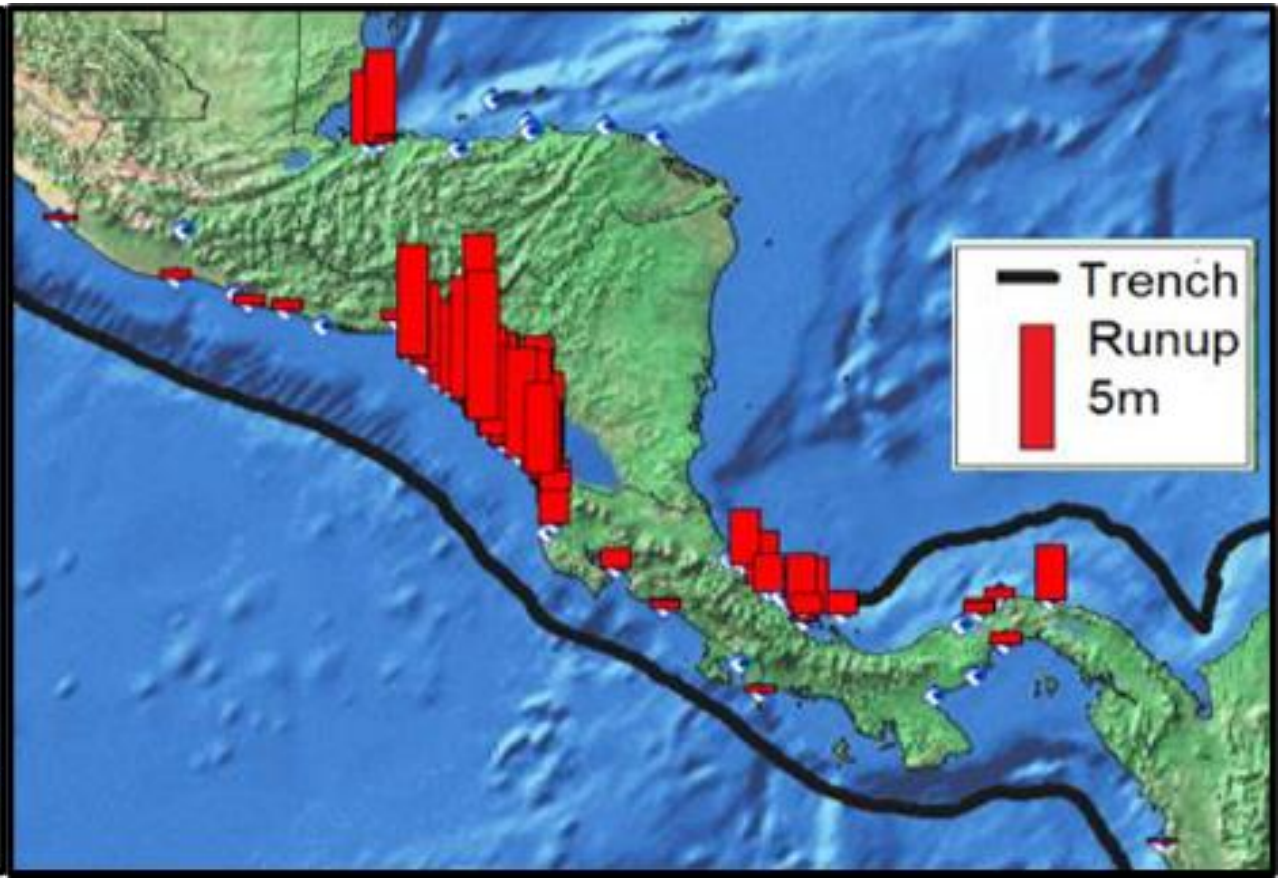
Type of Newsletter	Message	Criteria	Content	Time
Seismological information	Early Warning Earthquake Early Warning	**ML 4.5** and above	Location, depth and magnitude Predicted intensities	Less than 0.5 min
	Seismological message	**ML 4.5** and above	Location, depth and magnitude, Observed intensities	1-2 min
Tsunami Information	Only one bulletin	**ML 6.0-6.4**; or underground; o depth≥100km	Earthquake parameters and declaration No tsunami hazard	1-2 min
	Only one bulletin if no minor reportable waves observed	**MW 6.5-6.9**	Earthquake parameters (Magnitude Mw) and 'No Tsunami Hazard' statement	5-10 min
Tsunami Hazard Message	Bulletin with quantitative prediction	**Mw 7.0 and above**	Earthquake parameters and quantitative prediction of hazard level and estimated time of arrival (ETA).	5-10 min
	Supplementary with comments	Complex earthquakes, Mega earthquake, Tsunamis for which amplitudes are predicted to increase after several hours.	Earthquake parameters, quantitative prediction and tide gauge observations	When there is a revision of the earthquake or tsunami prediction, or of observations

CATAC - Seismic catalogues and tsunami source descriptions





Historical tsunami data base



CATAC progress in the pilot phase of operations from 2019 to 2021.

An experimental introductory and familiarization period of about 2 years duration, 2019-2021, was conducted. During this time, only seismological messages were routinely sent. Tsunami advisory was conducted in a less formal manner via social media communications with alert recipients in the region immediately after the earthquake. In the experimental phase, CATAC achieved the following advances:

The 24x7 shift staff was doubled, employing 2 people per shift. Staff was trained, especially the 8 new people on the shift that INETER additionally assigned for the 24x7 service.

