エルサルバドル国
環境監視総局（DGOA）

エルサルバドル国
地震・津波情報の分析能力強化

専門家業務完了報告書

2023 年 4 月

独立行政法人
国際協力機構（JICA）

一般財団法人　気象業務支援センター

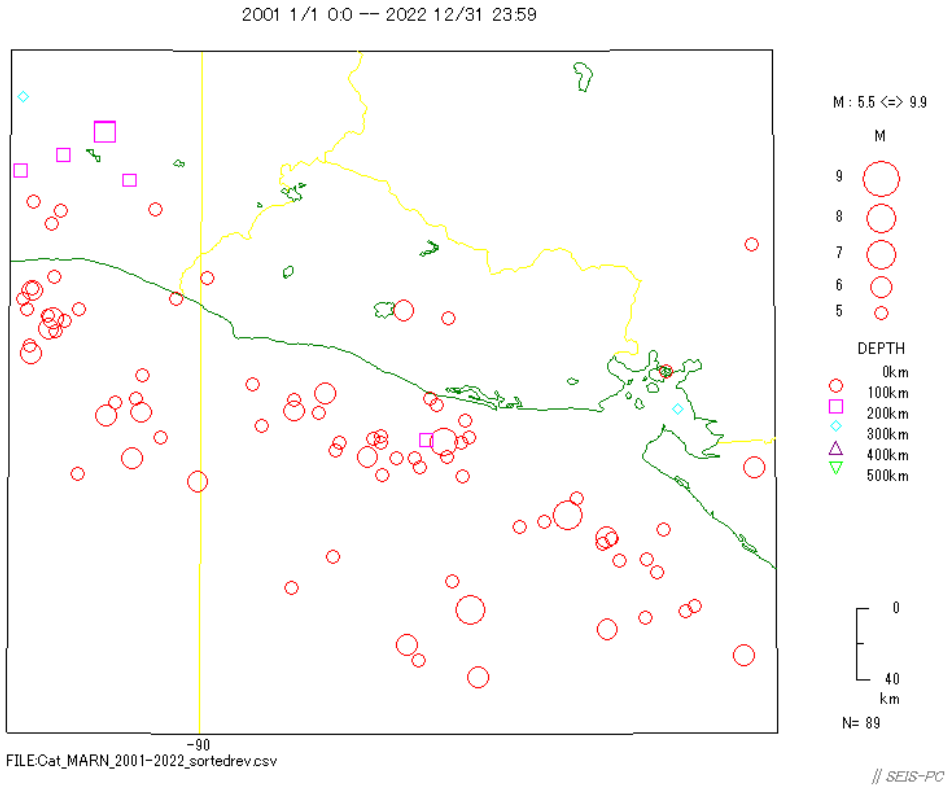
環境
JR
23-053

目　　次

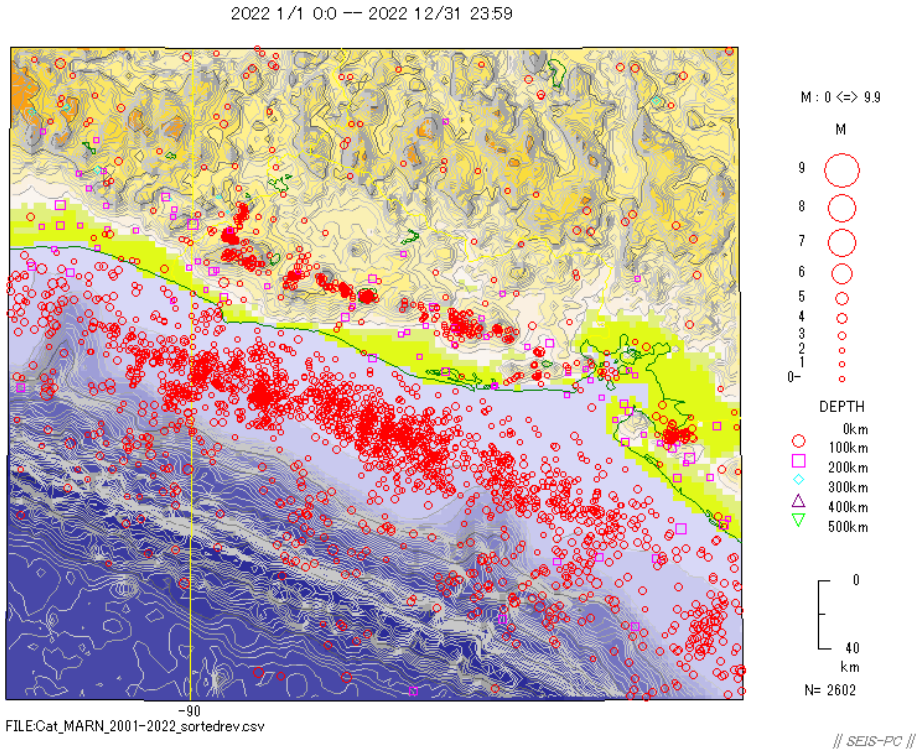
略語集

略語	正式名称	和訳
MARN	Ministerio de Medio Ambiente y Recursos Naturales	環境天然資源省
DGOA	Dirección General del Observatorio Ambiental	環境監視総局
C/P	Counterpart	カウンターパート
DGPC	Dirección General de Protección Civil	総務省市民防災局
CATAC	Centro de Asesoramiento de Tsunamis para América Central	中米津波警報センター
JICA	Japan International Cooperation Agency	独立行政法人国際協力機構
JMBSC	Japan Meteorological Business Support Center	一般財団法人気象業務支援センター
CMT	Centroid Moment Tensor	セントロイド・モーメント・テンソル
GUI	Graphical User Interface	グラフィカルユーザインターフェース
UTC	Coordinated Universal Time	協定世界時

エルサルバドルの地図・地形図（地震発生状況も併せて示した）

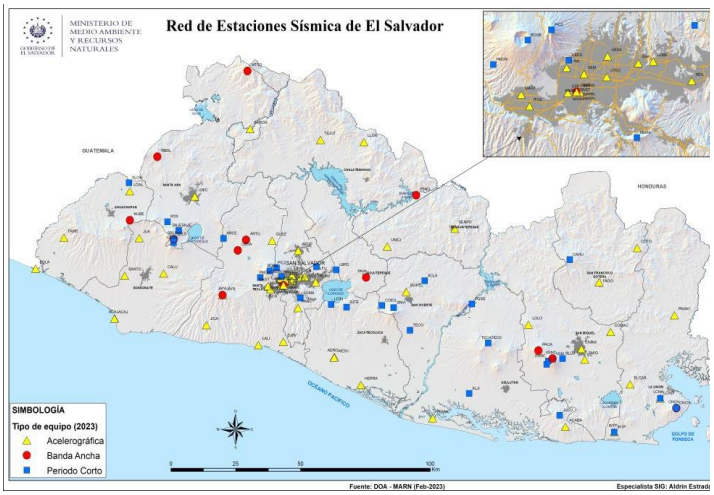


2001 年～2022 年の 22 年間に MARN が観測した「エルサルバドル及び周辺域に発生したマグニチュード 5.5 以上の地震」の震源分布図（赤丸が震源; SeisPC 利用）



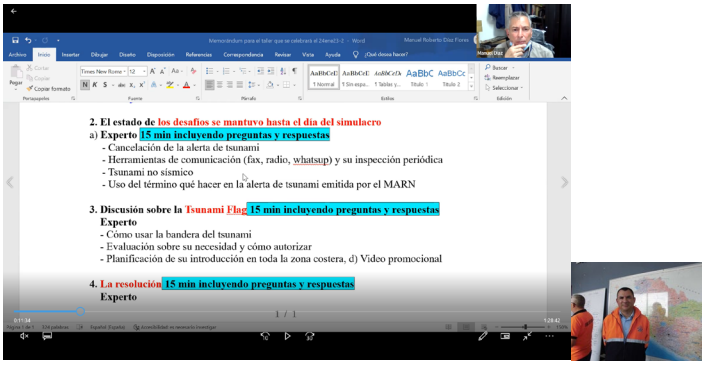
2022 年 1 年間に MARN が観測した「エルサルバドル及び周辺域で発生した地震」の震源分布図（赤丸が震源; SeisPC 利用）

口絵（参考図・写真）



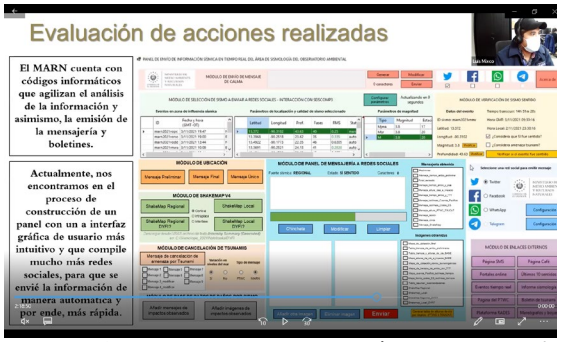
MARN 地震観測網（MARN ガイドブック 2023 から抜粋）

2022 年 7 月 14 日ウスルタン沿岸地域で
左：サイレン運用担当警察官への聞取り調査（MARN 撮影・提供）
右：聞取り調査時に MARN ガイドブック 2017 の提供（筆者撮影）



左：2023 年 1 月 24 日の DGPC 共催遠隔ワークショップでのスナップショット（筆者撮影）
右：2022 年 7 月 1 日防災監視責任者（DGPC監視室；「DGPC局長説明」時。筆者撮影）

2022 年 7 月 19 日ヒキリスコ湾調査（MARN 撮影・提供）



2022 年 1 月 25 日の DGPC 共催遠隔ワークショップでのスナップショット（筆者撮影）

2023 年 3 月 21 日（日本時間）環境監視総局長への活動結果遠隔報告会スナップショット（筆者撮影）

1. 業務の概要

1.1　案件概要

（1）業務名称　地震・津波情報の分析能力強化

（2）対象国名　エルサルバドル国

（3）履行期間　2021 年 4 月 5 日から 2023 年 4 月 28 日まで

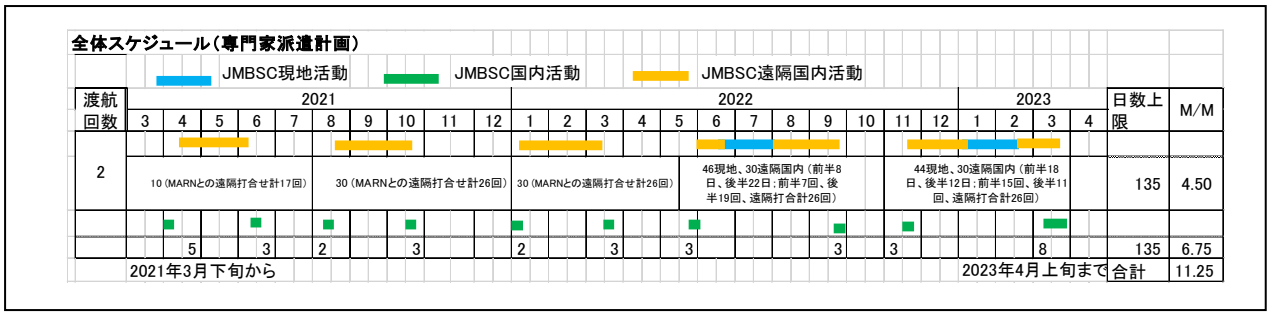


図 1-1 全体スケジュール（専門家従事計画）

1.2　業務の背景と経緯

エルサルバドルは、地理的条件から地震・津波が多発する国の一つであり、1859 年から 2017 年までに 23 回の津波を観測している。特に、2012 年にウスルタン沖でマグニチュード 7.3 の地震が発生した際には、2 メートルの津波がヒキリスコ湾に到達し、100 人を超える負傷者[1]、及び多大な経済的被害をもたらした。当国では 29 都市が太平洋に面しており、常に津波の脅威にさらされている。

当国においては、環境天然資源省（以下、MARN）の環境監視総局(以下、DGOA)が地震観測・津波監視業務、総務省市民防災局（以下、DGPC）が災害警報発令業務を担っており、DGOA では、全国 96 箇所[2]の地震観測施設、及び 3 箇所の津波観測施設を用いたリアルタイムによる地震・津波観測を行っている。

上述の過去の災害を受け、2015 年 10 月から 2018 年 2 月まで、地震・津波観測の能力強化を目的として DGOA に日本人専門家「地震・津波情報の分析能力強化」（以下、フェーズ 1）が派遣された。この協力により、CMT（セントロイド・モーメント・テンソル）解析の導入、津波情報発信の判断基準の改善、津波高や到達予測時刻の分析能力の改善、また、津波警報発令に関するプロトコルを改善するなどの成果が達成された。

本専門家派遣は、これら成果の強化、及び DGOA による地震・津波監視の信頼性と迅速性の向上を目的として要請され、引き続き同国の地震・津波の監視及び警報発令の能力向上に資することが期待されていた。

なお、本案件には中米地域で実施した防災分野における技術協力プロジェクトの成果の活用が下に示すように期待されていた。

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[1] 地震の揺れは激しくなかったものの、6 メートルにも達する津波が、ヒキリスコ湾の太平洋側に面するサン・フアン・デル・ゴソ半島に襲来した（Borrero et al.（2014）による）。また、住民が極めて少ない地域であったにもかかわらず、（死者はでなかったものの）少なくとも 40 名を負傷 させたとの聞き取り情報もある。

[2] MARN ガイドブック 2017 での数字。MARN ガイドブック 2023 によると 103 箇所。

（1）ニカラグア国「中米津波警報センター能力強化プロジェクト」(2016-2019)では、中米地域の津波警報体制の強化を目的として、中米津波警報センター（以下、CATAC）の津波警報発出に係る能力強化を行っており、同センターから発信される津波情報がエルサルバドルにおいて適切に活用されることが期待される。

（2）中米六ヵ国「中米広域防災能力向上プロジェクトフェーズ 2」（2015-2020）では、DGPC をカウンターパート機関とし、中央政府及びコミュニティレベルにおける減災と災害対応のための総合的能力強化が行われた。

加えて、本案件では、地方自治体との連携を考慮した警報発令プロトコルの強化について DGOA 及び DGPC との連携が期待されていた。

1.3 業務の目的

本業務従事者は、MARN の DGOA をカウンターパート（以下、「C/P」）機関とし、地震・津波監視及び警報発令業務の実施能力の向上を目的とし、期待された成果は第 1.4 節に示す４つであった（業務内容の詳細は、第２節に示す）。

1.4 期待される成果

成果１：フェーズ 1 で導入・提案した内容が適切に実践される。

成果２:CATAC から発出される津波情報が DGOA の津波予測システムに適切に反映され、両者間の情報共有が促進される。

成果３：DGOA が DGPC と共有する津波予警報のためのガイドライン・プロトコルが改善される。

成果４：地震・津波監視システムの高度化に資する技術が紹介され、システムの高度化に向けた今度の指針が定まる。

なお、本業務の実施に当たり、新型コロナウイルスの流行状況や先方政府側の対応に応じて、オンラインを活用するなど柔軟な対応を検討しつつ、現地渡航時期に関しては JICA 地球環境部と協議の上決定するとされており、当初の現地活動の計画は、適宜、国内遠隔活動に振り替えて実施された（打合簿にて変更措置）。

1.5 関係官庁・機関

- 環境天然資源省/環境監視総局（MARN/DGOA）
- 総務省市民防災局（DGPC）

1.6 業務期間

2021 年 4 月 5 日　から
2023 年 4 月 28 日　まで

2. 活動内容・活動実績

2.1 活動方法

図 2-1-1 に示す方法を用いて活動を行った。なお、当初遠隔実施は難しいと考えられていた方法のうち、「警報利用地域住民との意見交換」を除いて、図 2-1-1 に示す方法は全て遠隔で実施可能であった。

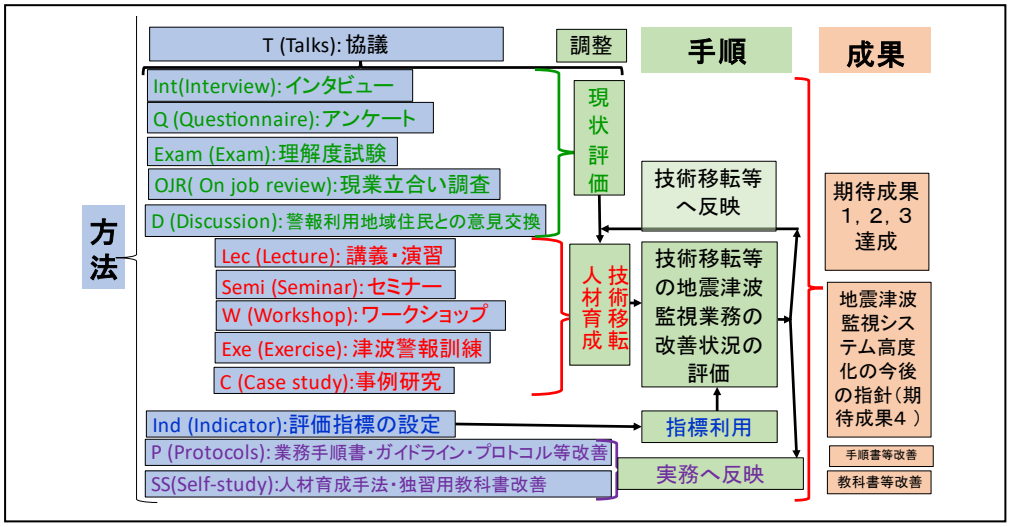


図 2-1-1 活動方法

また、活動に必要であった次の事項について、JICA 事務所の支援を得た。

A) 現地活動での便宜供与関係として、移動・宿泊手段確保、安全確保用携帯電話確保、英・西通訳雇用、冊子印刷（成果物の一つである「MARN ガイドブック 2023」）

B) 事業用物品調達（詳細「第 3.4 節 機材調達」参照）

一方、現地での活動及び遠隔での活動は次のやり方で実施した。

a) 現地活動では、仕事場は MARN が準備。MARN の勤務時間に従って勤務。海岸での調査には MARN の移動手段を利用。地方調査における警察への安全確保要請は MARN が実施。CATAC、DGPC 等外部機関との遠隔会合の手段は MARN が準備。

b) 国内遠隔活動では、遠隔会合の手段は専門家が準備。

2.2 作業手順

図 2-2-1、図 2-2-2 に示すように、5 回の活動は、遠隔活動 3 回、遠隔活動と現地活動を組合せたハイブリッド活動 2 回を実施した。

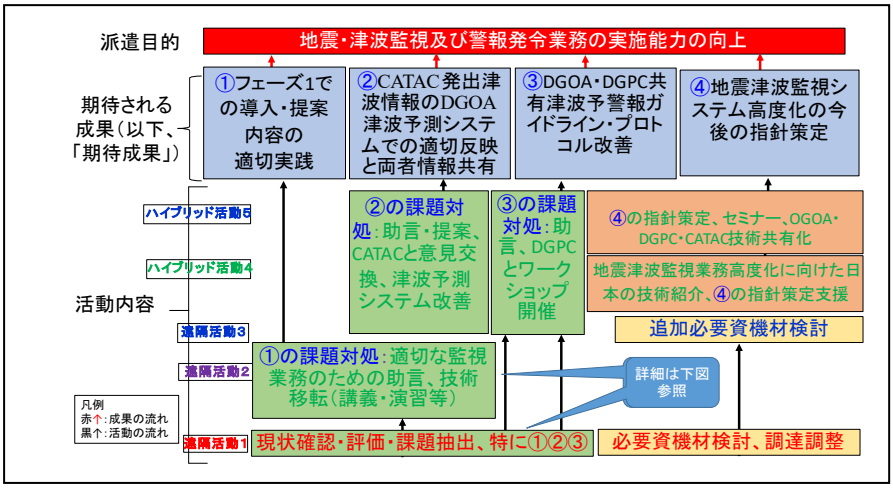


図 2-2-1 期待成果及び活動内容

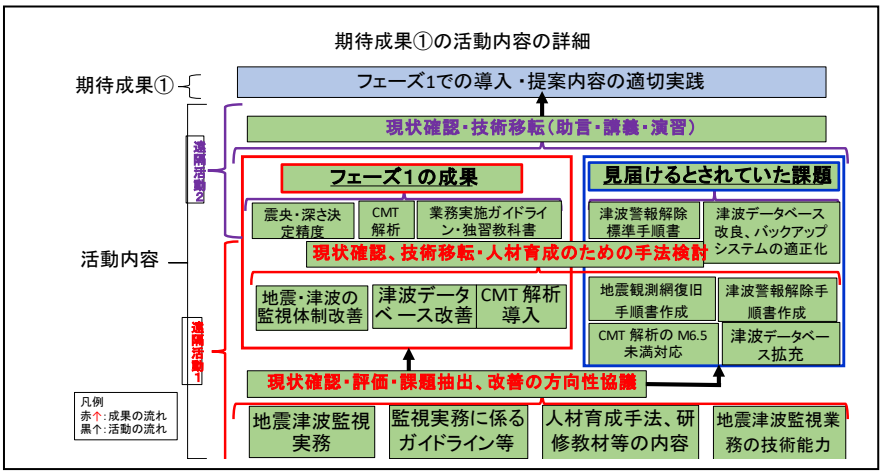


図 2-2-2 活動内容の詳細

2.3 MARN/DGOA の関係職員

添付資料 1 に本プロジェクト関係職員及びプロジェクトへの直接の協力者を示した。なお、添付資料 1 の表に示す肩書の MARN/DGOA における位置づけは、添付資料 2 の組織図に示した。

2.4 活動経過

5 回の活動内容及びそれによる目標到達度は、図 2-4-1 にある各業務結果の報告書に整理した。なお、第五次業務における現地業務結果は、第五次業務結果報告書に含めた。

報告書名	作成日
国内遠隔業務結果報告書（和文）エルサルバドル	26Jun21
第二次国内遠隔業務結果報告書（和文）エルサルバドル	26Oct21
第三次国内遠隔業務結果報告書（和文）エルサルバドル	14Mar22
第四次業務における現地業務結果報告書（和文）エルサルバドル	26Jul22
第四次業務結果報告書（和文）エルサルバドル	23Sep22
第五次業務結果報告書（和文）エルサルバドル	22Mar23

図 2-4-1 業務結果報告書　一覧

3. 業務の達成状況

3.1 達成概要

「第 1.4 節 期待される成果」に示した成果 1～4 について、次のように目標を達成した。

（第五次業務結果報告書から再掲。用語など一部修正。）

(1) フェーズ1で導入・提案した内容が適切に実践されていることの確認。→事例研究、MARN内遠隔セミナー、遠隔演習、現業立ち合い調査などの実施により、実践されていることを確認したか、そうでない場合、必要な措置をとり改善を図った。
(2) CATACから発出される津波情報がDGOAの津波予測システムに適切に反映され、両者間の情報共有が促進される。→CATACとの遠隔会合2回及び遠隔セミナー実施により、情報共有の促進を図った。
(3) DGOAがDGPCと共有する津波予警報のためのガイドライン・プロトコルが改善される。→DGPC局長との面談、DGPCとの合同津波警報訓練2回、訓練評価のためのDGPCとの共催ワークショップ2回、警報利用地域住民との意見交換（沿岸地域調査2箇所、ウスルタンでの「2012年津波記念式典」遠隔参加）により、ガイドライン（津波監視手引書）の改善を図った。
(4) 地震・津波監視システムの高度化に資する技術が紹介され、システムの高度化に向けた今後の指針が定まる。→MARN内遠隔セミナーの実施及び定例会議での議論などを通じて今後の指針を定めた。

3.2 具体的活動

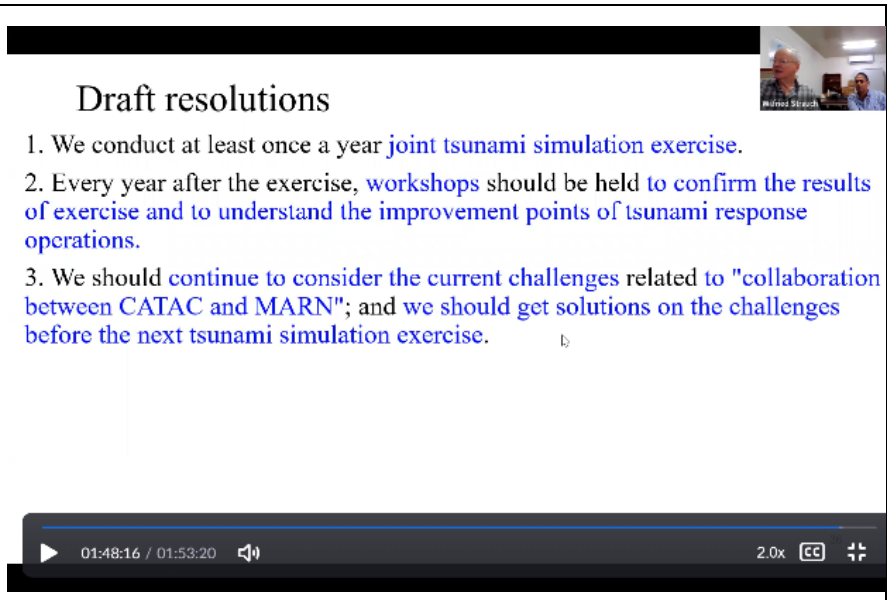
活動は、「第 2.1 節 活動方法」によったが、「セミナー」としては部内のものと CATAC と合同のもの（図 3-2-2 セミナー参照）をともに遠隔で実施、「ワークショップ」としては DGPC と共催で実施、「警報利用地域住民との意見交換」としては、沿岸地域 2 箇所の実地調査（図 3-2-1 活動写真参照：JICA 事務所提供）や津波被害を受けたサン・フアン・デル・ゴソ半島での「2012 年津波記念式典」遠隔参加という方法である。

これらの方法で、期待される成果に向けて、①「フェーズ 1 の成果」の確認と改善、②MARN/DGOA と技術移転・研修計画を策定、③CATAC から発出される津波情報を MARN/DGOA の地震・津波監視システムに反映させるなど、両者間の情報共有の促進、④MARN/DGOA と DGPC とで共有する津波予警報のための作業手順の改善、⑤津波地震監視システムの高度化に資する技術の紹介と、その高度化に向けた今後の指針の策定に取組んだ。

沿岸地域のライフセーバーとの意見交換

2012 年津波被害があったサン・フアン・デル・ゴソ半島の地域住民との意見交換

図 3-2-1 活動写真



CATAC との遠隔での意見交換（Zoom レコードのスナップ写真）

図 3-2-2 セミナー

3.3 具体的成果

上述の活動によって、表 3-3-2 に示す具体的成果を得た。これらは図 3-3-1 に示した要素で整理してある。即ち、地震・津波監視システムでは、地震津波の情報は、電力・インターネット等社会基盤で支えられつつ、「監視→分析→情報発表→情報の防災利用→社会基盤」と流れていくことから、これら 5 要素それぞれについて、成果を整理した。また、成果の詳細は、要素毎に、表 3-3-1 に示す「技術移転・研修計画」の文書及び「地震・津波監視業務の高度化に向けた今後の指針」に整理した。

表 3-3-1 技術移転・研修計画

Document name		Date of preparation
Plan on the technology transfer & the training about	Category 1	09Mar23
	Category 2	09Mar23
	Category 3	09Mar23
	Element 5(b) (Category 4 & 5)	22Mar23
	Element 3(c) (Category 6)	19Mar23
	Element 1(d) (Category 7)	22Mar23
Guideline for introduction of the additional technologies in monitoring tsunamis and earthquakes		20Mar23

表 3-3-2 要素と成果

要素	成果
監視	監視職員の自習体制整備、自習素材作成、津波訓練の効果的な実施体制整備などにより監視職員の能力維持・強化促進基盤が整備された。
分析	自動 CMT 解析（図 3-3-3）の対象領域の限定化により早期の解析結果取得、津波作業手順書作成、調査用 CMT 解析ソフト導入、遅れて襲来する津波の到着予想手法導入（図 3-3-2）などを通じて、「大地震時のマグニチュードを高精度で解析し、なおかつ早期（15 分～20 分）に発表が可能」としたこと や、監視作業の安定化が図られた。
情報発表	津波警戒情報発表早期化、新伝達手段導入、DGPC との調整（津波解除の統一、津波訓練・評価会合）、津波データベース改善、GUI 利用による地震情報（ニュースレター形式）発表自動化（図 3-3-4、図 3-3-5）などを通じて、地震発生から津波警報発表までに要する時間を 5 分～10 分で発表可能化（図 3-3-6）、津波到着時刻・高さの推定発表の早期化が図られた。
情報の防災利用	一般向け地震津波情報利用の手引きとしての MARN ガイドブックの更新、津波警報で用いる用語の調整、津波フラッグ導入などを通じて、MARN 発表情報の DGPC や一般住民の適切な利用の促進が図られた。
社会基盤	データ収集システムの回復、地震・津波監視システムサーバーのバックアップ強化、津波シミュレーション専用機導入などを通じて、地震・津波監視システムバックアップ体制全体の強化が図られた

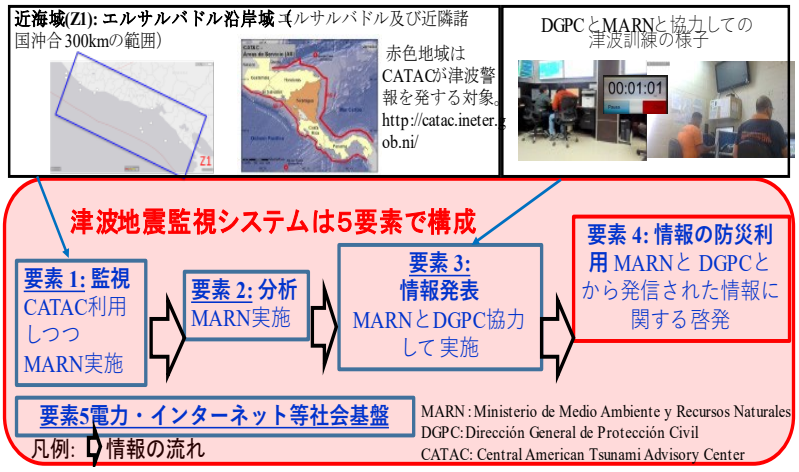


図 3-3-1 津波地震監視システム

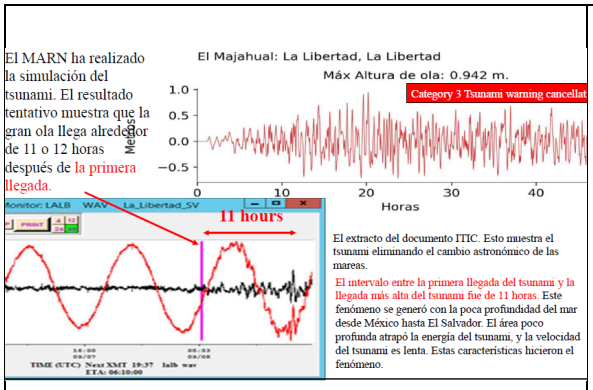


図 3-3-2 遅れて襲来する津波の到着予想手法関連

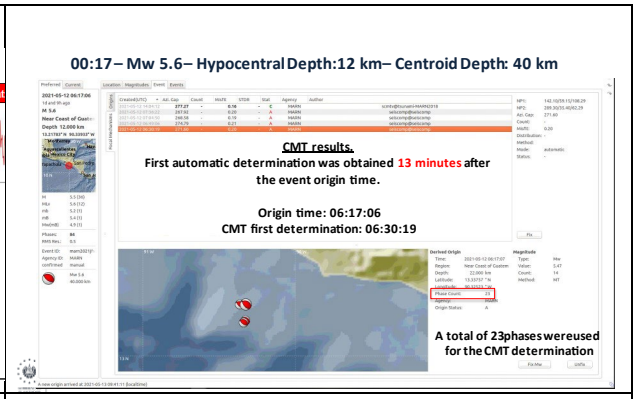


図 3-3-3 CMT 解析図

図 3-3-4 自動化アプリにより SNS 上に発信された地震・津波ニュースレター

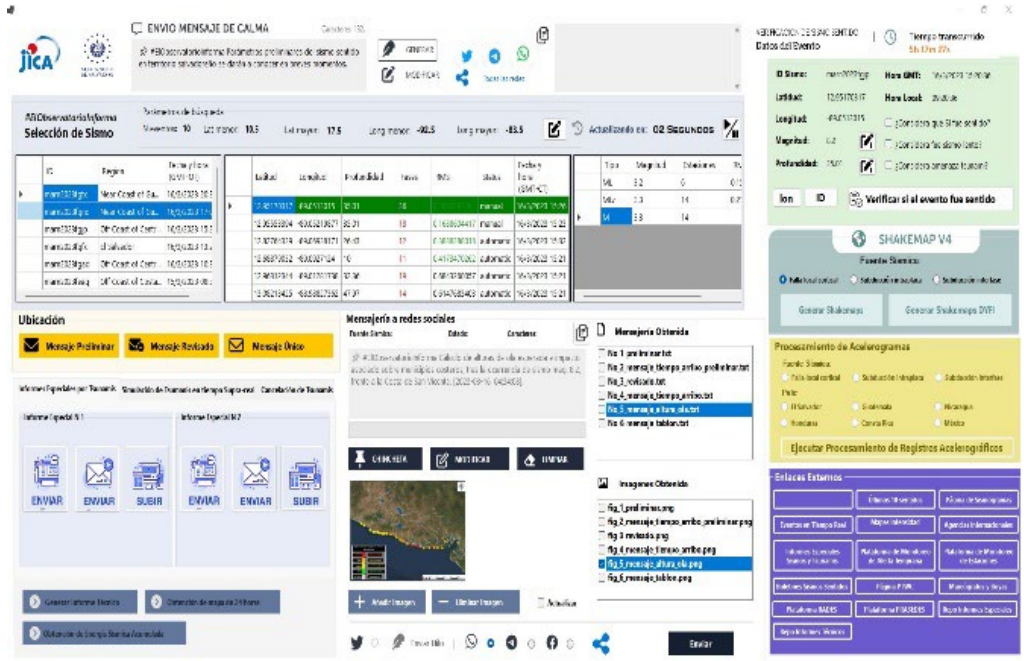
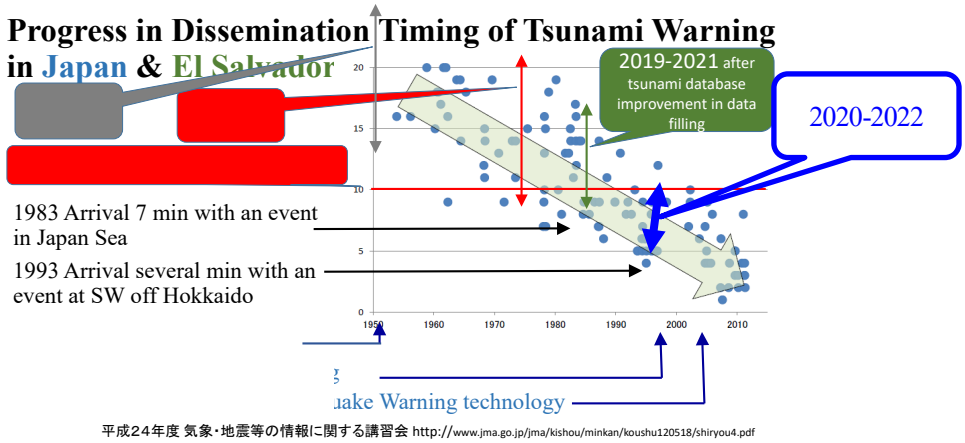


図 3-3-5 地震・津波予警報の自動化アプリ（GUI）



Progress of improvement in issuance timing of the messages related to tsunami warning in El Salvador through comparing with the progress of that in Japan during recent 60 years.

図 3-3-6 地震発生から津波警報発表までに要する時間の短縮化

具体的な成果物は**表** 3-3-3 に示す。

表 3-3-3 成果物

成果物	資料名称	ファイル形式	作成日
津波監視手引書	Guideline for how to proceed with the Tsunami Monitoring	WORD	24Mar23
自主研修体制	Self-training System	WORD	05Mar23
自主研修素材	How to handle CMT	PPT	16Mar23
	How to use initial motion focal mechanism	PPT	15Mar23
既存地震カタログ一覧	existing catalogue	Excel	10Feb23
MARNガイドブック 200部印刷(便宜供与)	Cm-Guia de sismos y tsunamis-actuali zacion-2023	WORD	01Mar23

図 3-3-6 サイレン管理者へ MARN ガイドブック 2017 年版の提供

図 3-3-7MARN ガイドブック 2023 年版

3.4 機材調達

仕様書で想定されていた資機材は次のものであった。

・地震観測所用デジタルラジオ（2 台 1 セット） / ・地震観測所サーバー（1 台）

そして、プロジェクト開始時で要請された資機材は、上記のものも含めて表 3-4-1 のものであった。地震観測所用デジタルラジオは Digital radios （無線通信機）と Dish antennas（アンテナ）、地震観測所

サーバーは Workstation とそれぞれ表現してある。

表 3-4-1 機材調達

MARN-Procurement as of 18Sep22 EQUIPMENT DESCRIPTION	COMMENTS/JUSTIFICATION	QUANTITY
Digital radios: Brand: Ubiquiti. / Model: AirFiber 5XHD / Range: Greater than 100Km Frequency 5Ghz / 802.11 security protocol	To strengthen the operation rate of the seismic network through the improvement of transmission lines using digital technology. To be used at the three locations: One of the sets of antennas, which is the below "link c", use "34dBi gain" due to the long distance between the locations that use the radio communications. a) SanJose - Jayaque (Codes: SNJE-JAYA, latter has a repeater.) -> (changed to) Tecapa volcano towards Cerro Las Pavas. - pending installation. -> (changed to) Link: Cerro Loma Larga - Marn (Installation date: end of August). b) Las Nubes - Lomas de Alarcon (Codes:NUBE-LOAL, latter has a repeater.) -> (changed to) Cerro Pacayal towards Tecapa volcano - pending installation.-> (changed to) Link: Cerro Tecapa - Cerro Pacayal (Installation date: end of September). c) Centro de Gobierno (repeater point) - Marn. Through this link, information comes from the Pacayal station (Code: PACA.) or "CEL government center towards MARN". Already in operation.	**6**
Ubiquite brand dish antenna, model AF-5G23-S45, frequency 5Ghz, 23dBi gain, range greater than 15km, include hardware for installation.		**4**
Dish antenna Ubiquiti brand, RocketDish 5G34 model, 5Ghz frequency, 34dBi gain, range greater than 15km, include hardware for installation.		**2**
Workstation: Workstation Model: Precision 7920 Tower Chassis CL. Processor: Intel Xeon Silver 4210R (2.4GHz, 3.2GHz Turbo,10C, 9.6GT/s 2UPI, 13.75MB Cache, HT (100W)) DDR4-2400. Operating System Windows 10 Pro for Workstations (6 Cores Plus) Multi - English, French, Spanish. Memory: 64GB 4x16GB DDR4 2933MHz RDIMM ECC Memory. Graphics Card: NVIDIA® Quadro® P1000, 4GB, 4 mDP (7X20T). Hard / Drive: M.2 1TB PCIe NVMe Class 40 Solid State Drive. Keyboard: Dell Black Wired 10 Key Numeric Keypad KB813 Smart Card Keyboard. Mouse: Dell USB Laser 6-Button Mouse. Monitor: Dell 27 Monitor - P2722H.	1. To run specialized seismological and tsunami monitoring software. 2. More focused on tsunami simulations in real time	**1**
Laptops: screen display size 13.3 Inches, max Screen Resolution 1920 x 1080 Pixels Processor 1.6 GHz i5 / RAM 8 GB SDRAM / Hard Drive 256 GB ssd Wireless Type 802.11ac	To be used in the field in the configuration and maintenance of the seismic network.	**2**
ISOLA (MatLab software & specific toolboxes) Perpetual Standard License Individual: it is allowed to install the software on 4 PCs but there can only be one user, who will have unique credentials, with which they can access the software and others tools.	To get 1) Display of moment rate function to understand the actual seismic magnitude earlier 2) Flexible calculation of GFDB and handling in-depth analysis related to the determination of the CMT Note 1 Its calculations are not in real time. Note 2 OSOP CMT doesn't have the above functions but can work in real time. Note 3 Both can handle initial motion (polarity) analysis for grasping focal mechanisms by entering polarities.	**1**

プロジェクト開始後、表 3-4-2 の資機材が追加で調達要請が MARN からあり、本プロジェクトでの目標達成に資することから、これらについて、調達手続きを行った。加えて、専門家（森）から、津波フラッグの利用を提案し、MARN の了解を得て、これも調達した。しかし、表の上から 2 番目と 3 番目の Platform 開発及び GPS 高度化は、コストの課題が解決できず調達を見送った。また、Textbook 6 冊のうち 3 冊は、在庫なし（1 冊）か配送途中での喪失（2 冊）で調達を断念した。

その後、津波監視に利用しているサーバーの不具合の発生で、バックアップ体制の強化が必要と認識され、MARN から表 3-4-2 の下表のハードドライブ（HD）の調達要請があり、バックアップ体制整備の小目標達成の観点から追加調達を実施した。

以上のことから、最終的に調達されたものは表 3-4-3 に示すもの及び津波フラッグ 5 本となった。そして、いずれも、JICA 事務所長から MARN 大臣への譲渡手続きを終えた（現地時間）：

津波フラッグ 5 本：2022 年 11 月 22 日の津波警報訓練実施前

Hard Drives を除くその他物品：2023 年 2 月 23 日

Hard Drives：2023 年 3 月末（注：サーバーへの設置・調整は、同サーバーの停止が必要なことから、作業手順と作業日程は十分検討してから、実施することにしている。）

表 3-4-2 追加資機材

MARN-Procurement additional items as of 18Sep22 EQUIPMENT DESCRIPTION	QUANTITY
GUI messages application (procurement of local engineer)	**1**
Seismic Station network maintenance platform (procurement of local engineer)	**1**
To telemeter the GPS of "Topcon NET-G3A (Reference station GNSS Receiver)" to get real time data from the stations	**2**
Workstation for GPS data	**1**
Tsunami flag	**5**
Textbook	**6**

	Servers	Datos disco	Quantity to be procured
1	SC-4 (2019)	Disco 10K SAS DS 1.2TB 872737. Servidor HP ProLiant DL380 Gen10	1
2	SC-4-EEW (2018)	Disco 512GB SATA 6GB SSD. Servidor Dell, ST:4ZN9XQ2	1
3	SC-3 (2017)	Disco 7.2K SAS 1TB 765872. Servidor HP ProLiant DL360 Gen9	1
4	Shakemap (2022)	Discos 480 GB SATA 6gb SSD. Servidor DeLL EMC R440	1
5	Earthworm (2022)	Disco 1.92 TB SATA 6Gb SSD. Servidor DELL EMC R740xd	1
6		Discos 480 GB SATA 6gb SSD. Servidor DeLL EMC R440	1

また、成果物の一つである MARN ガイドブック 2023 (200 部) も 2023 年 3 月末に譲渡された。

表 3-4-3 最終機材調達

物品名称 (Name of Property)	規格・品番 (Standard, Part Number)	個数 (Quanti
Ubiquiti airFiber radio portatil (digital radio)	AF-5XHD	
Ubiquiti airFiber antena (dish antenna)	X AF-5G23-S45	
Ubiquiti RocketDish (dish antenna)	RD-5G34	
UPS 120V	BX800L-LM	
Workstation	Precision 7920 Tower Chassis CL. Intel Xeon Silver 4210R (2.4GHz, 3.2GHz, Turbo,10C, 9.6GT/s 2UPI, 13.75MB Cache, HT (100W)) DDR4-2400. OS Windows 10 Pro for Workstations (6 Cores Plus) Multi - English, French, Spanish. Memory: 64GB 4x16GB DDR4 2933MHz RDIMM ECC Memory. Graphics Card: NVIDIA® Quadro® P1000, 4GB, 4 mDP (7X20T). Hard / Drive: M.2 1TB PCIe NVMe Class 40 Solid State Drive. Keyboard: Dell Black Wired 10 Key Numeric Keypad KB813 Smart Card Keyboard. Mouse: Dell USB Laser 6-Button Mouse. Monitor: Dell 27 Monitor - P2722H.	
Laptop Dell 3420 + estuche tipo mochila + mouse inalambrico	DELL 3420Latitud	
Antivirus ESET NOD32		
Microsoft Office Home & Business 2021, perpetua		
ISOLA (MatLab software & specific toolboxes)	Perpetual Standard License Individual: it is allowed to install the software on 4 PCs but there can only be one user, who will have unique credentials, with which they can access the software and others tools.	
UPS 120V		
Workstation for GPS	ProcessorIntel® Xeon® Silver 4210R (13.75 MB cache, 10 cores, 20 threads, 2.40 GHz to 3.20 GHz Turbo, 100 W) / OS Windows 11 Pro for Workstations (6 cores plus), English, French, Spanish / Chassis Options Precision 7920 Tower Chassis (BC_PCIe) CL FMX / Graphics CardNVIDIA® RTX A2000, 12 GB GDDR6, 4 mDP to DP adapters Memoryi48 GB, 6 x 8 GB, DDR4, 2933 MHz, ECC / Thermal CoolingSingle Processor Air Heatpipe / Operating System (Boot) DriveIntel NVMe PCIe SSD (Front PCIe FlexBay) / Storage Drive ControllersIntel Integrated controller (RST-e) with 1-2 Front FlexBay NVMe Drives Hard Drive 2 TB, M.2, PCIe NVMe, SSD, Class 40 / Storage Volume Boot drive or boot volume is greater than 2 TB (select when 3TB/4TB HDD is ordered) / KeyboardDell KB216 Wired Keyboard English Black / MouseMouse included with Keyboard / Power CordsUS Power Cord OptimizerDell Optimizer for Precision with AI / Warrantyi3 Years ProSupport with Next Business Day Onsite Service / Save an extra 5% on monitorsDell 24 Monitor – E2422H	
Textbooks	Foundations of Modern Global Seismology	
	The Seismicity of Central America: A Descriptive Catalogue 1898-1995	
	Introduction to Seismology	
Hard Drives	Disco 10K SAS DS 1.2TB 872737. Servidor HP ProLiant DL380 Gen10	
	Disco 512GB SATA 6GB SSD. Servidor Dell, ST:4ZN9XQ2	
	Disco 7.2K SAS 1TB 765872. Servidor HP ProLiant DL360 Gen9	
	Discos 480 GB SATA 6gb SSD. Servidor DeLL EMC R440	
	Disco 1.92 TB SATA 6Gb SSD. Servidor DELL EMC R740xd	
	Disco 2.4 TB SAS 12Gb 10k. Servidor DELL EMC R740xd	

以下には、譲渡した資機材の一部の写真を示した。

図 3-4-1 MARN 本部に設置した無線通信機とアンテナ（赤矢印がアンテナ。その裏側に無線通信機がある）ゴビエルモ中継通信所に設置したものと交信。

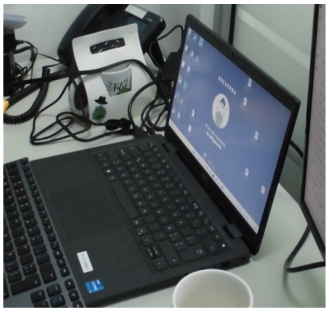


図 3-4-2 ラップトップ PC
（調達したプログラム 2 種類を搭載）

図 3-4-3 ISOLA ソフト

図 3-4-4 津波フラッグを利用した避難訓練
（ラ・リベルタ沿岸地域；MARN 提供ビデオからのスナップ写真）

4. プロジェクト実施中に遭遇した課題とそれへの対処

プロジェクト実施中の 2022 年 1 月 15 日 UTC に、トンガの火山噴火により、エルサルバドルにも津波が襲来した（アカフトラで 26cm も津波を観測）。このため、火山噴火による津波への対応が新たな課題となった。そして、日本の気象庁や太平洋津波警報センターの対応状況を勘案して、エルサルバドル用の対応策を考案・提案し、「要素 3 の技術移転・研修計画」及び「津波監視手引書」にそれを追記した。

5. 本プロジェクト終了後も MARN の対応が要請される事項

「本プロジェクト終了後も MARN の対応が要請される事項」について、１）第 3.3 節の分類別「技術移転・研修計画」及び「地震・津波監視業務の高度化に向けた今後の指針」に示した小目標毎に表 5-1 に、２）各成果物に記述した事項は、表 5-2 に整理した。