The accuracy and speed of earthquake and tsunami processing in general was improved.
Experience was gained with the processing of strong earthquakes that occurred in the region: 5 earthquakes with magnitudes greater than M=7; 8 earthquakes with magnitudes between 6.5 and 7, and a large number of earthquakes with M less than 6.5.

Areas have been identified where local tsunamis can impact in less than 10 minutes after the earthquake or tsunami generation. Thus, CATAC was dedicated to accelerate the processing of earthquakes and tsunamis. To reduce the processing time and improve the reliability of the products, a series of concrete measures were taken:

The seismic networks in Nicaragua, El Salvador, and Guatemala were greatly densified through the EWARNICA project with Switzerland, while improving the accuracy of earthquake locations. With the CATAC earthquake early warning methods, CATAC obtains a first location and magnitude of the earthquakes occurring in Central America within a few seconds after the start of the event and also accelerated the calculations of the Moment Tensor and the Mw magnitude.

CATAC finalized the **development of the tsunami database**, which yields tsunami parameters within a few seconds after establishing earthquake parameters.

Moment Tensor calculation was optimized (with the SCAUTOMT and SCMTV modules of SeisComP), allowing the use of data from **accelerographic stations** that are not saturated by strong shaking near the epicenter. Results - **in less than 10 minutes** the focal parameters of the earthquake and the Mw magnitude, which accelerates the tsunami simulation in real time and the generation of tsunami products.

CATAC optimized the configuration of the TOAST module for tsunami simulation in its SeisComP system.

CATAC also worked to improve the rapid dissemination of products in Nicaragua and the other Central American countries. It cooperated with various foreign (especially Switzerland, Japan, Central American countries) and national to develop and introduce in practice methods for mass dissemination of earthquake and tsunami warning messages. In Nicaragua, the **dissemination of messages via digital television has already started**. Through the EWARNICA project, CATAC also promoted the application of this method in other countries of the region in the coming years.

In Nicaragua, 40 additional sirens were installed in communities along the Caribbean coast. Together with the 60 sirens already in place since 2015 Nicaragua now has a total of 100 of these devices for tsunami warning and other emergencies. Thus, the vast majority of the entire population under tsunami danger can receive CATAC warnings by this means. **The installation of sirens has also begun in the other Central American countries**.

CATAC has also worked on the development of other methods for sending messages to the population through social networks, smart phone applications and direct communication between computers. An **experimental phone application** developed by CATAC allows the user located in a community on the Pacific coast to know the status of the tsunami warning and evacuation routes.

- **CATAC established its website catac.ineter.gob.ni** and continues to develop it. This site provides information on earthquakes and tsunamis for the target audience of CATAC products as well as for the general public.
- **CATAC in cooperation with ETHZ/Switzerland developed the Shakemaps website** (http://shakemapcam.ethz.ch/) of strong earthquakes recorded by CATAC that shows the impact of earthquakes which is important when assessing the situation of the coastal population after an event.
- As CATAC can be temporarily affected by adverse circumstances and lose its ability to work partially or completely, a closer **cooperation with MARN/El Salvador is developing with the objective of having MARN act as a backup for CATAC.**
- CATAC with other seismological institutions in Central America is preparing the **new KUK-AHPAN project together with Spanish Universities.** The project aims to investigate in the coming years the seismic hazard and crustal structure in northern Central America. Particular studies were proposed that will have beneficial results in the medium term for the tsunami warning theme, for example: a regional model of seismic velocities, improvement of the seismic monitoring of Honduras.
- **CATAC is preparing the use of GPS/GNSS in the process of seismological monitoring and characterization of large earthquakes.** In 2021, Nicaragua established real-time transmission of high frequency data sampling from 25 GPS/GNSS stations to CATAC, retransmitted these data to UNAVCO and is working to implement software that allows the data to be used routinely.

CATAC is aiming to guarantee its sustainability and impact:

- Documentation was elaborated to facilitate integration of CATAC and the earthquake warning system at the adequate level in INETER´s institutional structure to ensure sustainability according to the proposals of the joint project with JICA.
- Including requests to government of Nicaragua, Sinapred and CEPREDENAC to promote CATAC´s integration into the SICA system as a regional early warning agency.
- Adressing the CA countries, to share through the relevant scientific institutions, among themselves and with CATAC data in sufficient quality and quantity for the rapid processing of earthquakes and tsunamis from seismic, accelerographic, tide gauges and GNSS stations.
- Adressing the scientific institutions relevant to seismology and tsunami in CA increase their level of cooperation and integration to take optimal advantage of all capabilities.
- Adressing the civil protection agencies of the CA countries to take advantage of the new forms of alert dissemination to make alerts based on CATAC´s advisory quickly to the population at risk.
- That joint seismology studies be conducted to improve seismic wave velocity and attenuation models within the frame of regional and international projects

The ICG/PTWS 29 (Dec 2021) decided to admit the start of CATAC's full functionality on the interim service as of January 17, 2022, for the Pacific coasts of Central America.

ICG/Caribe EWS is asked to admit CATAC´s full operation for the Caribbean coasts of Central America.

Thank you!