表 5-1 目標とした成果及び小目標

目標とした成果及び小目標	結果（2023年3月28日現在） 本プロジェクト終了後もMARNの対応が要請される事項
要素 2/a:観測、分析、及び監視システム	
分類1: 地震津波監視	
1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	GUIの導入などで手順の改善・簡素化と合わせて、十分な頻度の津波訓練の実施。
1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	津波データベースの改善について、暫定的に採用することとした考えにおいて、次の事柄は実行可能な時期に速やかに対応することとする：1）データベース内の未対応のデータについて、宇津2001のスケーリング則で再計算、2）データベースの解像度が十分でないため、予想された中から県域で最も高い津波波高推定値を発信。
1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立	緊急作業手順を簡便に復習する道具として、ピラミッド形状ものを検討してきた。しかし、緊急作業手順の自動化や高度化の変化が大きいことから、必要に応じて監視担当官が自らこの種の道具を発案することが要請される。
1-2-f-4 異常地震活動対応標準手順：確立	2022 年 7 月 15 日の午前 2 時 41 分にエルサルバドル西部のアフアチャパンで発生した M4.4 イベントに対して取られた対応の結果に基づいて、内陸域での異常地震活動対応の標準作業では次のことを促進することとする：a) MT図使用、b) Calm 情報使用 / c) エルサルバドル沿岸域（Z1）での把握可能Mの下限値説明 / d) ベルリンと首都圏が特別扱いされる理由説明。
分類2: CMT及びMw監視	
4-4-a 地震波初動解析による発震機構把握	初動解析の使用方法に関する自習素材が作成された。これを利用しつつ、OSOP と ISOLA にある機能を使用して発震機構を把握するための実務における手順を準備する。
分類3:津波対応	
1-2-d 津波警報解除手順書：作成	この問題については以下の事情があるため、MARN の解除情報を使用するよう、引き続き DGPC と話し合う必要がある: a) DGPC は MARN情報 に加えて PTWC情報 を使用、b)「解除」という用語は、DGPC が提供する文書「Procedimiento Operativo ante Tsunami-SOP´s Nacional-DGPC Formato autorizado」のみに示されているが、「解除」を判断するための情報源が示されていない。
1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	遅れて襲来する大きな津波の速度として、48km/hを設定したが、これはMARN内において、暫定的にこの津波の到着時間の予想に、第一近似値として使用することとする。対象海域は、メキシコのサリナ クルス沖～ニカラグア沖の海底が浅い海域。また、毎年の津波訓練や毎年のワークショップで、DGPC にこの問題を定期的に思い起こしてもらうようにする。
1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	Tide Toolの有効活用のため、この監視方法の検討を進めることとする。また、La Libertad の潮位計は適切に管理する。
要素5/b: CATACを含む電力等社会基盤	
分類4: 復旧及びバックアップ	
1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）	Platformが無い状況では、監視担当職員は、地震波形を日々分析する中で、観測所の稼働状況の確認を着実に行う。また、観測所の復旧における優先順位付け基準を定期的に見直す。
1-2-e バックアップシステムの適正化：対応	- 監視センターから避難を余儀なくされた場合、監視担当職員の業務机に設置された公用スマホを利用してWhatsAppでCATACからの情報を使用する。 - 不測の事態対応計画策定推進。 - CATAC での津波監視システム SeisComP の更新を待ち、相互バックアップの問題に関する議論を進める。

分類5: CATACとの協力を含むデータ及び情報収集	
2 CATACとの情報の共有化の促進	①「地震・津波処理結果」をリアルタイムに交換／② 地震発生後、短時間で発表する情報の内容を統一／③永続的な音声およびビデオ接続の確立について、次の対応が必要: ①については、「CATACからリアルタイムで取得」、b)「MARNからリアルタイムで提供」上での「仕様」(内容、タイミング、安定性、信頼性、コスト)を明確にする。 ② については、CATAC の試験運用の状況を見つつ、統一する手順を確立する ③については、Skype と WhatsApp をテストしており、それらの使用方法に関する手順を作成する。 共同津波訓練と訓練の結果の評価のためのワークショップを毎年開催することに合意した。
4-1 GPS観測網の地震監視現業での活用(GPS 観測システムから得られるリアルタイムデータの活用) / 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定	Wphaseについては、広帯域地震計を使用することとする。 GPS に関しては、必要な予算が確保できるまで、情報収集をさらに続けることとする。また、予算としては、自局(現在2局)から「リアルタイムデータ」を取得することを優先する。そして、周辺国と協力してGPSリアルタイムデータを交換することを検討する。
要素1/d: 監視(人材育成)	
分類7: 自主研鑽	
1-1-c-2 津波監視現業体制での技術レベル:維持・改善研修体制確立	自習システムの考え方はMARNに引き継がれ、実施される。 「既存のカタログ」は、地震と津波のカタログの作成を支援する。
1-2-f-2 MARNガイドブック:確立	- MARN Guidebook 2023には ISC と 津波Flag を含めなかったため、同ガイドブックの web版 を準備することとし、それに実装する。 - 沿岸部を訪問して津波対策の状況を調査した結果を踏まえ、同ガイドブックの学校向けにダイジェスト版を作成し、SNSへの投稿を検討することとした。そのため、これらのことをさらに検討する。
1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制:部外者参加も含めた検討	フェーズ 1 では、MARN が部外者 (CTC や UES の学生など) を招待して、自習システムの活動に参加させるべきだと考えた。今後、パンデミックの状況及び自習システムの運用状況を見て、対応方法も含めて再度検討する。
要素3/c: MARNからの情報の利用(市民防災局、国民)	
分類6: DGPCとの協力を含む防災のための津波警報の発信	
1-2-f-3 e-mailの公式利用、FAX点検の日課への導入:確立	通信手段の点検は、点検表に基づいて実施することとする。DGPC に、毎週月、水、金の午前 7 時 30 分頃に MARN と一緒に点検を依頼することとする。 この手順を確立した上で、津波プロトコルを実情に応じて改正することとする。 また、公式利用するとした通信手段について、DGPCの理解を確認することとする。
3 DGPCの津波警報利用:適切化	今年のワークショップでは、以下の項目が検討されたことから、今後、津波警報の取り扱いと解除の共通手順が確立されることが期待できる: ・CATACからの情報の有効活用 ・津波対応手順の共有化 ・ 残された課題へ継続的な対応 ・津波警報対応における共通の手順の確立 ・津波警報を適切に解除するための共通手順の確立
4-2・4-4 今後の業務改善に向けた「他の技術の地震津波監視への導入」に係る提言	
4) 4-2 地震波形を用いた解析による震源断層の滑り量分布の把握	必要に応じて、津波地震監視システムに機能を導入するためのさまざまなツールを学習する必要がある。
5) 4-4-f 津波警報の精緻化のための海岸を分割した警報発表手法	この問題は、定期的な津波訓練の実施を通じてさらに検討する。
6) 4-4-g 津波観測測器がない海岸のボランティアによる監視安全・効率化	海岸での海面監視者の安全を守るための仕組みを考える必要がある。

表 5-2 今後の対応が要請される事項

成果物	本プロジェクト終了後もMARNの対応が要請される事項
津波監視手引書	あ) MARNは当文書に示すように、公式手続きとして、2名の担当職員が内容点検をし、地質課長が承認 い) MARNは本手引書Note1にしたがって、適宜青字部分を見直し う) 本手引書第7節に示された次の3課題に対処すること:1)EEWの津波監視作業での利用、2)EWBSの津波警報発表手段としての利用、3)津波フラッグの利用
自主研修体制	本体制説明書の第4-1節に従って、当該研修の実施
自主研修素材	自主研修素材"How to handle CMT"を実務研修での適宜の利用、特に津波警報訓練での利用
	要素2についての技術移転・研修計画の記述に従って、自主研修素材"How to use initial motion focal mechanism"に沿って実務実施
既存地震カタログ一覧	本「一覧」の適宜の見直し
MARNガイドブック200部印刷(便宜供与)	津波監視業務の改訂など業務の改善・変更があった際、適宜内容の更新(MARNホームページ版について実施)

なお、津波フラッグについては、MARN に 2023 年 3 月 24 日に、次のことを検討し、実施するよう要請した。

1) 今後実施する「避難訓練を伴う津波訓練」での津波フラッグの利用

2) 機会を捕らえて DGPC に津波フラッグの導入の奨励

3) MARN Guidebook 2023 について、MARN ホームページに掲載する機会があれば、津波フラッグの頁[3]を追加することの検討。

図 5-1 津波フラッグ

[3] 追加する津波フラッグの頁案及び津波フラッグの利用方法説明ビデオは、専門家(森)が今後準備。

6. その他事項

6.1 定着関係

「移転した知識・技術・知見が先方政府組織内に定着し、長く活用されるための工夫・取組について検討」（仕様書による）し、表 6-1-1、表 6-1-2 に整理した。

表 6-1-1 長く活用されるための工夫・取組 1

成果の詳細説明文書	移転した知識・技術・知見が先方政府組織内に定着し、長く活用されるための工夫・取組
地震津波監視に関する**計画***（分類１；要素2/a）	１．第5節に示した「本プロジェクト終了後もMARNの対応が要請される事項」を整理し、この履行をMARNに要請した。 ２．DGPCやCATACとの緊密な連携では、毎年合同の津波訓練やその評価のためのワークショップの実施について、これらの機関との間で合意をするとともに、合意したことを示す議事録を共有するように措置した。 ３．移転した知識・技術・知見の多くは、津波監視手順書に記述した。その上で、月2回実施するよう要請した津波訓練の準備に際して、この文書を利用して手順の確認にするよう要請した。
CMT及びMw監視に関する**計画***（分類２；要素2/a）	
津波対応に関する**計画***（分類３；要素2/a）	
復旧及びバックアップに関する**計画***（分類４；要素5/b）	
データ・情報収集に関する**計画***（CATAC関係を含む；分類５；要素5/b）	
自主研鑽に関する**計画***（分類７；要素1/d）	
防災のための津波警報発表に関する**計画***（DGPCとの協力を含む；分類６；要素3/c）	
今後の指針（地震・津波監視業務の高度化に向けた）	
注*:「**計画**」とは、業務の課題と改善の方向性についてのDGOAとの協議を踏まえたDGOAと定める技術移転・研修計画	

表 6-1-2 長く活用されるための工夫・取組 2

成果物	移転した知識・技術・知見が先方政府組織内に定着し、長く活用されるための工夫・取組
MARNガイドブック(要素4)	DGPCへ配布及び国民へオンライン提供され,活用される見込み。また、要約版もオンライン提供され、小中学校生の活用が期待される。なお、今後、オンライン提供されているものが必要に応じて適宜更新されると期待される。
津波監視手引書(分類1,2,3; 要素2/a. 分類6;要素3/c)	定期的に参照するよう、2月に1回程度実施される見込みの津波訓練の際、訓練実施担当職員がこの手引書を復習し、加えて復習時に気づいたことを適宜更新等するように記述した。このため、継続的に活用され、内容も改善されていくと期待される。
自主研修体制（分類7; 要素1/d）	MARN地震季報の作成過程を素材としたことから、定期的に実施され、継続的に活用されると期待される。また、地震季報内容改善努力を促すための a) 地震活動解析ソフト(SeisPC)、b) 既存地震カタログ一覧(地震活動データ、データ源整理)を準備したことから、改善も見込まれる。
自主研修素材（分類7; 要素1/d）	MARNから要請された自主研修素材(津波警報発表作業でのCMTの適切な利用を推進するためのもの)も含めていることから、一定の活用は期待できる。

6.2 中南米への裨益拡大

「中南米地域では、これまで JICA が取り組んできた防災分野の協力の成果を、ネットワーク化（仮想的なネットワーク）による域内の他国にも展開していく構想がある。エルサルバドルにおける地震・津波分野についても、その成果提供の一つのリソース国として、教材作成・提供、動画作成・提供、経験・成果の発信、エルサルバドル国内での学びの場の提供などを検討」（仕様書による）とのことで、検討した。

まず、中米 6 か国（ベリーズを除く）については、自然環境は比較的似ているものの、「中米地域 地震・津波観測能力に関する情報収集・確認調査」平成 27 年 3 月(2015 年)を踏まえると、各国地震・津波分野について、防災の観点からは、実施体制がエルサルバドルとは異なっており、エルサルバドルでの成果は、（部分的には、それぞれの国の事情に合わせて、参照する価値が見込まれるものの）そのまま提供しても利用が難しいと思われる。このため、提供や紹介する場合、国別に内容を手直しして、実施することが必要と思われる。そして、成果の提供に際しては、次のような事情を踏まえて、MARN 自

身による対応（リソース国としての活動）を期待し、それを支援していくことが望ましいと思われる：

あ）MARN と CATAC と相互協力について相談してきている。この中での成果の紹介

い）中米統合機構（SICA）や中米防災センター（CEPREDENAC）の枠組みでの成果の紹介（例えば、パナマで今年６月に開催される SICA 地域防災セミナーでの MARN による津波フラッグ利用を含む成果の紹介）

う）JICA「KIZUNA プロジェクトフェーズ２」のチリを拠点とした防災分野における中南米地域の人材育成の枠組みでの成果の紹介。

一方、南米については、国土の面積の違いや想定される津波の規模に違いがあるなど、エルサルバドルと条件がかなり異なっており、津波対応については、CMT 解析などの特定の技術についての利用状況の紹介などによる活動が望ましいと思われる。内陸に発生する地震対応については、MARN における本プロジェクトの成果への対応状況に応じて、やはり特定技術の利用状況の紹介が望ましい活動と思われる。また、上述の KIZUNA ファーズ２の枠組みでの成果の紹介を期待し、それを支援していくことが望ましいと思われる。

なお、スペイン語を母語とする中南米各国では人的交流もあるようなので、このことも勘案して考えていくのも一案と思われる。

6.3 第五次業務での収集資料

次の資料が MARN から提供された。なお、第一次～第四次までに MARN から提供された資料は第四次業務結果報告書（和文）エルサルバドル 23Sep22 にまとめてある。

- Metodología para simulación de tsunamis en tiempo supra-real (05Dec22)
- pc-centralsismica-revisada-2022-revisado (16Dec22)
- Sismo_15-12-22_08_32AM_Mw56 2 (19Dec22)
- Servers replacement plan as of 19Dec22ver2 (19Dec22)
- 2da_Alternativa_Procedimiento_usar_SeisComP3_secundario (21Dec22)
- Informe_Técnico_San_Lorenzo_Guatemala_200123l (20Jan23)
- Ubicacion-torres-guardavidas-playa-San-Diego (25Jan23)
- 2022-11-22-Evaluacion-de-mensajeria-distribuida-durante-simulacro-por-tsunami (25Jan23)
- Borrero_Pageph_Nic_14 (03Feb23)
- Multi event handling (01Mar23)
- Multi event handling / Informe_Técnico_2_San_Lorenzo_Guatemala_230123 (06Mar23)
- Resumen consolidado-modif Dera (06Mar23)
- Informe_Técnico_2_San_Lorenzo_Guatemala_230123 (Word-format)　(17Mar23)

6.4 付属資料

ここまでの報告に明示されていないものの、「技術移転・研修計画」の文書及び「地震・津波監視業務の高度化に向けた今後の指針」、及び成果物の中に引用されている資料としては次のものがある。

- Scenarios of tsunami simulation exercise as of 26Oct22
- Series of Scenarios as of 24Jan23
- Draft minutes of the workshop held on 24Jan23 as of 12Feb23_marn
- Proyecto de acta del taller celebrado el 24ene23 a partir de 12Feb23_marn
- Draft minutes of the seminar with CATAC held on 07Feb23 as of 12Feb23_marn

付属資料１　プロジェクト関係者及び協力者

表 6-4-1 に、本プロジェクト関係職員及び協力者（薄緑色の欄の 5 名）を示す。なお、この表に示す肩書の MARN/DGOA における位置づけは、図 6-4-3 の組織図に示す。

図 6-4-1 業務改善担当職員及び地震津波監視職員

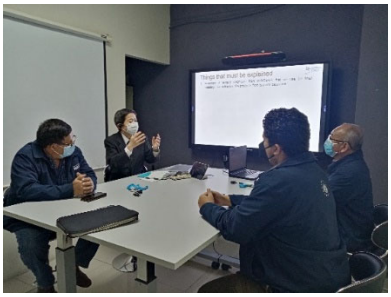


図 6-4-2 業務改善担当職員及び地震津波監視職員との津波訓練結果の評価会合

表 6-4-1 本プロジェクト関係職員及び協力者

Title	Name
Director of the Observatory of Threats and Natural Resources	Luis Eduardo Menjivar Recinos - New
Geology manager	Manuel Roberto Díaz Flores
Coordinator of the seismology area	Marta Griselda Marroquin
Seismologist	Rodolfo Elías Ayala Torrez - Retired on 01Jan23
Seismologist	Luis Ernesto Mixco Durán
Coordinator of the volcanology area	Vacant
Volcanology specialist	Carlos Demetrio Escobar Escobar
Vulcanologist	Francisco Salvador Montalvo Piche
Geological monitoring coordinator	Douglas Hernández
Impact forecasting specialist	Jacqueline Rivera - New
Geology technician / Landslide specialist	Mario Ernesto Reyes Martínez - New
Geologist	Angela Valeria García Lara - New
Seismology Technician	Rosa Amelia García Castro
Seismology Technician	Fabio Alvarado Molina
Seismology Technician	Kevyn Enrique Pineda Ortiz - New
Seismology Technician	Elsa Guadalupe Martínez de Gutiérrez
Seismology Technician	Francisco Elias Campos Moreno
Geological monitoring technician	Marlon Joel Bolaños Melendez
Geological monitoring technician	Cecilia Carolina Polío López
Geological monitoring technician	Rodolfo Castro
Geological monitoring technician	Elías Campos
Geological monitoring technician	Manuel Barrios
Geological monitoring technician	Rodrigo Fernando Méndez Alfaro - New
Oceanographer	Francisco Gavidia - He does not depend on geology

付属資料２　MARN/DGOA 組織図

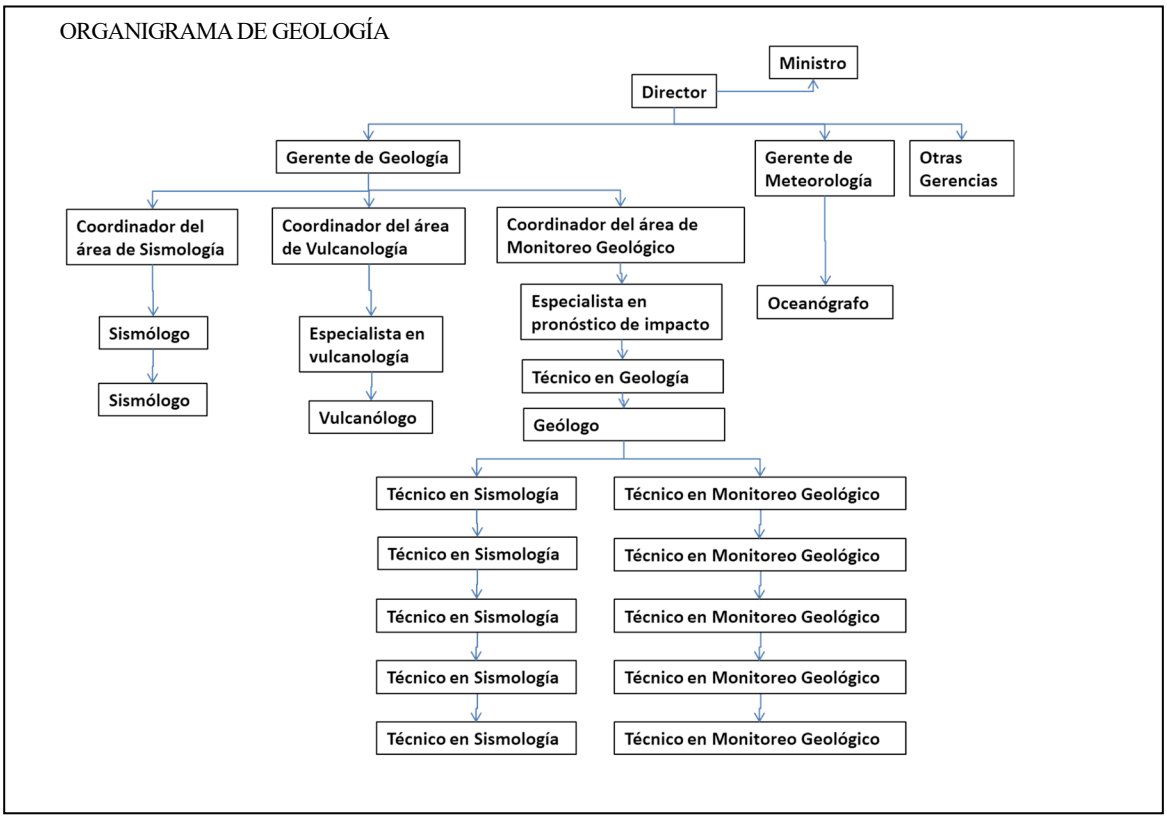


図 6-4-3 MARN/DGOA 組織図

付属資料３　MARN からのコメント

プロジェクトの成果として、地震津波監視システムを構成する「監視要素」について、「数分での地震・津波情報の発表や関連情報の発表を担う地震監視職員」の自己研鑽の仕組みが構築されました。また、この仕組みを支える新たなソフトウェアーや機材の導入もありました。

また、同じく「分析要素」では、エルサルバドル近海での津波の発生の迅速判断のツールが改善されました。その改善では、地震のマグニチュードと震源域の変位の大きさとの関係式について、日本と同様のものを使用しました。

さらに、「情報発表要素」では、「津波の脅威がある場合に備える」とともに「様々な事態に対しての現在の作業手順の適否を見直す機会とする」ための日常的な津波訓練の実施が促進されました。この促進には、専門家が作成した津波作業手順書による、津波が発生に係る様々な判断での基準の導入が重要な役割を果たしました。

最後に、「情報の防災利用要素」及び「社会基盤要素」に関連して、DGPC および CATAC との連携の強化が図られたことを強調しておきたいと思います。この強化は、地震や津波の脅威がある場合に、発表される情報の流れを阻害する物が無いようにし、かつ皆が同じ情報で防災活動を行うようにするものです。また、いずれかの機関で技術的な問題が発生した場合、他の関係者は必要な技術情報を共有することで相互に「バックアップ」しあうことを可能とするものです。

Plan on the technology transfer & the training about
seismic tsunami monitoring (Category 1)
in observation, analysis, and monitoring systems (Element 2/a)
Approved by MARN on 08Mar23
Revised by Expert on 09Mar23

Category 1: seismic and tsunami monitoring
1-1-a The proper & stable judgement on generation of tsunami
1-1-c-1 Tsunami Monitoring Manual
1-2-b Introduction of auto-filling-function and elaboration of depth handling in the tsunami database
1-2-f-1 Establishment of the Tsunami Monitoring materials
1-2-f-4 Establishment of the standard procedures that handle any abnormal seismic activities
4-4-e Station weighting/correction for enhancement to hypocenter determination

1. The proper & stable judgement on generation of tsunami (Target 1-1-a)

Detail of the target

To Verify the latest status of the "proper & stable judgement on generation of tsunami" established in Phase 1

Criterion: Its issuance timing should be within 10 min with sufficient accuracy level

Status

This target has been verified as follows.

Example 1 of "PRELIMINARY MESSAGE" from the scenario of the "05Nov21 drill"

DATOS PRELIMINARES: Sismo mag. 7.8, frente a la costa de La Libertad. [2021-11-05, 15:15:00]. Amenaza ALTA de tsunami para El Salvador. Se espera un nivel de impacto SIGNIFICATIVO frente a la zona epicentral. PREPARACIÓN.

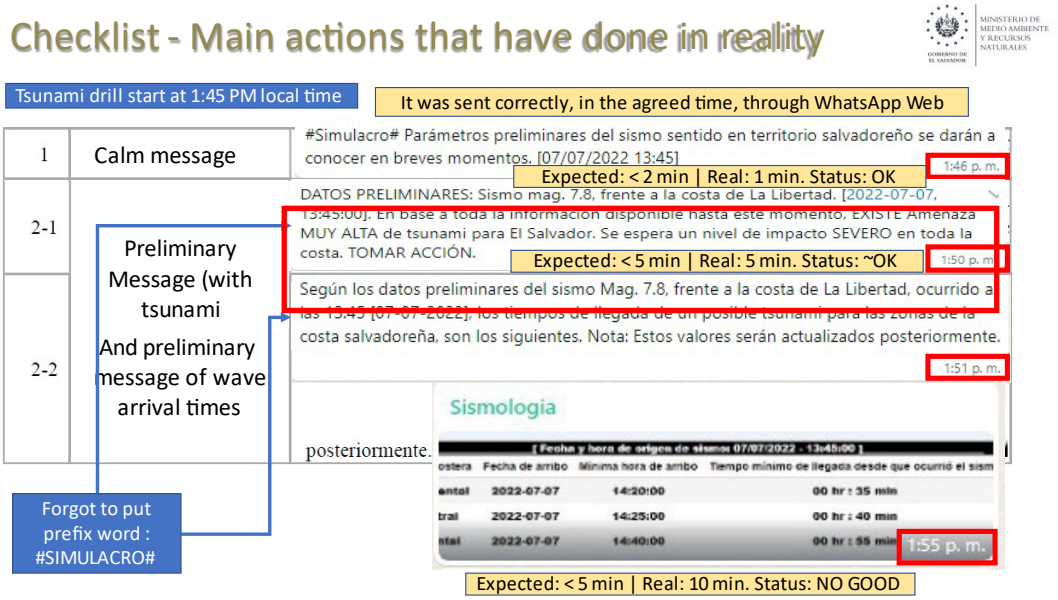
Example 2 of "PRELIMINARY MESSAGE" from the "Assessment_Drill_120722"

DATOS PRELIMINARES: Sismo mag. 7.8, frente a la costa de La Libertad. [2022-07-07, 13:45:00]. En base a toda la información disponible hasta este momento, EXISTE Amenaza ALTA de tsunami para El Salvador. Se espera un nivel de impacto SEVERO en toda la costa. TOMAR ACCION.

(Note 1: The term PREPARACION in Example 1 has been changed in Example 2. Expert feels the latter sounds best.)

(Note 2: Expert feels that the phrase, "En base a toda la información disponible hasta este momento", should be removed to simplify the warning to make the public catch the emergency information more easily.)

Excerpt from the document, "Assessment_Drill_120722"



(Descriptions with blue letters should be handled further even after finishing this project.)

1) Issuance timing of any messages related to tsunami warning

It has been further shortened by adding "checked M" and "comment on tsunami hazard" to the Preliminary messages since 2020. **See the column in the previous page.**

Detail of progress: In 2017, the latest stage in the Phase 1, the messages related to tsunami warning were called as "Final messages"; and the time needed for their issuance from their detection had been between 12 min 44 sec and 27 min 42 sec in 2014～2016 and was shortened to be between 9 min 28 sec and 21 min 12 sec. On the other hand, in 2020～2021, those have been covered by another messages called "Preliminary messages"; and the time were between around 5 min and 10 min 14 sec. And the issuance timing of "Final messages" have been shortened further as expected or between 8 min 58 sec and 17 min 23 sec during recent three year (2019 - 2021). See **the below list** and **the Figure 1**, which compares the progress with that in Japan of recent 60 years.

Time elapsed M>=4.0		Phase 1							Phase 2
		2014	2015	2016	2017	2019	2020	2021	Evaluation
Preliminary	Average	5:30			5:49	4:32	5:34	5:08	Kept
	Maximum	07:39 M4.2			09:00 M8.0		10:14 M4.2		Kept
Final	Average	20:13 +/- 7:29 (12:44 - 27:42)			15:20 +/-05:52 (09:28 - 21:12)	10:45 +/- 01:47 (08:58 - 12:32)	13:57 +/- 03:26 (10:31 - 17:23)	12:44 +/- 02:47 (09:57 - 15:31)	Improved
	Maximum	40:14 M4.2			35:43 M5.3	27:59 M4.4			Improved

-

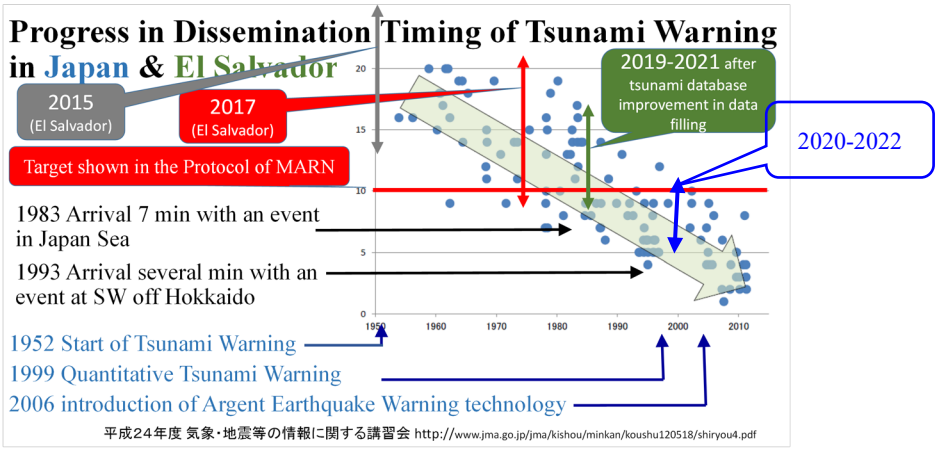


Figure 1: Progress of improvement in issuance timing of the messages related to tsunami warning in El Salvador through comparing with the progress of that in Japan during recent 60 years.

2) Accuracy of the information in Final messages

It has been kept at the best level. Namely, the root mean square (RMS) of residuals (Res) between observation times and calculation times of the information in Final messages had been around 0.91 – 1.44 sec in 2014 - 2015 and became smaller around 0.39 – 0.49 sec in 2017; and it has been kept around 0.46 – 0.53 sec in 2019 - 2021. See **the below list**.

RMS_Res (sec) M>=4.0		Phase 1							Phase 2
		2014	2015	2016	2017	2019	2020	2021	Evaluatio
Preliminary	Average					0.73	0.72	0.75	
	Maximum					1.95 M4.0			
Final	Average	1.09 - 1.44	0.91 - 0.97	0.38 - 0.41	0.39 - 0.49	0.53	0.57	0.46	Kept
	Maximum	2.6 M4.2			1.7 M6.1	1.23 M4.2			Kept

(Descriptions with blue letters should be handled further even after finishing this project.)

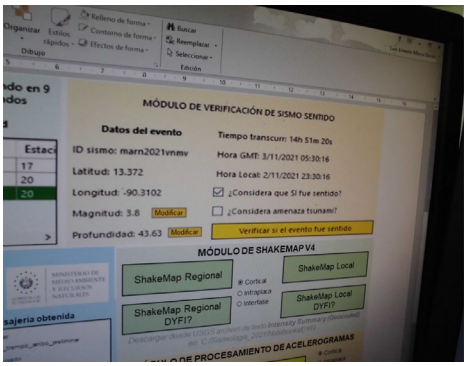
Challenges and actions against them

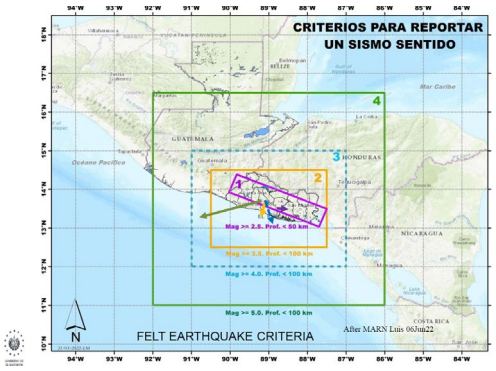
a) Maximum issuance timing

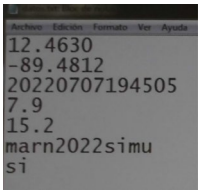
Those emergency messages must be steadily issued because they are surely related to save lives. The stable issuance also cultivates reliability to the MARN performance in the public. Therefore. the maximum issuance timing should be shortened as much as possible.

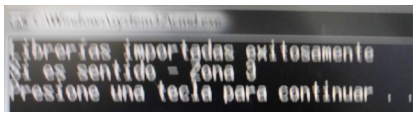
As for Preliminary messages, the maximum is 10 min 14 sec. It is reported that the event was M4.2; so, the monitoring staff had judged whether the event should be handled or not, because MARN has the norm that only felt events should be handled. The action of the judgment had consumed time.

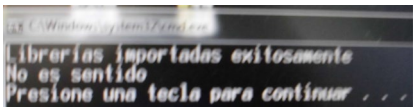
-> The issue has been resolved by introducing the automatic judgement function into the monitoring system. **See the below column.**



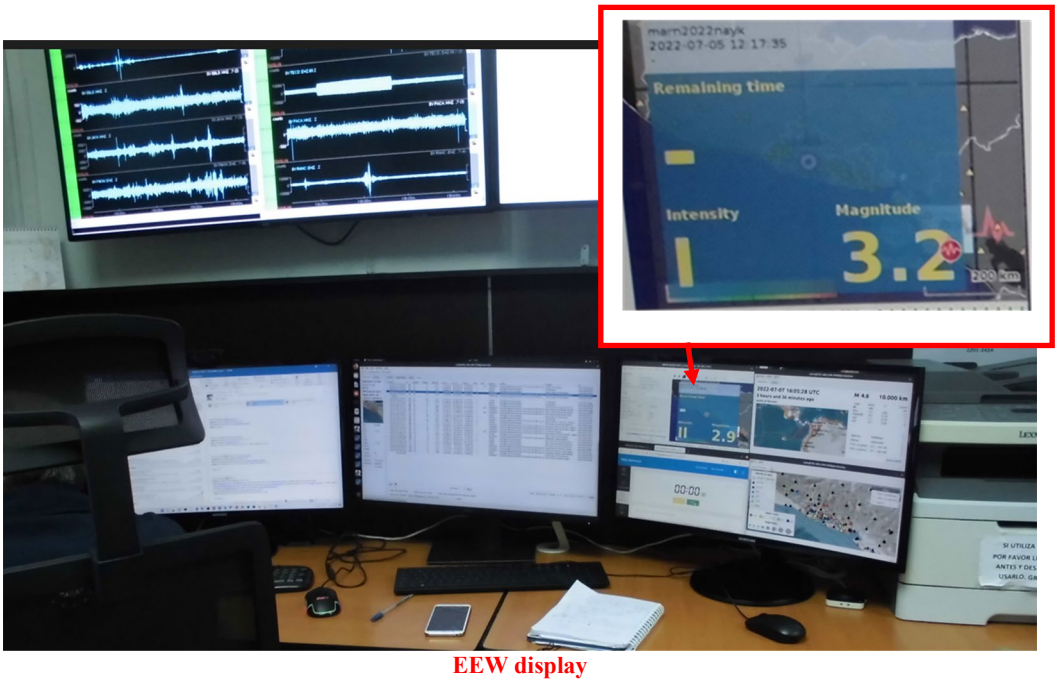








"si" = To be felt; "Si es sentido = Zona 3" = To be felt in Zone 3; "No es sentido" = Not to be felt



EEW display

(Descriptions with blue letters should be handled further even after finishing this project.)

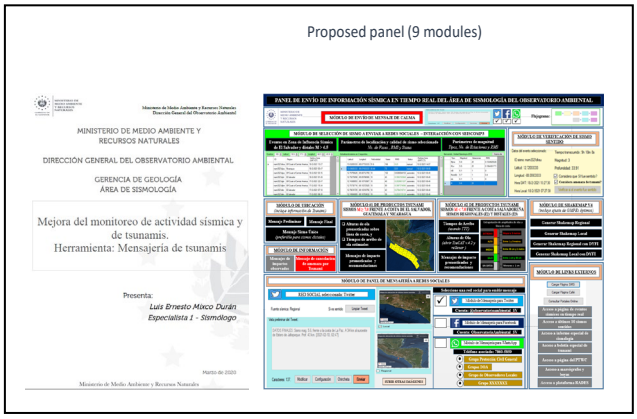
As for Final messages, the maximum is 27 min 59 sec. It is reported that the event was M4.4 and that each of the 5 events that needed longer than 20 minutes had special reason.
-> MARN has told that the delays came from being unaccustomed to handle tsunami issue. So, together with the improvement/simplifying the procedures like introducing GUI, we should plan tsunami drills of sufficient times.

b) Average issuance timing

It could be shortened with any support from EEW function, which gives seismic parameters earlier than SeisComP but independently. **See the column in the previous page.**

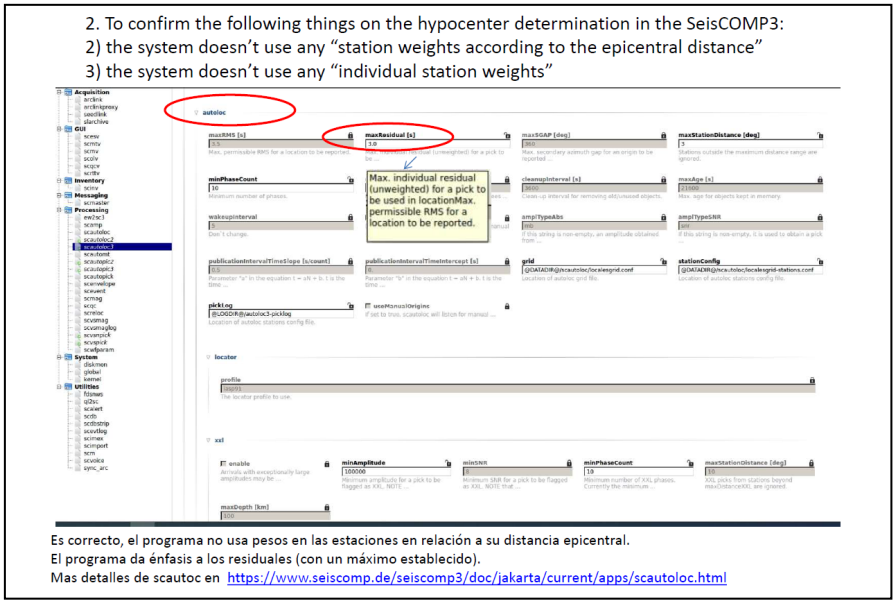
c) Issuance timing of the other messages to cover the Preliminary and the Final messages

MARN is handling the panel shown in **the right column**[1]. It is being developed to improve the monitoring actions by increasing reliability and shortening the "elapsed time". As one of its development procedures, MARN conducted a monitoring drill explained in the ppt file, "Tsunami_Drills_issue", provided from MARN on 21Aug21 at 06:57JST with this new technology. Further MARN has made the manual how to use it. In addition, we have developed and introduced the function to handle the panels with GUI that had been procured during this Project.



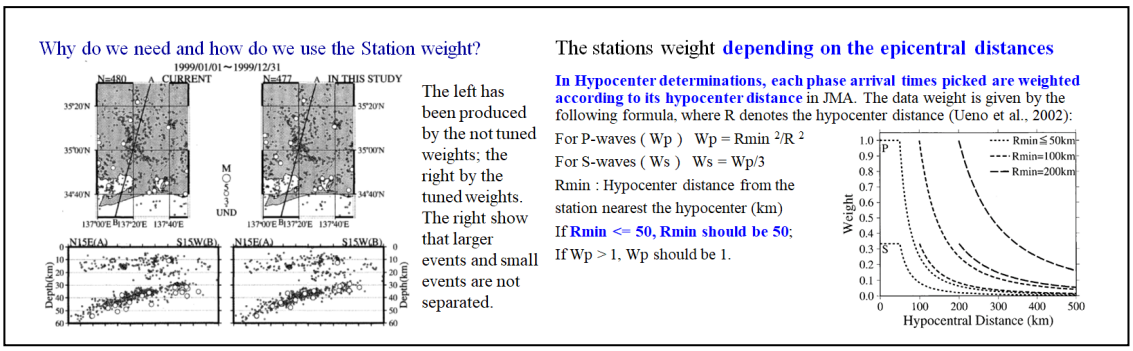
d) Accuracy

The hypocenter determination in the SeisCOMP3 doesn't use "station weights according to the epicentral distance" nor "individual station weights". But it uses RMS to evaluate the data to be used. **The right figure** shows "Max. individual residual (unweighted) for a pick to be used

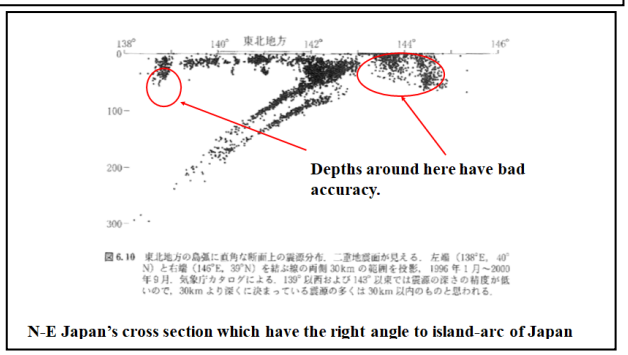


[1] The panel figure has the following explanation about it, "This document shows all the new functions that should exist in the update of the seismology panel for automatic sending of messages about the occurrence of earthquakes; where on this occasion, it is intended to include the part of tsunamis and its derivative products, as well as information on the level of impact on the threatened population. / It took 2.5 min to handle maps and tables in past days; but now with the panels it took only 23 seconds. This shortening would give the technician time to do other things during the seismic event. / One of the features of this new panel is that we will guarantee a reduction in the creation time of messages and maps, since we use other scripts and computer libraries that speed up the process.

in locationMax, permissible RMS for a location to be reported." The program emphasizes residuals (with an established maximum). More details can be seen in the site[2].
(Note: The SeisComP4 has the same function as described above.)
Expert thinks that it might be better for us to check if there is any separation in locations of large events and moderate/small ones that are obtained from automatic calculation. **See the below column.**



In addition, we should know that the depth issue shown in **the right figure**.



N-E Japan's cross section which have the right angle to island-arc of Japan

2. Tsunami Monitoring Manual (Target 1-1-c-1)

Detail of the target

To verify the latest status of the "Tsunami Monitoring Manual" established in Phase 1.
Criterion: Tsunami Monitoring Manual that has the purpose shown in the below column should be maintained and be used accordingly. It might be called "**Guideline for how to proceed with the Tsunami Monitoring**".

> **Purpose**: **to establish the detail procedures with timeline during 30 minutes after occurrence of a large earthquake** under the condition of having the authorized protocol for handling tsunami and seismic activity, and **to inform DGPC and the people, as early in advance as possible**, about the occurrence of tsunamis that may cause disasters around the marine coastal zone.

Status

This target has been checked, and it has been noticed that the Guideline should be updated. Expert has thus done so to get the new **Guideline**[3].

Challenges and actions against them

Those are described in the **Guideline**.

[2] https://www.seiscomp.de/seiscomp3/doc/jakarta/current/apps/scautoloc.html"
[3] Its title is "Guideline for how to proceed with the Tsunami Monitoring Duty in El Salvador" and its file name is "Guideline for how to proceed with the Tsunami Monitoring 06Mar23".

3. Introduction of auto-filling-function and elaboration of depth handling in the tsunami database (Target 1-2-b)

Detail of the target

To verify the latest status of the "Auto-filling-function and elaboration of depth handling" established in Phase 1.

Status

We have verified the achievement.

The elaboration of depth handling in the tsunami database has been achieved as shown in the Excel file document prepared by Griselda. **See the below column**.

Improvement of the database in the Tsunami scenarios

MARN currently has 561 scenarios modelled:

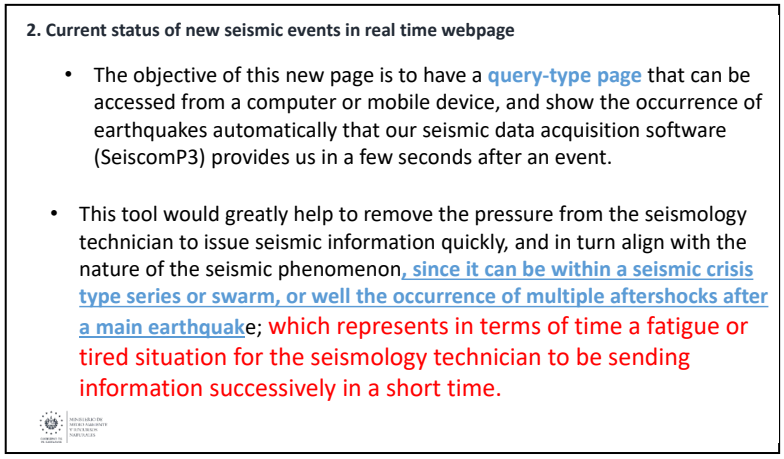
1) M: from 7.0 to 8.0 in 0.1 steps (11 scenarios)
2) Depth: three depth values for each of the 27 selected seismic sources (3x27=81 scenarios)
3) Wave height: forecasted at 71 points along the coast
4) Results: tabulated at the municipality level to simplify the results (Note: a municipality can have several forecast points - where the highest value is taken)
5) Wave height values: associated in ranges, <0.3 m, 0.3 - 1.0 m, 1.0 - 3.0 m, and > 3.0 m
6) Earthquake with tsunamigenic characteristics: there is a module of the information dissemination platform that compares the data obtained from Seiscomp3 and the one drawn from the database scenario that most closely resembles the earthquake that has occurred.

(Note: the above was translated into English by the Expert with Google translation software from the email in Spanish sent from MARN.)

The auto-filling function has been already working at the script level and MARN has been testing it with scenarios with all the technicians. The "at the script level" means that the technician executes the individual codes and not within a panel.

Challenges

a) MARN has been working on developing the panels (**see the below column**.), which would further facilitate the generation of messages to address tsunami threats. But with the results from the development that was procured in the project, this issue has been finished, or we have now some GUI function to handle the panels accordingly.



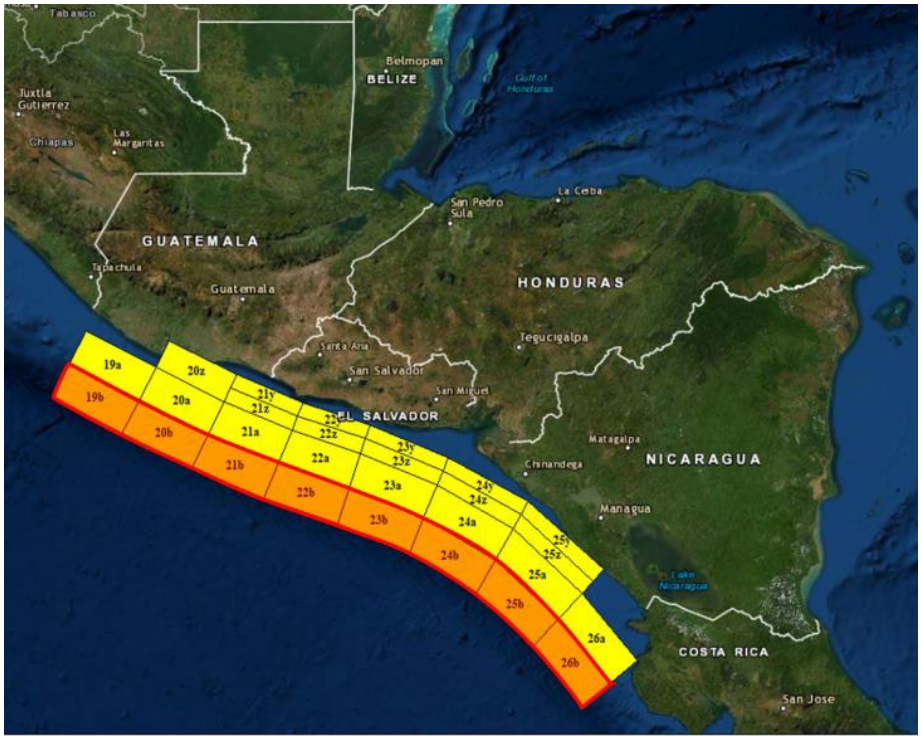
b) It has been noticed by Expert that the scaling law used for making the tsunami database had some feature of under-estimation of tsunami height through comparing the database and the observations in the 2012 Usultan event.

Further, through comparing the observed heights and the estimated heights obtained from the standard scaling law like Blaser 2010 or Utsu 2001/1984, we have understood that it should be reconsidered due to its under-estimation of the heights. With the reconsideration, we have **tentatively** approved to take the below idea to improve the tsunami database.

Idea: 1-1) The tsunami heights of the Gozo area from the events in 23a,b and 24a,b (**see the below map**.) should be handled as a special case, and should be the observed heights as the estimated ones for the Mw7.3 event due to any bathymetric/topography feature or to other

(Descriptions with blue letters should be handled further even after finishing this project.)

unknow reason there through following a scientific paper[4]; and, for the Mw 7.0 through to M8.0 except Mw 7.3, those of the Gozo area should be given by multiplying original estimations by some factors based on the actual observations; 1-2) Other data in the database should be re-calculated with the "Utsu scaling law, Utsu 2001" of "MARN guidebook 2017"; 1-3) We should inform the public of the highest estimation in the area because our database does not have high resolution.
Further, the Idea 1-1 has already been implemented, but the Ideas 1-2 and 1-3 have not yet. The latter will be done soon.



After "Metodología para simulación de escenarios tsunamigénicos en tiempo supra-real utilizando el programa EasyWave."

	Blaser 2010	Reverse		0.50 M - 3.22		25GPa	10.398
			0.57M - 2.37	0.47 M +7.33 - log μ	0.46 M - 1.86	μ GPa	log μ
2012 event simulation Mw7.3				0.47 M - 3.21		35GPa	10.544
		Normal	0.46M - 1.61	0.70 M + 5.79 - log μ	0.34 M - 1.08	μ GPa	log μ
			0.52M - 1.91	0.62 M + 6.21 - log μ	0.36 M - 1.20	μ GPa	log μ
2017 event simulation Mw8.2				0.62 M - 4.33		35GPa	10.544
	Utsu 2001	All	0.5 M - 1.85	0.5 M + 7.10 - log μ	log (L/2) = 0.5M -2.15	μ GPa	log μ
MARN Guidebook 2017 MARN Guidebook 2023	Utsu 2001	All	0.5 M - 1.85	0.5 M - 3.1	log (L/2) = 0.5M -2.15	U(m)/L(km)=5x 10^{-2}, *17GPa*	10.24
	Utsu 1984	All	0.5 M - 1.9	0.5 M+7.2 - log μ	log (L/2) = 0.5M -2.2	μ GPa	log μ
JMA Tsunami database		All		0.5 M - 3.2		25GPa	10.398
MARN Tsunami database Unit: L100km, W50km U1m Mw7.5	Commit	8.0>=Mw>= 7.0 All	2.00	1.48M - 11.14	1.70	45GPa	10.65
		All	*0.5 M - 1.75*	*0.5 M - 3.75*	*log (L/2) = 0.5M -2.05*	*45GPa*	10.65

~~The above list was revised on 18Dec22. Italic letter item, *17GPa*, has calculated by MORI; it is originally written as 50MPa.~~

[4] Borrero et al 2014 "Observations and Modeling of the August 27, 2012 Earthquake and Tsunami affecting El Salvador and Nicaragua" (File name is "Borrero_Pageph_Nic_14".)

(Descriptions with blue letters should be handled further even after finishing this project.)

	MARN Tsunami database			2012 event simulation Mw7.3			MARN Guidebook 2017			JMA		
Mw	Dislocación (metros) U	Ancho (km) W	Largo (km) L	Dislocación (metros) U	Ancho (km) W	Largo (km) L	Dislocación (metros) U	Ancho (km) W	Largo (km) L	Dislocación (metros) U	Ancho (km) W	Largo (km) L
7.0	0.2	50	100	1.2	22.9	41.7	2.5	22.4	44.7	2.0	20.0	39.8
7.1	0.3	50	100	1.3	25.5	47.5	2.8	25.1	50.1	2.2	22.4	44.7
7.2	0.4	50	100	1.5	28.3	54.2	3.2	28.2	56.2	2.5	25.1	50.1
7.3	0.5	50	100	1.6	31.5	61.8	3.5	31.6	63.1	2.8	28.2	56.2
7.4	0.7	50	100	1.8	35.0	70.5	4.0	35.5	70.8	3.2	31.6	63.1
7.5	1.0	50	100	2.0	38.9	80.4	4.5	39.8	79.4	3.5	35.5	70.8
7.6	1.4	50	100	2.3	43.3	91.6	5.0	44.7	89.1	4.0	39.8	79.4
7.7	2.0	50	100	2.5	48.1	104.5	5.6	50.1	100.0	4.5	44.7	89.1
7.8	2.8	50	100	2.8	53.5	119.1	6.3	56.2	112.2	5.0	50.1	100.0
7.9	4.0	50	100	3.2	59.4	135.8	7.1	63.1	125.9	5.6	56.2	112.2
8.0	5.6	50	100	3.5	66.1	154.9	7.9	70.8	141.3	6.3	63.1	125.9

4. Establishment of the Tsunami Monitoring materials (Target 1-2-f-1)

Detail of the target

To prepare any item that shows the essence of the Guideline made in the Target 1-1-c-1.

Status

One of the ideas provided from MARN was "making a pyramid that show the essence" as shown **in the next page column**. It seems MARN has no item like that now.

Target 1-1 f-1 on going
Verified the actions on **Tsunami Monitoring materials** that were left in Phase 1 to be taken later on

An idea considered in Phase 1
To make the most of the contents in **the guideline** through setting **a pyramid-shape memo** with the tsunami handling timeline on the faces. The Expert had tried to make a prototypical item after the Phase 1 activities.

The three photos here are the one set on a table.

Challenges

1) Based on the results from the internal tsunami warning issuance drill[5] in DGOA held on 07Jul22, it was decided to use the guideline when preparing for the drills and to promote the simplification of the procedures of the issuance.
2) Expert has been considering anything like the pyramid, but he now understands that the issue should be handled by monitoring officers by themselves according to their necessity.

4. Establishment of the standard procedures that handle any abnormal seismic activities (Target 1-2-f-4)

Detail of the target

To see the latest status of establishment of the standard procedures that handle any abnormal seismic activities. That was proposed in Phase 1.

Status The procedures have been established, and its guideline[6] was made.

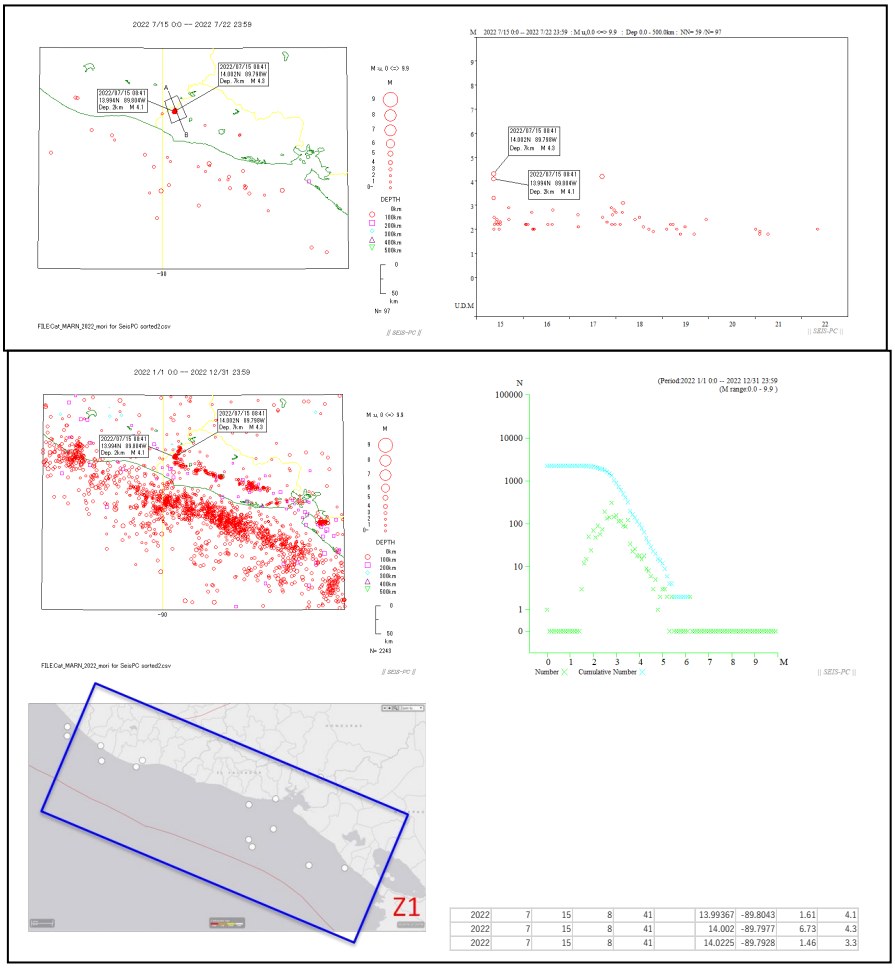
Challenges

Based on the results from the actions taken to the M4.4 event that occurred at Ahuachapán in western El Salvador at 2:41 a.m. on July 15,2022, it was decided to promote
a) use of the Magnitude & Time (MT) diagram (See **the below figure**.),

[5] See the "**Draft results from the tsunami exercise of MARN held on 07Jul22 as of 25Jul22**".
[6] Actuación por Amenaza de Sismos en El Salvador (File name: IAM-MFN-PA-08 Actuacion por Amenaza de Sismos en El Salvador 2021)

(Descriptions with blue letters should be handled further even after finishing this project.)

b) use of Calm information[7],
c) explanation of the complete coverage magnitude in the local area (Z1) (See **the right bottom column**. It roughly shows the magnitude seems 3.0 in 2022. The swarm has three events with M larger than 4.0. Two of them occurred one after another in 1min),
d) explanation of the reason why Berlin and Metropolitan are handled specifically (See **the below column.**).

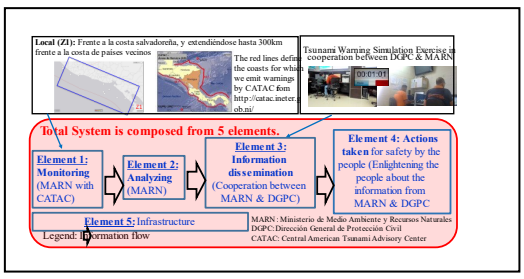


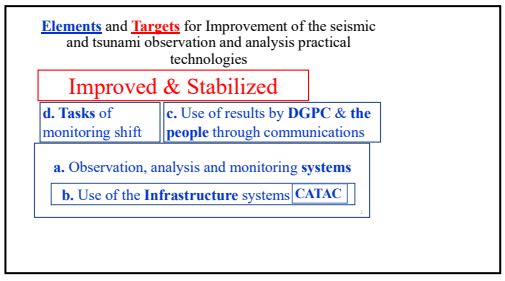
2022	7	15	8	41	13.99367	-89.8043	1.61	4.1
2022	7	15	8	41	14.002	-89.7977	6.73	4.3
2022	7	15	8	41	14.0225	-89.7928	1.46	3.3

a) The reason why Berlin is specifically handled is that the area has seismic swarms so often or seismicity is higher than the other areas,
b) The reason why Metropolitan (AMSS) is specifically handled is that its population is so dense that earthquakes with small magnitude can be sensed so often according to the density.

5. Station weighting/correction for enhancement to hypocenter determination (target 4-4-e)
Status This issue has been handled in the **sub-target 1-1-a.**
Challenges It should be considered in the above sub-target.

Appendix **What are "Elements"?**





Period

[7] See the "**Guideline for how to proceed with the Tsunami Monitoring 07Sep22**".

(Descriptions with blue letters should be handled further even after finishing this project.)

Plan on the technology transfer & the training about
CMT and Mw monitoring (Category 2)
in observation, analysis, and monitoring systems (Element 2/a)
Approved by MARN on 08Mar23
Revised by the Expert on 09Mar23 & 28Mar23

Category 2: CMT and Mw monitoring
1-1-b The CMT analysis in the practical monitoring task to get focal mechanism and Mw
1-2-a Introduction of GFDB based on the local seismic velocity structure to cover the events under M6.5 in CMT
4-3 Making displaying source time function to understand the actual seismic magnitude earlier
4-4-a Initial motion analysis for grasping focal mechanisms

1. The CMT analysis in the practical monitoring task to get focal mechanism and Mw (Target 1-1-b)

Detail of the target

To verify the latest status of the "CMT analysis in the practical monitoring task to get focal mechanism and Mw" established in Phase 1
Criterion: CMT analysis in the practical monitoring task should get focal mechanism & Mw[1] for the evens larger than M6.5 within appropriate timings[2].

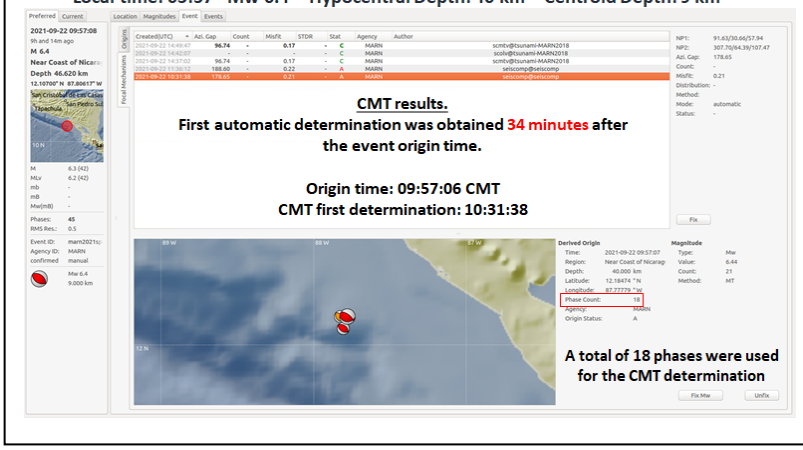
Status

We had an event that had taken 34 minutes to obtain the CMT results. It was the Nicaraguan Mw6.4 event of 22Sep21. **See the below column.** Its time length comes from fitting parameters to finish the automatic calculation. So, MARN has taken the below actions:
a) they made the "analysing process to get the optimum CMT result" shorter by reducing the search range of depths[3].
b) they made the "area covered in the automatic CMT analysis" narrower by excluding the global area (Z3). Because, even excluding Z3, we can expect that CMT and Mw of Z3 would be covered by those published by any foreign country institutions like USGS, JMA et al.

Challenges

The monitoring officers should have sufficient knowledge on the CMT analysis to handle the results from OSOP properly. So, Expert has prepared the self-training material[4] on the CMT analysis.

It took 34 minutes to obtain the CMT results as shown below.



[1] On the page 1, MARN on 06Jul21: It is planned to carry out this performance of the tool for events of considerable magnitude in order to show the opportunities for improvement of the tool and also as a comparison parameter, when being post-processed with the ISOLA software. There are 2 more analyses, where the determination time shows variations.
[2] The latest procedures shown in the "**tsunami Guideline**" tells 18-20 min is the limit timing.
[3] Expert made the comment that the search range should be selected according to the locations of epicenters. Namely the locations that have deep earthquakes should have the wider range.
[4] CMT handling 06Mar23

(Descriptions with blue letters should be handled further even after finishing this project.)

2. Introduction of GFDB based on the local seismic velocity structure to cover the events under M6.5 in CMT (Target 1-2-a)

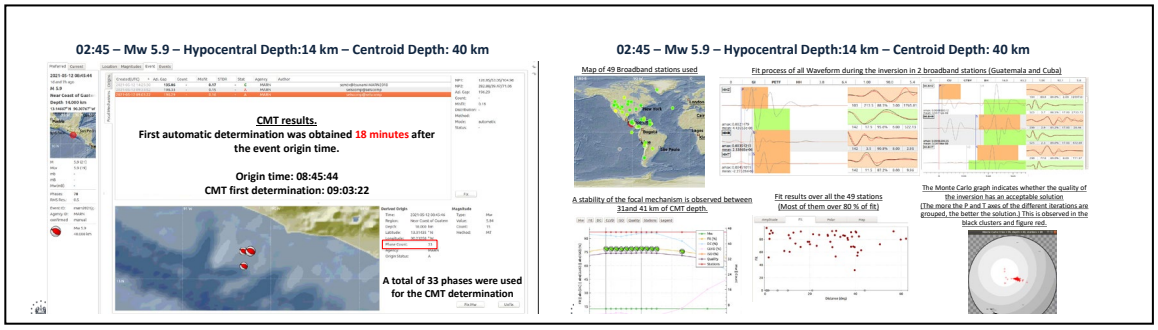
Detail of the target

To verify the latest status of "Introduction of GFDB based on the local seismic velocity structure to cover the events under M6.5 in CMT" that has been left without finishing because the procurement of the GFDB had been on the way in Phase 1.

Criterion: The introduction should be finished with the procured GFDB.

Status

The introduction has been verified as shown in the latest status that explains the event that has 5.9 as magnitude, which is smaller than 6. See **the below figures** that show a Mw5.9 event was well handled to get CMT result by 18 min of its elapsed time**.** We have no challenges now.



3. Making displaying source time function to understand the actual seismic magnitude earlier (Target 4-3)

Status

Introduction of displaying source time function could be handled by the MatLab ISOLA that has been procured. See **the below table** that is excerpt from procurement table for MatLab ISOLA.

ISOLA function
To get 1) Display of moment rate function to understand the actual seismic magnitude earlier 2) Slip distribution in a finite fault area, 3) Flexible calculation of GFDB and handling in-depth analysis related to the determination of theCMT Note 1 Its calculations are not in real time. Note 2 OSOP CMT doesn't have the above functions but can work in real time. Note 3 Both can handle initial motion (polarity) analysis for grasping focal mechanisms by entering polarities.

Challenges

We have initially thought to use the function of ISOLA, but now we understand that the function does not cover the real time. So, instead of its usage, we should consider new tools to evaluate underestimate of M like "M100s" (Displacement, period 100 sec)[5].

4. Initial motion analysis for grasping focal mechanisms (Target 4-4-a)

Status

Introduction of grasping focal mechanisms with initial motion analysis could be handled by both OSOP and ISOLA.

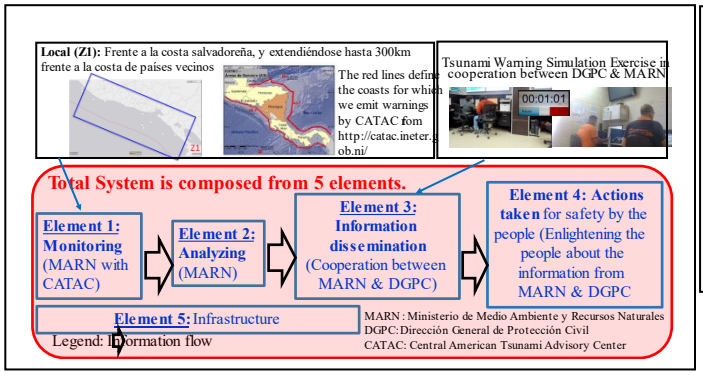
Challenges

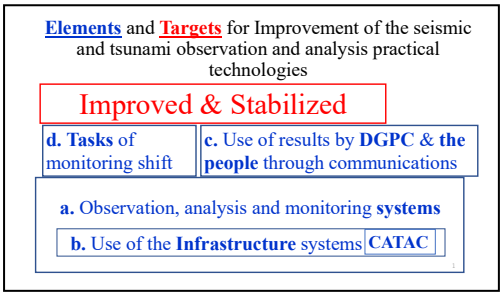
Expert have prepared a document about how to use the initial motion analysis. With it, we should develop the practical procedures to grasp focal mechanisms with OSOP and ISOLA.

[5] See the "Guideline for introduction of the additional technologies in monitoring tsunamis and earthquakes as of 09Mar23"

(Descriptions with blue letters should be handled further even after finishing this project.)

Appendix What are “Elements”?





(Descriptions with blue letters should be handled further even after finishing this project.)

Plan on the technology transfer & the training about
tsunami handling (Category 3)
In observation, analysis, and monitoring systems (Element 2/a)
Approved by MARN on 08Mar23
Revised by Expert 09Mar23

Category 3: tsunami handling
1-2-d Establishment of tsunami warning cancellation procedures
1-2-f-5 Introduction of the "Tsunami Forecast" that alerts the people about the small remaining tsunami
1-2-f-6 Introduction of estimating the arrival of larger tsunamis after diminishing of initial tsunamis
1-2-f-7 Promotion of using the Tide Tool in the tsunami monitoring procedures to seize live tsunami arrivals

Additionally, we have described how to handle non-earthquake tsunami in **the tsunami Guideline**.
Note: MARN has the procedures to handle the events larger than M5.5. Tsunamis generated by the events of M6.4 in Z1 could be covered by the action.

1. Establishment of tsunami warning cancellation procedures (Target 1-2-d)

Detail of the target

To verify the latest status of "Establishment of tsunami warning cancellation procedures" that has been left to be considered in Phase 1.
Criterion: Tsunami warning cancellation procedures should be established somehow.

Status

It is verified that the cancellation procedures are handled in the Protocol as shown in **the below column**. It shows the term, "two hours", that is reportedly obtained from PTWC. PTWC has reportedly introduced the "two hours" just to keep the safety side in cancellation of very diverse types of tsunamis.

The excerpt from the Protocol (Translated from Spanish by the Expert)
(Note: The below all conditions are the authentic cancellation conditions.)

Conditions to be met to cancel tsunami threat

- That the final parameters of the earthquake do not meet the threshold of tsunamigenic eventgeneration.
- Do not observe significant changes or increases in sea level (less than 10 cm) in tide gauges near th coast of El Salvador after the estimated time of arrival of the tsunami.
- Do not observe changes or increases in sea level (less than 10 cm) in tide gauges near the seismic sourc after the estimated time of arrival of the tsunami. (In case of regional or distal sismos) .
- Corroborate the direction of energy propagation from PTWC products.
- Sufficient tsunami decay after a long time (at least two hours according to PTWC after estimated arriv times).
- That the PTWC indicate that the threat has passed to the Salvadoran coasts.
- That local conditions do not continue to produce strong water currents in canals or ports that require th prolongation of the tsunami warning state.
- That the area has not been hit by damaging waves for at least two hours.

On the issuance of the cancellation

Finally, DGPC is informed of the cancellation of the threat and the cancellation is disseminated by th different media and social networks, for this see in annex 3 the formats of cancellation messages, in additio to including in the closing report of the event the cancellation of the threat.

Challenges

We should continuously talk DGPC to use only MARN's cancellation information because we have the below status on the issue.
a) DGPC uses PTWC's in addition to MARN's.

b) The term “cancelación” is shown only in the document “**Procedimiento Operativo ante Tsunami-SOP´s Nacional-DGPC Formato autorizado**” that is one of the three documents provided by DGPC as shown **in the below column**.
c) But that doesn’t show any information source to judge cancellation.

10. FLUJOGRAMA
Los flujogramas están dados a partir de las etapas del SAT ante tsunami, siguiendo este las acciones que realiza la institución en el manejo del evento, identificadas como:
a. Monitoreo ante tsunami
b. Nivel de Alerta ante tsunami
c. Divulgación de la declaratoria de alerta ante tsunami
d. Activación de la Respuesta ante tsunami
e. **Cancelación:** Dejar sin efecto la declaratoria de alerta
SAT stands for Sistema de Alerta Temprana.
10. FLOW CHART
The flowcharts are given from the stages of the EWS before a tsunami, following this the actions that the institution performs in handling the event, identified as:
a. Tsunami monitoring
b. Tsunami alert level
c. Dissemination of the tsunami warning declaration
d. Tsunami Response Activation
e. **Cancellation**: Leave the declaration of alert without effect
EWS stands for Early Warning System.

2. Introduction of the “Tsunami Forecast” that alerts the people about the small remaining tsunami (Target 1-2-f-5)

Detail of the target

To verify the latest status of “Introduction of the “Tsunami Forecast” that alerts the people about the small remaining tsunami” that has been left to be considered in Phase 1.
Criterion: the “Tsunami Forecast” that alerts the people about the small remaining tsunami should be introduced somehow.

Status

1) The alert information is clearly stated in the tsunami protocol after the tsunami warning is canceled, as shown in **the below column**. Further, the idea of "tsunami Forecast" has already been included in the tsunami impact analysis, which is integrated into the new protocol and also considered in the panel ("auto-filling function"). The analysis handles all of the arrival times, expected wave heights and impacts and recommendations for the population, according to the degree of threat and level of impact determined.

The excerpt from the Protocol (English was translated from Spanish by the Expert.)
Cancellation Messages 3. The threat of tsunami off the coast of El Salvador has passed, however, it is recommended to stay away from the beaches. (118 characters)
Mensajes de Cancelación 3. La amenaza por tsunami en costa de El Salvador, ha pasado, sin embargo, se recomienda mantenerse alejados de las playas. (118 caracteres)
If abnormal fluctuations in the sea surface are expected due to the "tsunami" even after cancellation, the following notifications should be added to the cancellation information: "The sea may show abnormal fluctuations in the sea surface, but we do not expect damage or no damage." (238characters).
En el caso de que se esperen fluctuaciones anormales en la superficie del mar debido al "tsunami" incluso después de la cancelación, se debería agregar las siguientes notificaciones a la información de cancelación: "El mar puede mostrar fluctuaciones anormales en la superficie del mar, pero no esperamos daños o no hay daño." (238caracteres).

2) The treatment of a very small tsunami is not clear. That is, handling tiny tsunamis caused by earthquakes that did not lead to the announcement of the tsunami warning is not clear. The idea of “Tsunami Forecasts”, **which is explained in the below next page column**, is partially handled in the notification to be issued to the public when issuing cancellation as mentioned above, but the earthquake that should generate “Tsunami height less than 0.2 meters is expected” is apparently not handled. But the Protocol tells in the “Table 3. Levels of impacts

and recommendations for the population" that MARN should issue any advisories against the tsunami with its height is smaller than 0.3m like "Caution for the development of marine

Tsunami Forecast https://www.data.jma.go.jp/svd/eqev/data/en/guide/tsunamiinfo.html
After an earthquake occurs, if no damage is expected, JMA issues Tsunami Forecasts.

Forecasted sea level changes	Message
No tsunami is expected	"No tsunami is expected." (To be included in Earthquake Information.)
Tsunami height less than 0.2 meters is expected	No damage is expected because sea level changes will be less than 0.2 m, and no special action is needed.
Slight sea level changes are expected to continue after Tsunami Warnings/advisories are cleared	Particular attention is needed when fishing, swimming, or engaging in other marine activities because tsunami-related sea level changes have been observed and may continue for a while.

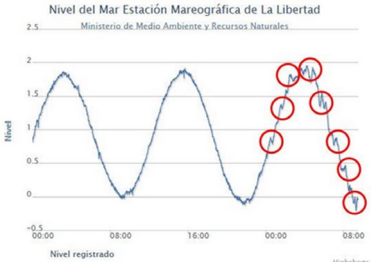
activities." as the message to be informed. This surely covers the remained issue.
This target has thus no challenges now.

3. Introduction of estimating the arrival of larger tsunamis after diminishing of initial tsunamis (Target 1-2-f-6)

Detail of the target

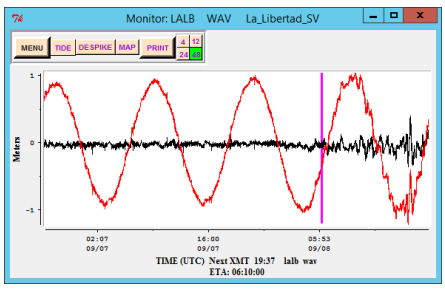
To verify the latest status of "introduction of estimating the arrival of larger tsunamis after diminishing of initial tsunamis" that has been left to be considered in Phase 1.
Criterion: Estimating the arrival of larger tsunamis after diminishing of initial tsunamis should be introduced somehow.

The internal document in MARN
Compilation of information and actions carried out by earthquake of magnitude 8.1, off the coast of Chiapas, Mexico, on September 7, 2017, at 22:49:21 (El Salvador time)



Unfortunately, there is no evidence of the times when the information on tsunami threat is disseminated by the radio of the **civil protection** system.
For the Sept. 7 earthquake, the first message via twitter, that there is a threat of a tsunami threat to the Salvadoran coast, is published at 00:20:39 after the earthquake occurred (Annex 8). For the earthquake on November 24, 2016, it was approximately 9 minutes after the earthquake occurred.

Note: It was observed in the Mexican event of 07Sep17[1] shown in **the right two columns.** One of the figures shows that the interval between the first tsunami arrival and the highest tsunami arrival was 11 hours. This phenomenon was generated with the shallow sea depth from Mexico through to El Salvador. The shallow area trapped the tsunami energy, and the velocity of tsunami is slow. These features made the phenomenon.
Note: The event 24Nov16 shown in the above column was checked. Its result is shown **in the Appendix 1**of this document.

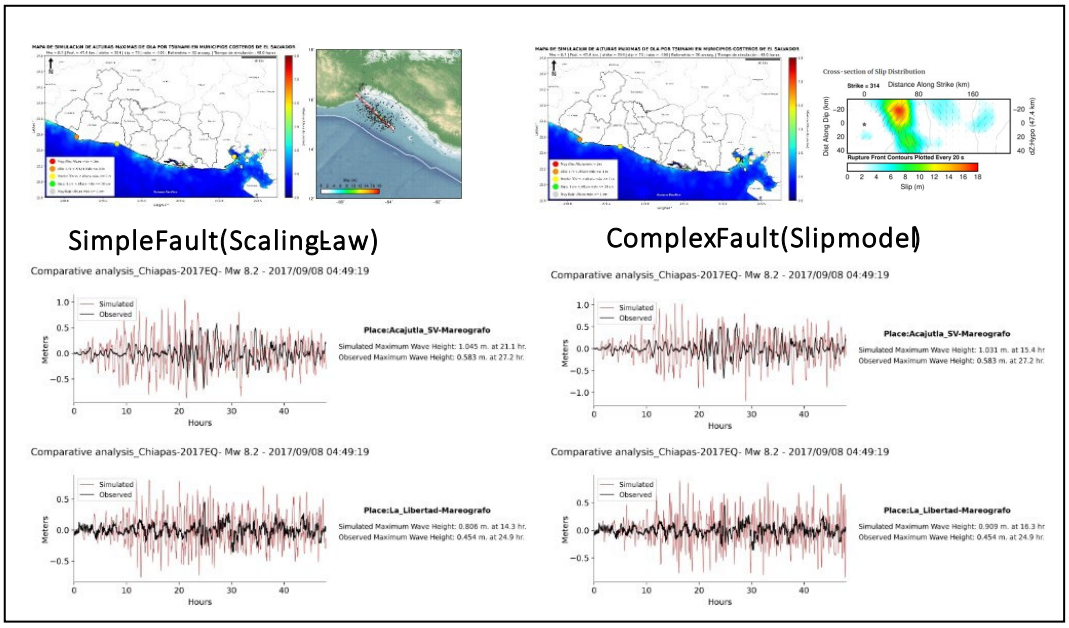


The excerpt from ITIC document. This shows the tsunami by removing the astronomical tidal change.

Status

1) MARN removed the astronomical tide change from the raw data at La Libertad to emphasize the tsunami to compare it with the simulation results. The simulation output has the similar feature of the duration to the observed one, even its amplitude is different from the observed one.
2) MARN has conducted the same action on Acajutla data. **See the next page column.**
3) MARN took the similar action on the events, whose hypocenter should be located outside of the coastal shallow sea depth area to consider the area where we should expect the "later

[1] File name is "The_2017_M_w_8.2_Chiapas_Mexico_Earthqua; title is "The 2017 Mw 8.2 Chiapas, Mexico, Earthquake: Energetic Slab Detachment" by Lingling Ye, Thorne Lay , Yefei Bai , Kwok Fai Cheung , and Hiroo Kanamori; 2017



attack". The results are wrapped up in the ppt, "**Comparative analysis of tide records from Chiapas EQ**".

4) The scientific paper[2] shows that the remarkable later attacks are noticed just around El Salvador. **See the right column.**

Challenges

1) Expert should consider the area where we should expect the "later attack" based on the above information in **the Status**.

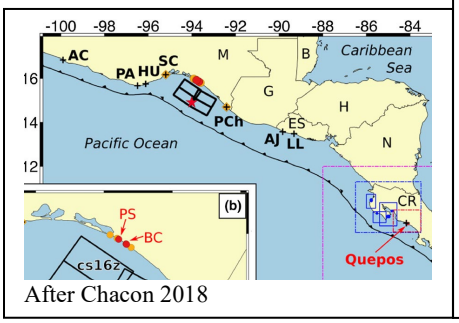
-> We have used the observed data in the earthquake of magnitude 8.1, off the coast of Chiapas, Mexico, on September 7, 2017, at 22:49:21 (El Salvador time) to get the velocity of the later attack tsunami from arrival time at the Libertad and its distance from the epicenter as follows:

Source - La Libertad = 580km

16:50 - 04:49 UTC = 12h

Then, 580km /12h = 48km/h

This velocity, 48km/h could be internally and tentatively used to estimate the arrival time of the later attack tsunami as the 1st approximation for the events occur in the area



After Chacon 2018

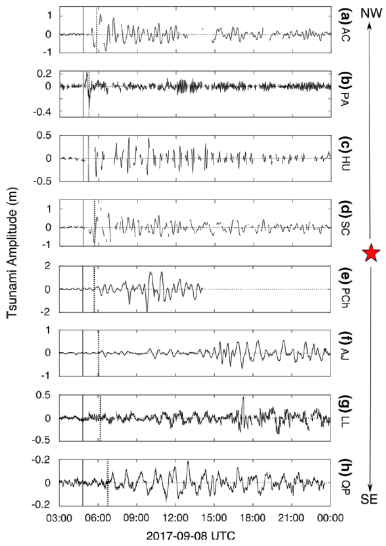


Figure 6

Filtered records of the 2017 México tsunami at gauges within 690 km north and south the epicenter and at Quepos. **a** AC: Acapulco (México), **b** PA: Puerto Ángel (México), **c** HU: Huatulco (México), **d** SC: Salina Cruz (México), **e** PCh: Puerto Chiapas (México), **f** AJ: Acajutla (El Salvador), **g** LL: La Libertad (El Salvador) and **h** QP: Quepos (Costa Rica). Gauges locations are shown in Fig. 1. Vertical lines mark the earthquake time (solid line) and the forecasted arrival time by PTWC (dotted line). Arrows show the orientation of the gauges in relation to the epicenter (NW: northwest and SE: southeast), depicted with a red star. Mexican records were provided by the Servicio Mareográfico Nacional de México and El Salvador records by the Ministry of Environment and Natural Resources (MARN), all of which were downloaded from the IOC/UNESCO website

After Chacon 2018

[2] File name is "2018Mexico"; title is "The 2017 Mexico Tsunami Record, Numerical Modeling and Threat Assessment in Costa Rica" by SILVIA CHACON-BARRANTES; 2018

(Descriptions with blue letters should be handled further even after finishing this project.)

with shallow sea depth from the sea off Salina Cruz (Mexico; SC in the above map) to the sea off Nicaragua.
2) The tsunami Protocol of MARN covers the "later attack" of harmful tsunami somehow but not so clear. So, the guideline[3] prepared by Expert includes the above idea.
3) We should make DGPC regularly remind this issue in annual tsunami drills and in annual workshops.
4) As for the current tsunami database, MARN has tried to improve the simulation software by subdividing "calculation depth length" from 450m (or 15 arc seconds) to 300m (or 10 arc seconds). (Note: The database has been revised further as explained in the target 1-2-b in the "Category 1".)

4. Promotion of using the Tide Tool in the tsunami monitoring procedures to seize live tsunami arrivals (Target 1-2-f-7[4])

Detail of the target

To verify the latest status of "Promotion of using the Tide Tool in the tsunami monitoring procedures to seize live tsunami arrivals" that has been left to be considered in Phase 1.
Criterion: Using the Tide Tool in the tsunami monitoring procedures to seize live tsunami arrivals should be introduced somehow.

Status

Tide Tool is monitored in the drill and in the daily monitoring but is not found in the Protocol.

Challenges

1) It might be better for us to consider how to monitor it in order to use it effectively.
2) The tide gauge at La Libertad should be properly nursed.

[3] "Guideline for how to proceed with the Tsunami Monitoring 06Mar23"
[4] As for promotion of using the Tide Tool in the tsunami monitoring procedures to seize live tsunami arrivals", Tide Tool has no function to automatically detect tsunami to alarm us about it. We should consider the automation of the detection further.

Appendix 1 24Nov16 event shown in the Item 3

Reuters **Magnitude 7 offshore quake shakes Central America, no damage seen By Nelson Renteria**

People play at La Pazon beach after a tsunami warning was lifted following a 7.0 magnitude undersea earthquake off the Pacific Coast of Central America, in La Libertad, El Salvador, **November 24, 2016.** ***REUTERS/Victor Pena***

SAN SALVADOR (Reuters) - A strong earthquake off the Pacific Coast of Central America shook the region on Thursday just as a hurricane barreled into the Caribbean coasts of Nicaragua and Costa Rica, but there were no immediate reports of any quake damage.

Emergency services in El Salvador said on Twitter it had received no reports of damage at a national level, but urged those living along the country's Pacific coast to withdraw up to 1 kilometer away from the shore.

The **7.0 magnitude quake, initially reported as a magnitude 7.2**, was very **shallow at 10.3 kilometers** below the seabed, which would have amplified its effect.

Its **epicenter was located some 149 km south-southwest of Puerto Triunfo in El Salvador**, according to the U.S. Geological Survey.

PTWC warned that tsunami waves of up to **1 meter** could **hit the Pacific coasts of Nicaragua and El Salvador** after the quake, but later said that available data showed the threat had passed.

Nicaraguan President Daniel Ortega declared a state of emergency due to the quake and Hurricane Otto, which landed on the country's southeastern coast earlier on Thursday, his spokeswoman said.

"We were serving lunch to the lawmakers and the earthquake started and we felt that it was very strong," said Jacqueline Najarro, a 38-year-old food seller at the Congress in San Salvador. "We were scared."

Earlier on Thursday, the Category 2 Hurricane Otto hit land near the southeastern coast of Nicaragua, where thousands had already been evacuated away from vulnerable coastal areas and into shelters.

Additional reporting by Sofia Menchu in Guatemala, Gustavo Palencia in Honduras and Ivan Castro in Nicaragua; Writing by Gabriel Stargardter; Editing by Sandra Maler and Simon Gardner

Our Standards: The Thomson Reuters Trust Principles.

https://www.reuters.com/article/us-quake-central-america-idUSKBN13J20A

El Salvador earthquake: Tsunami threat passes after powerful magnitude-7 tremor

Posted Fri 25 Nov 2016 at 4:19amFriday 25 Nov 2016 at 4:19am, updated Fri 25 Nov 2016 at 5:46am

https://www.abc.net.au/news/2016-11-25/7-magnitude-quake-strikes-off-el-salvador/8056676

Earthquake hits off coast of Central America

Catherine Shoichet-Profile-Image

By Catherine E. Shoichet, CNN

Updated 2139 GMT (0539 HKT) November 24, 2016 The Pacific Tsunami Warning Center said El Salvador and Nicaragua could see waves reaching 0.3 to 1 meter above the tide level.

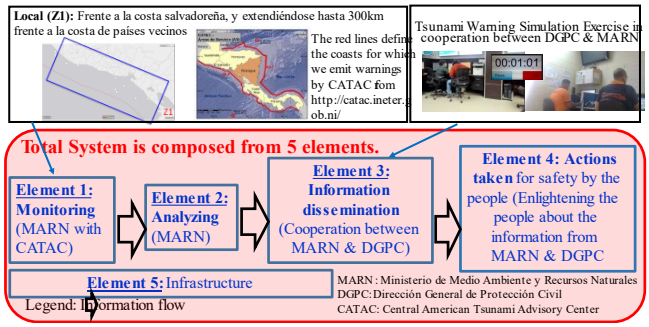
El Salvador's civil protection service issued an alert for people living on the country's Pacific coast to evacuate 1 kilometer inland.

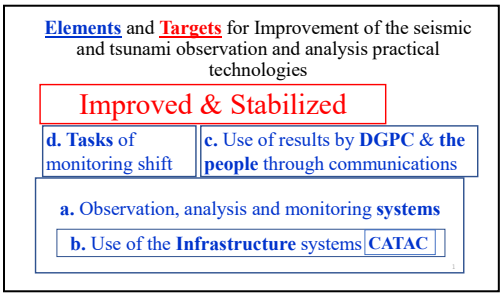
There were no immediate reports of damage or injuries.

CNN's Natalie Gallon contributed to this report.

https://edition.cnn.com/2016/11/24/americas/central-america-earthquake/index.html

Appendix 2 What are "Elements"?





Period

(Descriptions with blue letters should be handled further even after finishing this project.)

Plan on the technology transfer & the training about
Self-training (Category 7)
in Monitoring Shift actions (Element 1/d)

Prepared by Expert on 17Mar23
Approved by MARN on 17Mar23
Revised by Expert on 22Mar23

Element 1/d: "Monitoring Shift actions"
Category 7: self-training
1-1-c-2 The self-training system & materials to keep the tsunami handling skills in the monitoring shift officers
2) Verified the actions on some issues that were left in Phase 1 to be taken later on
1-2-f-8 Consideration on the "self-training system"
1-2-f-2 Establishment of the MARN guidebook to make DGPC and the people properly use the information sent from MARN **(Element 4)**

1. The self-training system & materials to keep the tsunami handling skills in the monitoring shift officers (Target 1-1-c-2)

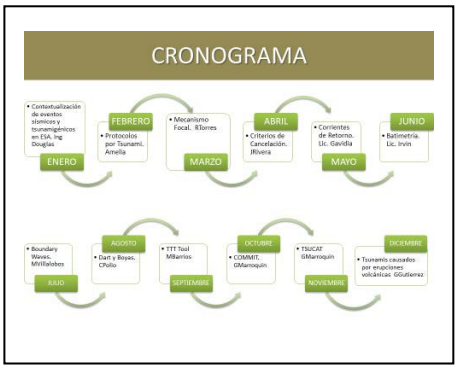
Detail of the target

To Verify the latest status of the "The self-training system & materials to keep the tsunami handling skills in the monitoring shift officers" established in Phase 1
Criterion: They are kept as they were.

Status

The self-training system was once established. See the right column. But it was finished after conducting the series of mutual presentations. In Phase 2, Expert has been trying to prepare simpler training materials through considering that the trainings should mainly contribute to monitoring shift officers. The below items have tentatively been proposed to be handled in the material:

a) How to make Travel Time Table
b) How to determine hypocenters
c) How to analyze focal mechanism
d) Making **Tsunami Chart** (See **the right figure** that shows an example.)



Note 1: When we get M and depth of an event, with the chart, we can get rough estimation on the tsunami height at various coastal area located at any epicentral distance. MARN commented that tide gauge should provide actual data. Expert explained that this kind of chart would contribute to cultivate a sort of "sense" on the relation between M and area to be affected.

Note2: It might be better for us to check the MARN tsunami database through making tsunami chart from the database. **See the Appendix 1.**

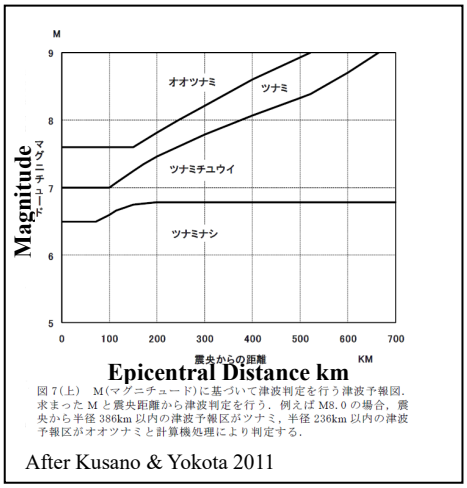


図 7(上) M(マグニチュード)に基づいて津波判定を行う津波予報図．求まった M と震央距離から津波判定を行う．例えば M8.0 の場合，震央から半径 386km 以内の津波予報区がツナミ，半径 236km 以内の津波予報区がオオツナミと計算機処理により判定する．

After Kusano & Yokota 2011

e) Scenarios for buildup and release of stress on a fault. See **the right column**.

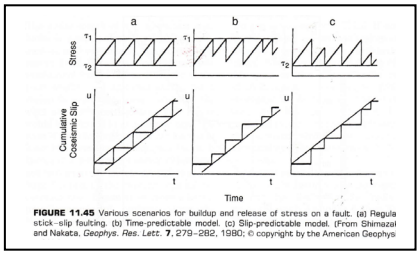
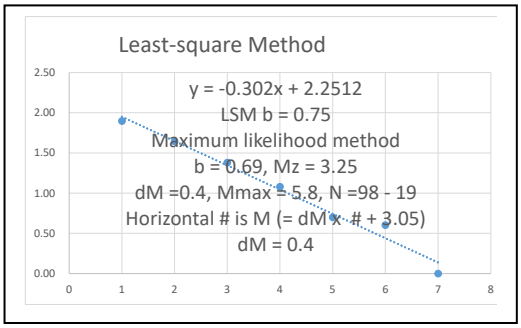


FIGURE 11.45 Various scenarios for buildup and release of stress on a fault. (a) Regula stick–slip faulting. (b) Time-predictable model. (c) Slip-predictable model. (From Shimazal and Nakata, *Geophys. Res. Lett.* **7**, 279–282, 1980; © copyright by the American Geophys

(Descriptions with blue letters should be handled further even after finishing this project.)

f) Usage of the b-value (See **below three columns**. They are obtained from the M-T diagram shown in **the "g" item**.)

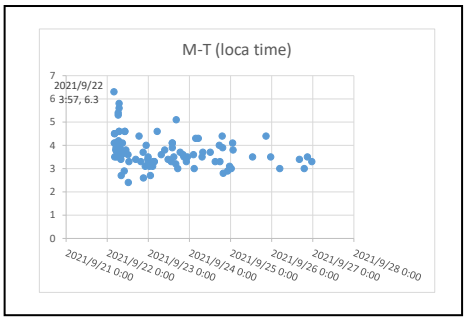


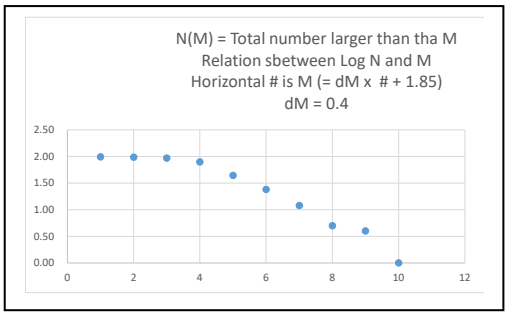
——(P.S.)
The b-value reported in the meeting were as follows:
Least-Square Method 0.65 and Maximum Likelihood Method 0.69.
But the former should be changed to 0.75 due to my "data handling error". (So sorry!)
So, the b-value should be roughly 0.7.
(Note 1: the accuracy level of MLM is higher than LSM.)
(Note 2: the b-value calculated from dM larger than 0.25 gives us slightly smaller amount.)

Blue area handles Maximum Likelihood Method.
b = log e / ("average M" – Mz)
log e = 0.43429; Mz is the smallest M to be used to calculate.
The "dM" is the width of handling M.
M widths are "2.05 – 2.45", "2.45 – 2.85", —

dM	0.4	n(M)	Σlog n	N(M)	Log N	Mz	3.25	Mean M	3.9	0.69	for MLM
2.1	2.4	1	0.00	98	1.99						
2.8	2.8	4	0.60	97	1.99						
3.8	5.2	14	1.15	93	1.97						
3.9	5.6	35	1.54	79	1.90						
3.7	4.0	20	1.30	44	1.64						
4.1	4.4	12	1.08	24	1.38						
4.8	4.8	7	0.85	12	1.08						
5.8	5.2	1	0.00	5	0.70						
5.8	5.6	3	0.48	4	0.60						
5.7	6.0	1	0.00	1	0.00						
6.1	6.4	1	0.00	1	0.00						
						Not icluded due to Main event					
		Total #	66.80								

g) Usage of **M-T diagram** (See below)





Challenges:

1) Expert should develop any new and robust self-training system. The latest idea is to use the process of preparation of monthly seismic newsletters that are prepared as internal documents. The members of the monitoring shift officers should mutually contribute to enhance the contents of newsletters that are made and issued monthly to the public. The below is being conducted by Expert to get assurance that the idea would work accordingly. On the other hand, Expert has provided MARN with a software for analysing seismicity to support the preparation of them.

Step1: To look at the latest monthly seismic bulletin (Boletín Mensual de Actividad Sísmica Marzo 2021) closely to consider how to establish the "system through preparing monthly bulletin.

(Descriptions with blue letters should be handled further even after finishing this project.)

Step2: To try to enhance it, if possible, through additionally introducing the followings:

a) M-T diagrams

Expert should try to make a M-T diagram on **the right data or figure**.

Note 1: Example of M-T diagram can be seen in the documents, "202103sekai_jishin_kobetsu_1", and "202103tohoku_kobetsu_1".

Note2: The above M-T diagram excerpted from the document "Minutes of the virtual meeting held on 29Sep21 ver2" shows that the aftershock activity is gradually diminishing.

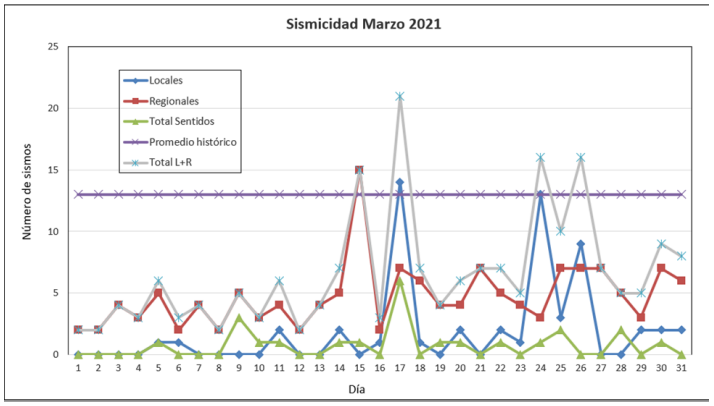


Figure 1: Behaviour of seismic activity during the month of March 2021, note the increase in the number of earthquakes on the 17th and 24th, corresponding to the seismicity to the west and east of the country.

b) Old large events

As shown in the document, 2. 202103nihon_jishin, the information on the "old" large events would contribute to consider any recurrence of thrust type events. Expert would try to introduce any tool to "analyze (select)" and draw such a kind of figures. The tool would be used to analyze the epicenter distirubion map of the appendix.

Step3: To prepare the procedures to handle the monthly seismic bulletin.

Step4: To implement the procedures as a trial and to make an actual bulletin.

Note: The information to be regularly or urgently issued to the public from MARN could be listed up as **below**. The list should be considered further to make the target of the above bulletins clear.

Earthquake bulletin list (Tentative as of 16Sep21)

Type	Feature		Name	Frequency	Timing	Authorization (Guideline)	Purpose (Output)		Target (Outcome)	
							Note: All are includoing tsunami.	Mainly for who?	Disaster prevention	Others
1	Emergent information			Irregularly issuing	Just after occurrence of disastrous earthquakes	Tsunami Protocol Earthquake Protocol (*Daily activity list*) (*guideline to be considered*)	1 To identify the damaged area and the size of disaster as soon as possible	First aid organizations	Contribute to disaster prevention	Support the first aid
2	Emergent information	Additional If necessary		Irregularly issuing	After issuance of emergent information		2 To make DGPC and the public understand the feature of the event	DGPC The public		Contribute to disaster mitigation
3	Technical Information		Informe_Tecnico	Irregularly issuing	The internal protocol says its issuance frequency as follows: **Notice: more than 0; Warnig: 1 / day; Alert: 2 / day; Emergency: more than 2 / day**	**Earthquake Protocol** (*template to be considered*)	3 To properly consider occurrence of any additional large disastrous event	DGPC		Cultivate reliability of MARN in the society
							4 To contribute to the scientific society	Scientist		
4	Newsletter	Monthly newsletter		Monthly issuing	Within 10 days from the end of the month		5 To understand the state of seismic stress distribution	MARN		Have the chance of OJT
							6 To cultivate the knowledge of the DGPC and the public for understanding seismic stress distribution	DGPC The public		
5	Explanation of the basic knowledge on earthquakes	Including the information issued from MARN	MARN Guidebook	Always shown (updating)	Just when any change is made in duty works of MARN or is developed in scientific knowledge		7 To cultivate the knowledge of the DGPC and the public for understanding the meaning of the information issued from MARN	DGPC The public		

-> Expert has prepared the document, "**Self-training System as of 05Mar23**". It is accepted and will be followed by MARN.

2) The seismic and tsunami catalogue should be established.

-> Expert has prepared the document, "**existing catalogue as of 10Feb23**", to support the establishment of the seismic and tsunami catalogue.

3) Self-training materials should be prepared.

-> Expert has prepared the document, "**How to handle CMT 16Mar23**" and "**How to use initial motion focal mechanism as of 15Mar23**", that include self-training materials.

(Descriptions with blue letters should be handled further even after finishing this project.)

2. Consideration on the "self-training system" (Target 1-2-f-8)

Detail of the target

To verify the latest status of the "Consideration on the self-training system" that has been left without confirming in Phase 1.

Criterion: Regarding the training system for maintaining and further improving the technical level of the tsunami monitoring shift officers, MARN should invite outsiders (CTC[1], UES students, etc.) to participate in this activity.

Status

Expert has made no action on the issue.

Challenges

Expert and MARN have considered the issue, and we have had the conclusion that we should not invite outsiders under the "pandemic". In the future, we will review the situation of the pandemic and the operation status of the self-training system, including how to respond.

3. Establishment of the MARN guidebook to make DGPC and the people properly use the information sent from MARN (Element 4) (Target 1-2-f-2)

Detail of the target

To check if the Guidebook has been made and been used for the purpose explained **the below note**, any material, which explains the contents of the information, its issuance timing and its issuance tool, would be helpful for the populations.

Criterion: The establishment should be confirmed.

Note: The Expert understands that the Tsunami advisory/information and other seismic disaster prevention information issued from MARN should be used properly by the people who need to protect themselves from the threat generated by any hazardous phenomena. In order to make them do so, the issued information should be understood properly by the people and DGPC.

Status

It was made. **See the right column**, which is now obtained from the MARN's web[2].

Expert has made "Outline to update the MANR seismic and tsunami Guidebook as of 12Aug22ver2" based on the results from the current status of tsunami countermeasures in coastal areas. Further, it was decided to prepare an updated version and a digest version for schools, and to consider providing the latter on SNS.

Challenges:

1) We should update the 2017 version.

2) The ISC issue (see the Appendix 4) and the Tsunami Flag issue (see the Appendix 6) might be better for us to show them in the guidebook.

3) Based on the results from surveying the status of tsunami countermeasures in coastal areas through visiting there, it was decided to make a digest version for schools when we prepare an updated version, and to consider posting the digest one on SNS.

-> Regarding challenge 1: we have made the 2023 version.

-> Regarding challenge 2: we are not able to include ISC and Tsunami Flag. So, we should consider implementing the issue by chance like when preparing the 2023 version for web of MARN.

-> Regarding challenge 3: we should further consider implementing the issue.

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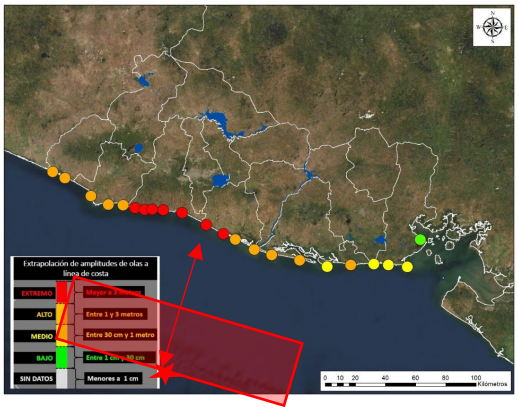
[1] CTC: Scientific Technical Commission made up of specialists in the area, from institutions such as Civil Protection, Universities, Government Institutions.

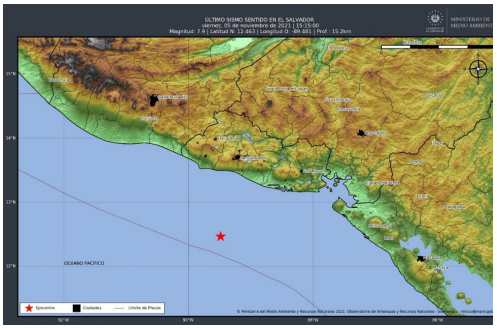
[2] https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/
Guía de sismos y tsunamis 2017 | CIDOC Virtual<https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/>

Appendix 1 Tsunami Chart

Cálculo de alturas de ola esperada e impacto asociado sobre municipios costeros, tras la ocurrencia de sismo mag. 7.9, frente a la costa de La Libertad. [2021-11-05, 15:15:00].
Calculation of expected wave heights and associated impact on coastal municipalities, after the occurrence of earthquake mag. 7.9, off the coast of La Libertad. [2021-11-05, 15:15:00].



DATOS FINALES: Sismo Mag. Revisada: 7.9, frente a la costa de La Libertad. A 110.0 km al suroeste de Playa Las Hojas. Prof. 15 km. [2021-11-05, 15:15:00]. ACTUALIZACIÓN: Se mantiene la Posible amenaza ALTA de tsunami para El Salvador.
FINAL DATA: Mag earthquake. Revised: 7.9, off the coast of La Libertad. 110.0 km southwest of Playa Las Hojas. Prof. 15 km. [2021-11-05, 15:15:00]. UPDATE: The Possible HIGH tsunami threat to El Salvador remains.



Tsunami chart that used by JMA around 1977 – 1987 ***(Note: the criteria should be reviewed.)***
If M is 8.0, Tsunami warning should be issued to the area within 386 km, and Big tsunami warning should be issued to the area within 236 km.

Legend
震央からの距離: Epicentral distance km
マグニチュード: Magnitude
オオツナミ: Big tsunami warning H≧3m
ツナミ: Tsunami warning H≧1 – 0.8 m
ツナミチュウイ: Tsunami advisory H < 0.8m
ツナミナシ: No tsunami H = 0.0m

From MARN Guidebook 2017

M	U (m)	L (km)
7.8	6.31	112.20
7.9	7.08	125.89
8	7.94	141.25

Appendix 2 Any tool for analysing the seismic activity
https://www.jma.go.jp/jma/press/2202/08a/2201kyusyu.pdf

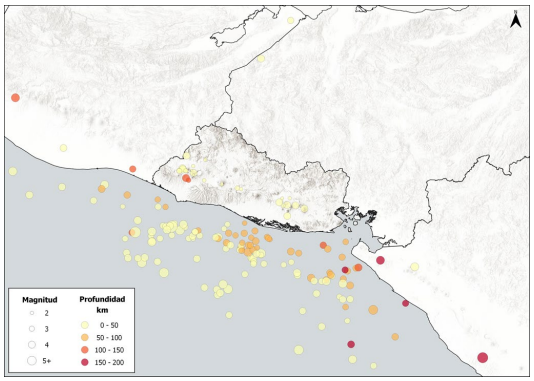
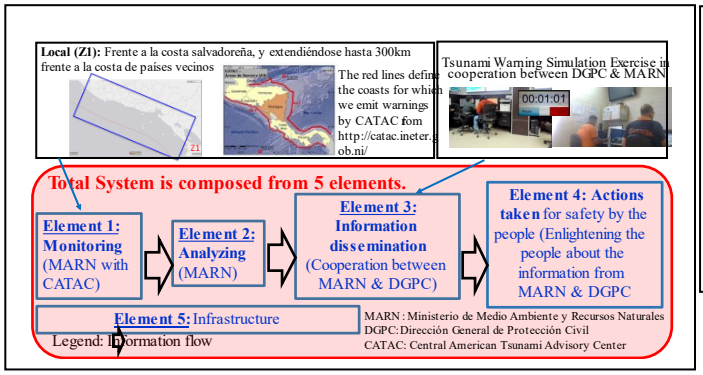


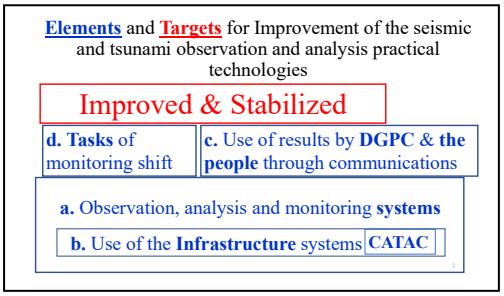
Figura 2: Mapa de sismos localizados en marzo de 2021. Obsérvese la sismicidad frente a la costa del departamento de La Paz, Sonsonate y Usulután, y dentro del territorio, al occidente y oriente del país.

Excerpt from Boletin Mensual de Actividad Sísmica - Marzo 2021

(Descriptions with blue letters should be handled further even after finishing this project.)

Appendix 3 What are “Elements”?





Appendix 4 ISC

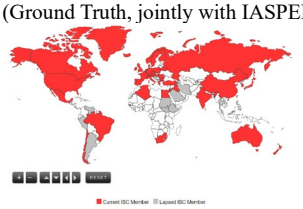
MARN mentioned that **MARN was regularly providing data to ISC**. Expert mentioned that then we didn’t need to become “member of ISC”, because MARN was contributing already to the world by the action.

http://www.isc.ac.uk/ **About the International Seismological Centre**

ISC was set up in 1964 with the assistance of UNESCO as a successor to the International Seismological Summary to follow up the pioneering work of Prof. John Milne and Sir Harold Jeffreys in collecting, archiving and processing seismic station and network bulletins and preparing and distributing the definitive summary of world seismicity.

Under the umbrella of the IASPEI, ISC always played a role in setting up international standards such as the International Seismic bulletin Format, the IASPEI Standard Seismic Phase List and the IASPEI Manual of the Seismological Observatory Practice. **The ISC was always serving the scientific research**.

The current mission of the ISC is to maintain: 1) ISC Bulletin – the longest continuous definitive summary of World seismicity; 2) International Seismographic Station Registry (jointly with NEIC/USGS); 3) IASPEI Reference Event List (Ground Truth, jointly with IASPEI).



Appendix 5 Tsunami Flag

Points to note when operating tsunami flags

As a result of continuing to communicate tsunami flags in operation, such as waving tsunami flags, evacuation of the implementers should not be delayed. Depending on where the earthquake occurred, a tsunami may hit the coast without time. For this reason, only in cases where the safety of the person who carried out the transmission is ensured, the flags should be used. And it is important that the implementer of this transmission fully recognizes this and fully informs users of the beach.

Note 1: Tsunami Flag Specifications

1) It has been proposed that **the size** should be at least 100 cm on the short side, but there is no provision. This will be judged based on the size of the coast.

2) **Red** is not a detailed color specification.

3) The **checkered pattern** is similar to the "U flag", which is one of international maritime signal flags.

Note 2: The international maritime signal flag is a universal flag used to communicate between ships on the sea. The usage is determined by the International Code of Signals (INTERCO), and the signal by the international maritime signal flags is called Flag Signaling.

Note 3: The U flag is an international signal flag that means "your ship path is at risk” and is used overseas as a flag to signal emergency evacuation from the sea. On the other hand, the U flag can be a different meaning when combined with other international signal flags. For example, if you use a combination of "U flag" and "W flag", it means "pray for safety navigation".

Note 4: Price of the flag A company in Japan shows 8000yen (70 US Dollars; ¥ 7300 & $ 63 without tax). Its size is 100cm×150cm. Its material is plain weave of polyester 100%.

(Descriptions with blue letters should be handled further even after finishing this project.)

Plan on the technology transfer & the training about
issuance tsunami advisory for disaster prevention including cooperation with DGPC
(Category 6)
in communications with users including DGPC (Element 3/c)

Prepared by Expert on 17Mar23
Approved by MARN on 17Mar23

Element 3/c: "Communications with users including DGPC"
Category 6: issuance tsunami advisory for disaster prevention including cooperation with DGPC
1-2-f-3 Introduction of the daily inspection of radio, fax, and email as the authorized transmission methods to DGPC
3 Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC

1. Introduction of the daily inspection of radio, fax, and email as the authorized transmission methods to DGPC (Target 1-2-f-3)

Detail of the target

To verify the latest status of the "Introduction of the daily inspection of radio, fax, and email as the authorized transmission methods to DGPC" that has been left without confirming in Phase 1.
Criterion: The introduction should be confirmed.

Status

In the last year tsunami drill conducted on 05Nov21, the tools for issuance of tsunami warning to DGPC were set as shown in **the right column**. In the 3rd week of March in 2022, a trial use of the inspection list for communication tools in daily monitoring work was done. Its procedures are prepared in the documents, "**Memo for conducting a trial use of the inspection list for DGPC as of 07Mar22**". And the latest "**Inspection checklist on communication tools between DGPC and MARN"** is the 15Aug22 version. **See the below column.**

Herramientas a utilizar en el ejercicio del 05Nov21

Time of issuance	Actual	Type	Elapsed time from OT	Tools for issuance to DGPC			
			Actual	radio ->	fax ->	SMS ->	SNS
3:15		**Start message**	**0 min**	**Actual**	**Actual**		
3:17	1	Calm message	2 min	Actual		virtual	virtual
3:18			3 min	Actual			
3:19	2	Preliminary message	4 min		Actual		
3:27			5 min			virtual	virtual
3:25			***10 min***	***Actual***			
3:26	***3***	***Tsunami message***	***11 min***		***Actual***		
3:27			***12 min***			***virtual***	***virtual***
3:30			***15 min***	***Actual***			
3:31	***4***	***Updated message***	***16 min***		***Actual***		
3:32			***17 min***			***virtual***	***virtual***
3:15 - 3:45		**Cancellation of the Exercise**	**Depend**	**Depend**	**Depend**		
3:43		Tsunami message	28 - 30 min	virtual	virtual	virtual	virtual
3:45	5	Cancellation message	30 min	Actual	Actual	virtual	virtual
3:46		**End message**	**31 min**	**Actual**	**Actual**		

Lista de verificación para que DGPC inspeccione las herramientas de comunicación entre MARN y DGPC ver.2
(Nota: los siguientes "elementos a verificar" deben ser los de las comunicaciones entre MARN y DGPC. Los elementos solo para la comunicación interna no deben aparecer en esta lista).
Fecha (fecha, mes): , **Hora de El Salvador 2022**

Estado	Herramienta	Elementos a comprobar	MARN	DGPC
Autorizado por ambos	Radio (Voz de "prueba")	Función	Conexió ☐Ok / ☐No	
Autorizado por ambos	Fax (Hoja de prueba)	Función	Conexió ☐Ok / ☐No	
		Papel		Certificado ☐Si / ☐No
Equipo esencial para el uso del fax	Impresora	Función		
		Papel		
A autorizar / Copia de seguridad para radio	WhatsApp (Voz de "prueba")	Función	Conexió ☐Ok / ☐No	
Autorizado por ambo	Email (Mensaje de "test from MARN")	Función	Emitido/Recibido ☐Ok / ☐No	
Autorizado por cada institución	MARN Twitter	Función		
	MARN Web-site	Función		
Autorizado por cada institución	DGPC Twitter	Función		Marcado ☐Ok / ☐No
	DGPC Web-site	Función		Marcado ☐Ok / ☐No

Lista de verificación para que MARN inspeccione las herramientas de comunicación entre MARN y DGPC ver.2
(Nota: los siguientes "elementos a verificar" deben ser los de las comunicaciones entre MARN y DGPC. Los elementos solo para la comunicación interna no deben aparecer en esta lista).
Fecha (fecha, mes): , **Hora de El Salvador 2022**

Estado	Herramienta	Elementos a comprobar	MARN	DGPC
Autorizado por ambos	Radio (Voz de "prueba")	Función	Conexió ☐Ok / ☐No	
Autorizado por ambos	Fax (Hoja de prueba)	Función	Conexió ☐Ok / ☐No	
		Papel	Certificado ☐Si / ☐No	
Equipo esencial para el uso del fax	Impresora	Función	Certificado ☐Si / ☐No	
		Papel	Certificado ☐Si / ☐No	
A autorizar / Copia de seguridad para radio	WhatsApp (Voz de "prueba")	Función	Conexió ☐Ok / ☐No	
Autorizado por ambo	Email (Mensaje de "test from MARN")	Función	Emitido/Recibido ☐Ok / ☐No	
Autorizado por cada institución	MARN Twitter	Función	Marcado ☐Ok / ☐No	
	MARN Web-site	Función	Marcado ☐Ok / ☐No	
Autorizado por cada institución	DGPC Twitter	Función		
	DGPC Web-site	Función		

Based on the results[1] from grasping the current situation of the facilities of the DGPC headquarters and its Monitoring Center on 01Jul22, and the results[2] from observing the handover process of the monitoring shift in MARN on 05Jan22, it was decided to make

[1] The results are wrapped up in the document, "**Draft minutes of the meeting with DGPC held on 01Jul22 only with Spanish ver2**"
[2] The results are wrapped up in the document, "**Results from observation of the shift takeover process as of 26Jul22**"

(Descriptions with blue letters should be handled further even after finishing this project.)

proposals on any revision of **the official tsunami protocol** (hereinafter called the Protocol) to set it in line with the actual situation about the authorized transmission methods to DGPC.

Challenges

We should take below actions:

1) To establish the procedures to daily inspect the authorized transmission methods for DGPC based on the "**Memo for conducting a trial use of the inspection list for DGPC as of 07Mar22**",

2) To revise the Protocol according to the actual situation,

3) To get confirmation from DGPC on the status of the authorized transmission methods to DGPC.

-> Regarding the **above challenge 1**, as mentioned in the documents, "**Draft minutes of the workshop held on 24Jan23**" and "**Guideline for how to proceed with the Tsunami Monitoring Duty in El Salvador**", like "The idea on the regular inspection of the official communications tools has been understood in the workshop" and "the inspection of communication tools should be carried out with the checklist --- through asking DGPC to take actions together with MARN on every Monday, Wednesday, and Friday around 07:30 am", it will be expected to be solved, even though it is not yet fixed.

-> Regarding the **above challenge 2**, it is also expected to be solved after establishing the above procedures.

-> Regarding the **above challenge 3**, the above "**Draft minutes of the workshop held on 24Jan23"** is being considered by DGPC, so it is also expected to be solved.

2. Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC (Target 3)

Detail of the target

To verify the latest status of the "Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC" that has been left without confirming in Phase 1.

Messages to be issued from MARN to DGPC in the tsunami simulation exercise on 05Nov21

Time of issuance	Actual	Type	Elapsed time from OT		Contents of Information (Controlled or Automatic)	Purpose of issuance	Description in the message (To be elaborated further)
			Virtual	Actual			
3:15	**Start message**			**0 min**	**Start of the exercise (C)**	**To inform the start of the exercise**	**The exercise start.**
3:17	1	Calm message	< 2 min	2 min	Felt, occurrence of earthquake (A)	To calm the pubic	Preliminary parameters of the earthquake felt in Salvadoran territory will be released shortly.
3:18	2	Preliminary message	< 3 min	3 min	Preliminary M and the epicenter location (A, C)	To tell how to consider the event (Local; 7.8 = high tsunami threat)	Seismic magnitude 7.8, off the coast of El Salvador; there is a high ttsunami hreat.
3:19			< 4 min	4 min			
3:27			< 5 min	5 min			
3:25	***3***	***Tsunami message***	***< 10 min***	***10 min***	***Judgement on the tsunami threat (A,C)***	***To tell if we should evacuate immediately***	***There is high tsunami threat to El Salvador. The waves will begin to reach El Salvador by 03:43 on 2021-11-05.***
3:26			***< 11 min***	***11 min***			
3:27			***< 12 min***	***12 min***			
3:30	***4***	***Updated message***	***< 15 min***	***15 min***	***Updated seismic parameter with the epicenter map with CMT/Mw (C)***	***To tell how to consider the event (7.9 = high tsunami threat)***	***Seismic magnitude 7.9, off the coast of El Salvador 110 km south of La Libertad. Depth 15 km. The waves could be greater than 3 meters along the entire Salvadoran coast.***
3:31			***< 16 min***	***16 min***			
3:32			***< 17 min***	***17 min***			
3:15 - 3:45	**Cancellation of the Exercise**			**Depend**	**Cancellation of the exercise due to any contingent issue (C)**	**To stop the exercise**	**The exercise should stop immediately.**
3:43		Tsunami message	< 35 min	28 - 30 min	Observation of tsunami (C)	To tell if we should evacuate further	Tsunami has been observed at La Libertad.
3:45	5	Cancellation message	2 hours	30 min	Judgement on the tsunami advisory cancellation (C)	To tell that we cancel the advisory	Earthquake 11/05/2021, 14:15 SV time, Salvadorian coast, Mag. 7.9, tsunami threat to El Salvador is cancelled. However, it is recommended to stay away from the beaches for several hours.
3:46	**End message**			**31 min**	**End of the exercise (C)**	**To inform the endt of the exercise**	**The exercise has been finished.**

(Descriptions with blue letters should be handled further even after finishing this project.)

Criterion: It should be confirmed that the protocols and procedures on tsunami threat in use by MARN and DGPC should be reinforced.

Status

1) On 05Nov21, tsunami simulation exercise together with DGPC was done. The result is sorted out in the document, "**Result of tsunami exercise of DGPC and MARN on 05Nov21 as of 18Feb22**". **See the above list** that was prepared for the exercise.

2) On 22Jan22, workshop co-hosted by MARN and DGPC was done. The result is sorted out in the document, "**Minutes of the workshop held on 25Jan22ver2**". The tentative conclusions were as follows:

a) We conduct at least once a year joint tsunami simulation exercise. / b) As for the next exercise, we will bring it closer to reality with the participation of one or two municipalities such as La Libertad. / c) Every year after the exercise, workshops are held to confirm the results of exercise and to understand the improvement points of tsunami response operations. / d) We should continue to consider the current challenges related to "collaboration between DGPC and MARN"; and we should get solutions before the next tsunami simulation exercise.

3) On 22Feb22, remote meeting with DGPC was held to discuss how to handle non-earthquake tsunamis and to review the actions taken until the day to reinforce protocols and procedures on tsunami threat. The result is sorted out in the document, "**Draft minutes of the virtual meeting with DGPC held on 22Feb22ver2**".

4) On 01Jul22, the visit and the talk on the tsunami handling under cooperation between DGPC and MARN were held to grasp the status of facilities of the DGPC headquarters and its Monitoring Center. Those results are sorted out in the document, **"Draft minutes of the meeting with DGPC held on 01Jul22"**.

5) On 26Aug22, tsunami celebrations at Isla de Mendez (Jiquilisco) were held by the local DGPC. MARN made some cooperative actions as shown in **the below "Time schedule of the program"**.

Aim of Celebration
1) Remembering what happened (at 22:47 or 10:37 pm on 26Aug12).
2) Why it happened,
3) What have been the advances of the community to mitigate the risk of tsunami, but above all,
4) What we need to deal with the next tsunami in the best possible way.

Time schedule of the program (TENTATIVE AGENDA as of 19Aug22)

09:00 Open
10:00 Start
1. Welcoming remarks, Gabriel Chávez, President of the Communal Civil Protection Commission (3 min)
2. Words Alluding to the event, Roberto Misael Pérez, Mayor Jiquilisco (5 min/8min)
3. Prayer, Pastor Francisco Gómez, Universal Prophecy Church (3 min/11 min)
4. Projection of videos, comments, and reflections: MARN Technicians.
   Video 1: Ready we drink to be (7 min projection and 3 min comments /21 min)
   https://drive.google.com/file/d/1AzysZwJyRrs_7k8ta5wkRe8458a11QH1/view?usp=sharing
   Video 2: The Power of Knowing (5 min screening, 3 min of commentary, here emphasize that the community hold commemorative events on August 26 /29 min).
   https://drive.google.com/file/d/1Gqm56Vvy4bw8MgzZPTg9GMx5YxMpT1Ed/view?usp=sharing
   Video 3: Lessons that save lives (5 min screening, 3 min of commentary /37 min)
   https://drive.google.com/file/d/1BfGDVKTYuCjS2uJgalScGmGZX_y_BiYj/view?usp=sharing

10:37
5. Testimonies of 5 inhabitants of the Isla de Méndez community who survived the tsunami of 2012 (30 min/1 hour 7 min)

11:07
6. Delivery of a wheelchair (3 min/1 hour 10 min), courtesy of the municipality of Jiquilisco.
7. Lessons learned from other tsunamis in the world and the Méndez Island tsunami, MARN technicians (10 min/1 hour 20 min)
8. Projects or actions carried out to mitigate the risk of tsunamis. MARN Technicians (10 min/1 hour 30 min), including
   1) the construction of a shelter for vertical evacuation,
   2) signaling of evacuation routes and installation of sirens,
   3) improvements in the earthquake/tsunami monitoring network and dissemination of tsunami threat warnings (here we can rely on the data presented in the triptych),
   4) capacity building for earthquake/tsunami analysis (JICA project).
   Accreditation of the communal commissions of Civil Protection.

11:30
9. How we can prepare to face the next tsunami, following the guidelines of the UNESCO tsunami ready programme, MARN technician (10 min/1hour 40 min) - Here it will be proposed to carry out a drill on o5Nov22 (World Tsunami Awareness Day).
10. Open microphone for three public comments (10 min/1hour 50 min)
11. Closing remarks, Javier Torres, municipal delegate of civil protection (3 min/1hour 53 min)

11:53
12. Deliver refreshments (Courtesy of JICA)

12:00 End
(Note: If MARN has spare "tsunami Guidebooks", MARN might present them to the survivors.)

Participants expected to attend
Organizer and supporter: President of the Communal Commission for Civil Protection, MARN
Special Guest: 1. Mayor of Jiquilisco, 2. Departmental Governor, 3. Director General of Civil Protection, 4. Civil Protection Coordinator, Usulután, 5. Red Cross of Jiquilisco, 6. Usulutan Red Cross, 7. Mangrove Radio, 8. Mr. Gustavo Guerrero, 9. Director of the Pablo Tesak Institute/ Comité from School Protection, 10. Directer C. E. Gustavo Guerrero/Comité de Protección Escolar, 11. Director C. E. El Llano/School Protection Committee, 12. Director C. E. /C. Civil Protection School, Ceiba Doblada, 13. Méndez Island Health Unit, 14. Civil National Police, 15. Pastor Universal Prophecy Church, 16. President ADESCO, 17. Zonal Education Coordinator
Local people: community leaders, siren-managers
(Note: At least five students for each school is expected to attend.)

6) MARN has requested CATAC to add the addresses of DGPC on 24Aug22 at 08:53 AM JST and 05Oct22 at 4:27 AM JST. So, the latest CATAC message received on 13Oct22 at 09:00 AM JST have the addresses in it. See **the below column**.

-----Original Message-----
From: CATAC <catac@ineter.gob.ni>
Sent: Thursday, October 13, 2022 9:00 AM
To: jrmartinez@proteccioncivil.gob.sv; rgonzalez@proteccioncivil.gob.sv; lmontenegro@proteccioncivil.gob.sv; fperez@proteccioncivil.gob.sv; lamaya@proteccioncivil.gob.sv; indireccion@insivumeh.gob.gt; jpoliva@insivumeh.gob.gt; geofisica.informa@insivumeh.gob.gt; alfa.boletines@insivumeh.gob.gt; robin.yani@insivumeh.gob.gt; mori@jmbsc.or.jp; luis.menjivar@marn.gob.sv; sismologia@marn.gob.sv; deslizamientos@marn.gob.sv; cph@marn.gob.sv; gmarroquin@marn.gob.sv; ahernandez@marn.gob.sv; mdiaz@marn.gob.sv; fgavidia@marn.gob.sv; franciscogavidia@hotmail.com; mgmarroquin@yahoo.com; douglas_hc@yahoo.com; mrdiazflores@hotmail.com
Cc: echichaco@yahoo.com; martincito1968@yahoo.com; dngpr2016@gmail.com; oscaririas2002@yahoo.com; oscarmencia@copeco.gob.hn; sismologia@gf.ineter.gob.ni; wilfried.strauch@yahoo.com; ineter.tsunami@ineter.gob.ni; sismologia.ineter@gmail.com; rogeliodcen@yahoo.es; ggonzalez@sinapred.gob.ni; secretariaejecutiva@sinapred.gob.ni; sinamot.cr@gmail.com; silviach@una.ac.cr; sinamot@una.cr; tsunamis.panama@up.ac.pa; rababolanos@gmail.com; control1h@gmail.com; coepanama@gmail.com; tsunami@bomberos.qob.pa; mathytorres@hotmail.com; mtorres@bomberos.gob.pa; asanchez@amp.gob.pa; emilio.talavera@ineter.gob.ni
Subject: Mensaje_dummy CATAC-PacWave22

CENTRO DE ASESORAMIENTO DE TSUNAMI PARA AMIRICA CENTRAL (CATAC)
****
PRUEBA DE COMUNICACIONES CATAC PARA EL EJERCICIO PACIFIC WAVE 2022
EMITIDO POR CATAC (INETER)

EMITIDO: 13 DE OCTUBRE 2022 00:00 UTC
12 DE OCTUBRE 2022 18:00 HORA DE CENTROAMERICA
12 DE OCTUBRE 2022 19:00 HORA DE PANAMA

ESTE ES UN MENSAJE DE PRUEBA PARA EL EJERCICIO PACIFIC WAVE 2022.

ESTE MENSAJE ES PARA PRUEBAS ZNICAMENTE.

ESTE MENSAJE DE PRUEBA SE HA ENVIADO A CADA ORGANIZACISN BENEFICIARIA PARA PROBAR LA RECEPCISN DE MENSAJES CATAC, COMO PARTE DEL EJERCICIO PACIFIC WAVE (PACWAVE) 22.

SE REQUIERE SU ACCISN.

TENGA EN CUENTA LA HORA EN QUE RECIBE ESTE MENSAJE Y EL (LOS) MITODO (S) POR EL CUAL USTED RECIBE ESTE MENSAJE, E INFORME A TRAVIS DE LA ENCUESTA DE EVALUACISN EN LMNEA POST-EJERCICIO DE PACWAVE22 A PARTIR DEL 23 DE OCTUBRE DE 2022.

Challenges

1) MARN and DGPC need to regularly conduct cooperative works shown as follows:
   a) Annual implementation of **tsunami simulation exercises**
   b) Annual holding of the **workshops** to review the tsunami simulation exercises and the status of the improvement of the tsunami warning system of El Salvador
   c) Effective usage of the information from CATAC
   d) Sharing the tsunami handling procedures among us (**See the top column in the next page.)**
   e) Continuous handling of the remained challenges.
2) Common procedures in tsunami warning handling should be established according to the comment made by the DG of DGPC at the meeting on 01Jul22.
3) Establishment of the common procedures on how to cancel tsunami warning properly (**See the bottom column in the next page** that is excerpt from DGPC procedures.).

-> Regarding the above challenges 1), 2) and 3), MARN and DGPC had a **tsunami simulation exercise** on **22Nov22** and a **workshop** on **24Jan23** as explained in the document, "**Draft minutes of the Workshop to review and plan the tsunami simulation exercise co-hosted by DGPC and MARN**". At the latest workshop, the **above items 1-c), 1-d), 1-e), 2) and 3)** were considered, so we can expect that the common procedures in tsunami warning handling and in the cancellation could be established in the future.

Timeline in the Guideline as of 14Mar23

Tables of actions against the events with Magnitude 6.5 or larger
(for "Aviso y Alerta de Tsunami" for LOCAL (Z1); the red actions are the main body of this table.)

Elapsed time (min)	Status of the environment	Procedures to be started by the elapsed time	
		Actions taken by Seismic shift	Actions taken by Landslide shift
0	Occurrence of an earthquake (Origin Time (OT) = Time of detecting the event - around 10 sec): Starting the procedures		
1	Given observed seismic waveforms of any stations		
2	Given automatic hypocenter & M	Issuing and disseminating **Calm message** via radio, WhatsApp (fax), Twitter	Checking information in CISN
3		Selecting hypocenter & M according to the criteria based on data number & average RMS Checking consistency with other information collected until this timing	
5	Receiving seismic parameters & tsunami potential level from outside	Issuing **Preliminary message** with checked M, epicenter location, indication of tsunami threat, and any term to tell what to do, via radio & WhatsApp (fax); disseminating it via Twitter & Web Issuing and disseminating **Tsunami Bulletin 1** with estimated tsunami arrival times (ETA) via radio, WhatsApp (fax), email, Twitter & Web	Responding to supervisors and to the public
		Evaluating the latest hypocenter according to **the criteria** / Calculating manually seismic parameters / Selecting M according to **the criteria**	
10		Issuing **Final message** with degree of tsunami threat via radio & WhatsApp (fax); disseminating it via Twitter & Web	
10-20		Assessing the information from CATAC, PTWC, USGS and other outside organizations; judging necessity of updating the information; disclosing the information by adding to the Tsunami bulletin	Issuing and disseminating **Tsunami Bulletin 2** with seismic parameters, degree of tsunami threat, ETA , and estimated tsunami height via WhatsApp, fax, email, Twitter & Web
15	Getting Mw from CMT	Judging necessity of change of tsunami degree based on the Mw / **If necessary,** issuing and disseminating the message with updated information via WhatsApp (fax), Twitter & Web	Checking the information in the Twitter & Web / Sea level gauges are monitored with Tide Tool (arrival times and heights)/ Disseminating **the data** via Twitter &Web / **Informing authorities of the CMA** / Communicating with officials in the coastal zone / Monitoring the information in international agencies, media, twitter & web
15-20		Issuing & disseminating **the ShakeMap** with WhatsApp (fax) Twitter & Web	
		Locating aftershocks manually	
20-30		Addressing media	

Note 1: Issuance & dissemination of Preliminary and Final messages are handled separately by Seismic and Landslide officers now. But when we introduce the "GUI" developed into the procedures, Issuance & dissemination would be done together by Seismic officer.
Note 2: The parentheses for fax like "WhatsApp (fax)" means that "fax" should be redundancy for "WhatsApp".

10. FLUJOGRAMA
Los flujogramas están dados a partir de las etapas del SAT ante tsunami, siguiendo este las acciones que realiza la institución en el manejo del evento, identificadas como:
a. Monitoreo ante tsunami
b. Nivel de Alerta ante tsunami
c. Divulgación de la declaratoria de alerta ante tsunami
d. Activación de la Respuesta ante tsunami
e. **Cancelación:** Dejar sin efecto la declaratoria de alerta
SAT significa Sistema de Alerta Temprana.

10. FLOW CHART
The flowcharts are given from the stages of the EWS before a tsunami, following this the actions that the institution performs in handling the event, identified as:
to. tsunami monitoring
b. Tsunami alert level
c. Dissemination of the tsunami warning declaration
d. Tsunami Response Activation
and. **Cancellation**: Leave the declaration of alert without effect
EWS stands for Early Warning System.

4) To discuss how to monitor the local people response in the Workshop.
-> Regarding the above challenge 4), we can expect that it would be considered in the regular workshop, if necessary.

(Descriptions with blue letters should be handled further even after finishing this project.)

5) The below 2 columns show challenges.

MARN internal challenges

5) As for the Assessment of the drill,
Observation 4 "information sending panel" should resolved by preparing opportunity when shift officers could take its training. The preparation would be considered by MARN. Further, it would be resolved by introducing the applications that are under consideration in procurement
Observation 6 "checking the values of TIDETOOLs and also a strong training in the interpretation of measurement differences in wave heights" should resolved by preparing opportunity when shift officers could take its training. The preparation would be considered by MARN. Further, it would be resolved by new Workstation that is under procurement.
Idea against **Observation 7** "handling CMT properly" should resolved by preparing self-training materials that would be used by shift officers. Expert should try to develop the materials.
Idea against **Observation 8 &9** "As for drills, we could establish an annual goal of doing this type of exercise, and also a feedback process from the technicians" and "the identification of opportunities for improvement in each of the steps was evidenced. In addition, it was also possible to ensure the correct functioning of the "information delivery panel" tool." would need various scenarios. Expert should try to develop the series of Scenarios.

EWBS issue

6) Result 2-2: MARN has explained the "test of EWBS" under the EEW project and has provided the document with the below explanation in the column.

> In the following link, I have placed a report generated in the earthquake early warning project, on pages 21 to 24 you can find information on theEWBSs that Japan delivered to El Salvador within the framework of the JICA-SIGET project, as well as preliminary results of the tests that have been carried out to measure the delay times from the moment the earthquake occurs until it is transmitted by digital television.
> Now in El Salvador only digital television is broadcast for the Metropolitan Area of San Salvador.
> https://drive.google.com/file/d/1d2nbUUv5UPACyrUgdz9wSEqSuU0_LhYz/view?usp=sharing

Expert has updated the EWBS document made by himself. -> Expert thinks that EWBS could be used not only for EEW but also for Tsunami warning to the public. So, itmight be better for us to talk the idea of its usage for tsunami warning to DGPC.

-> Regarding MARN internal challenges, Observation 4 could be solved by introduction of the GUI newly developed. Observation 6 should be considered further. Observation 7 has been handled with the document, "**How to handle CMT 16Mar23**", prepared by Expert. Observations 8 & 9 have been handled with the document, "**Scenarios of tsunami simulation exercise as of 26Oct22**" and "**Series of Scenarios as of 24Jan23**".
-> Regarding EWBS issue, we can expect that it would be considered in the future regular workshop.

6) We should propose the tsunami drills according to the idea shown **in the below column.**

	Day	Tentative Time	Tentative Scenario		Organizer/Participants				Participants		Actions	
					DGPC		MARN	CATAC	Local government			
1	10-Oct-22	09:00-10:00	10-Oct-86	Off Usultan	Human Talent department.	○	○			Usultan	Issuance tsunami warning	Evacuation from the office
2	13-Oct-22	09:00-10:00	1-Sep-92	Off Nicaragua			○	CATAC			Issuance tsunami warning	
3	04Nov22 / 07Nov22	09:00-10:00		Off La Libertad		Monitoring Center	DGOA	○	La Libertad		Issuance tsunami warning	Hand over tsunami flag and Guidebook to DGPC beforehand

The above idea was produced based on the below information:

(Descriptions with blue letters should be handled further even after finishing this project.)

a) Information from DGPC **(See the below column.)**

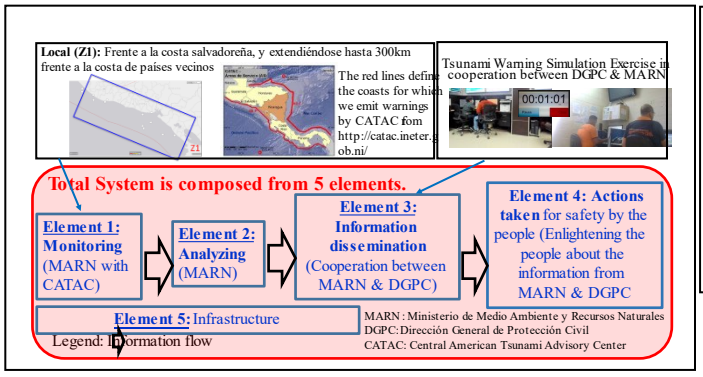
Wrap-up of the response from DGPC to MARN

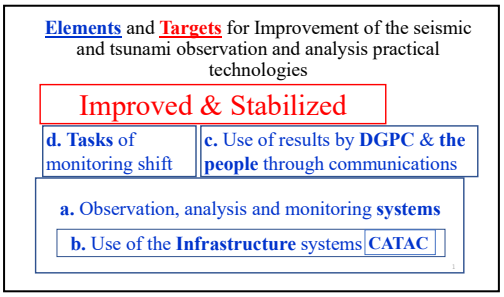
(DG of DGPC (Luis Alonso Amaya Duran), Head of Human Talent department (Jilma Lainez), CTS Scientific liaison)

1) If a drill is planned, as every year for October 10.
2) Regarding the same, according to what the Director General tells me, its planning is in charge of the Human Talent department.
3) The scenario used in recent years has been the earthquake of October 10, 1986.
4) It is appropriate to propose a scenario that includes local mechanisms, in the east and west of the country, with seismic swarms in the municipalities of Tecoluca, Berlin, Candelaria la Frontera, the San Miguel volcano and/or in other locations, where there are already historical records of their occurrence.
5) It is appropriate to propose a scenario to carry out the exercise with the tsunami ready municipalities.
6) We remain attentive and to any proposal that enriches this exercise

b) Information from "Exercise Pacific Wave 2022 Informational Webinar on13Sep22"
-> Regarding tsunami drills to be held in the future, we should keep in mind the above information like the comment from the DG of DGPC.

Appendix What are "Elements"?





(Descriptions with blue letters should be handled further even after finishing this project.)

Plan on the technology transfer & the training about
Recovery and backup (Category 4) and
Data and information acquisition including cooperation with CATAC (Category 5)"
in Use of the Infrastructure systems including "CATAC in Element 1" (Element 5/b)
Approved by MARN on 08Mar23
Revised by Expert on 09, 22Mar23

Category 4: recovery and backup
1-2-c Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network
1-2-e Establishment of backup for the tsunami warning system
Category 5: data and information acquisition including cooperation with CATAC
2 Promoted DGOA to share any information with CATAC
4-1 Use of the real time data of the GPS stations in the system in order to get accurate Mw earlier through observing W-phase with the data
EEW by Swiss (EWBS)

I. Recovery and backup (Category 4)

1. Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network (Target 1-2-c)

Detail of the target

To Verify the latest status of the introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network. **See the below column.**
Criterion: The Platform should be introduced into the maintenance of the seismic observation network.

c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network
The Platform project was once stopped but would restart soon. It would take care of the rapid recovery actions with the station network map. The Expert should continuously watch its progress from now.

- On the other hand, the rate of operation of the seismic network lookskept around 86% in recent years as shown in the below list.But it is 67% in 2020, if including the stations that are stoppin for a long period. T he main causes of the long outage s come from "GPS clock" down and "repeater" outage.
- The Expert should consider whether we have any measures to fix the outage earlier like 1) keeping spare equipment or 2) establishing the system to give us how to handle the issue like showing any "priority".

Tipo de alimentación	2015 (%dias funcionado)	2016 (%dias funcionado)	2017 (%dias funcionado)	2018 (%dias funcionado)	2019 (%dias funcionado)	2020 (%dias funcionado)
Promedio general	65%	74%	83%	82%	76%	67%
total estaciones	46	45	45	47	48	55
Estaciones no consideradas para promedio corregido (marcadas en amarillo) - ver justificación en notas	7	4	3	4	9	13
Promedio corregido	74%	81%	85%	88%	86%	84%

In order to introduce the recovery procedures with the Platform to effectively maintain seismic observation network (Sub-target 1-2-c).
Namely, the Platform should be monitored by the officers in the monitoring shift, who should try to keep the performance level according to the criterion that the operational rate should be higher than 86% (*to be reviewed*) through
1) dispatching offcers to the station to fix the outage earlier with spare equipment (to be prepared beforehad)
2) handling the issue based on the "priority".
It would take 9 months for manufacturing.

(Descriptions with blue letters should be handled further even after finishing this project.)

Status

The procurement of a new application to get Platform[1] (**See the below column**.) was dismissed

> **Seismic station network Platform specified with the functional specifications (Application for the development of software or graphic applications/dashboards)**
> To geterate computer applications with Seismic station network map on a screen (Platform) aimed at:
> 1) supporting monitoring officers to identify the status performance of the network at a glance,
> 2) urging them to take the rapid recovery actions with the station network map,
> 3) telling them how to do through showing the feature of the stations and the propirty of them.
> Specifications: Draft of Specifications om making Platform applicatoins for Seismic Network Monitoring 16Feb22

om 30Aug22 at 14:49 JST, because in the Platform Developer hiring issue, 1) the negotiation process was not successful as there was an important difference between the financial offers and the Predetermined Price, 2) due to time constraints, JICA has decided not to go through another process (modifying the content or scope of the derivable) as it is unlikely to have a product on time (before march/2023), 3) MARN has agreed not to go through.

Challenges.

We should consider how to achieve the target, to effectively maintain seismic observation network, without the "Platform" in our project together with MARN. -> The essence of the function of the "platform" is **1)** to detect any deterioration of seismic stations **earlier** and **2)** to understand **earlier the scale of its effect to the level of event detection and the accuracy of hypocenter & M determination**. Therefore, without the platform, a) we should steadily conduct checking seismic stations performance (**see the right column** showing the current checking list to be used in the daily handover process. It has the item of "Review Seismograms and Spectrograms".) through daily analysing seismic waveforms by monitoring shifts, and b) we should regularly review the station prioritisation criterion (**see the below column**.).

> ***Rough and tentative (to be regularly reviewed and revised)***
> Seismic station prioritization criterion
> 1 Location in thin distribution
> 2 With data relay function
> 3 Broadband
> 4 Short period
> 5 Acceleration

Checking list

CHEQUEO DEL TURNO SISMOLOGICO

Encargado: _____ Fecha: _____
Etapa: MONITOREO ○ PRE-AVISO ○ AVISO ○ ALERTA ○

Entrega de turno sismológico: Hora Entrega _____			
Recibió comentarios sobre el turno:	Si ☐	No ☐	
Reviso PC's y equipos:	Si ☐	No ☐	Horas:_____
Conteo de sismos turno anterior	Si ☐	No ☐	
Revisar Sismogramas y Espectrogramas	Si ☐	No ☐	Horas:_____
Informe de CAPRES (hasta nuevo aviso)	Si ☐	No ☐	Horas:_____
Envío de Informe Integrado	Si ☐	No ☐	Horas:_____
Envío de RSAM de VSM	Si ☐	No ☐	Horas:_____
REVISAR APLICACIONES			
CISN Display	Si ☐	No ☐	Horas:_____
Seisgram – SeisComp	Si ☐	No ☐	Horas:_____
Cámaras de Vigilancia	Si ☐	No ☐	Horas:_____
TideTools	Si ☐	No ☐	Horas:_____
Registró sismos (procesados)	Si ☐	No ☐	Nº:_____
Registró sismos sentidos:	Si ☐	No ☐	Nº:_____
Envió Informe por Twitter, SMS y Radio	Si ☐	No ☐	
Datos finales por Twitter, SMS y Radio	Si ☐	No ☐	
Registró evento(s) distal relevante	Si ☐	No ☐	Nº:_____
Recepción de información PTWC:	Si ☐	No ☐	
Elaboración de mapa TTT:	Si ☐	No ☐	
Chequeo de registro Tide Tools:	Si ☐	No ☐	
Envío de datos Twitter, SMS y Radio:	Si ☐	No ☐	
Sismicidad Local Importante:	Si ☐	No ☐	
Localización de sismicidad:			
Número de Eventos:			
Cambio de Etapa por evento:	Local ○	Regional ○	Distal ○ Volcán ○
Elaboración de página de conteo:			
Cambio a: Pre-Aviso: ○	Aviso: ○	Alerta: ○	Regreso a Monitoreo ○
Informe Especial:	Si ☐	No ☐	

2. Establishment of backup for the tsunami warning system (Target 1-2-e)

Detail of the target

To Verify the latest status of the establishment of backup for the tsunami warning system. In the Phase 1, the document, "**Duties for tsunami monitoring, Systems for them & Backup System or idea of backup (as of 28Sep17)**" (File name: **10Backup Systems**), was developed.

[1] The image of the Platform is explained in the ppt. "bosquejo-plataforma-desempeno-red-sismica", prepared by MARN.

Criterion: The backup should be established for the tsunami warning system.

Status

How to handle the evacuation from the building or the premises is remained. The issue could be handled with cooperation with CATAC. **See the below column.**

Updated from "Report of results from the remote activities for Phase 2 07Jul21"

1-2-e Establishment of backup for the tsunami warning system

The backup issue is achieved accordingly as follows:

- The building, where the seismic system and the monitoring shift staff are working, is the same during recent years or is earthquake-proof. So, it is safe against the strong motion/shake by earthquakes. Now it is being "repaired"; the "repairment" is not related to earthquake-proof function, though.
- The backup system is installed in the other building. On the other hand, one of the servers is needed to be duplicated. The server is requested in this Project.
- The internet congestion has not occurred after prioritizing the seismic line. On the other hand, the SNS like twitter for the public to get information issued from MARN has been experiencing a sort of "congestion" or response slowdown due to a surge of access when any remarkable earthquake occurred.
- The server system, where SeisCOMP3 is working, is configured to have the duplication like mirror site.
-As for the power supply issue, MARN has confirmed that a renewal plan of batterie had been established.

But the below items should be watched further:

-As for handling some slight possibility to evacuate from the building due to fire or something unknow, we should consider any measurement against the possibility.

-As for the case that the entire MARN should evacuate from the premises, we should discuss how to manage the case. One idea was that we should use any portable tool like a smart phone to get information sent from CATAC/PTWC and to issue tsunami warning to DGPC. (Note: The commercial internet line for receiving emails from CATAC and PTWC are duplicated or contracted with two companies. So, one of them could backup another.)

Additionally, MARN is now carrying out establishment of the contingency plan. The issue should be considered from establishment of backup for the tsunami warning system.

Challenges.

1) We should consider the remained issue: how to handle the status when we should evacuate from the monitoring center. -> We should use the information from CATAC with WhatsApp in the official smartphone equipped at the monitoring desk.
2) To make the contingency plan. See **the below column**.

From: Luis Ernesto Mixco Durán <lmixco@marn.gob.sv>
Sent: Wednesday, August 31, 2022 11:16 PM JST
Subject: Request for guidelines for adaptation a Seismological Monitoring Center
Dear Professor Mori
Since contingency plans are currently being carried out at MARN to withstand extreme events, such as earthquakes, floods, fires, etc. One of our facilities that has been identified as critical is the "Seismic Center", where we have all our servers and analogue transmission systems, radio, etc.
Then the IT department of MARN has requested information from us to be able to readjust this place in the best way and classify it as "safe, resilient" and that the important equipment used to carry out seismic monitoring functions is not damaged, and that after an earthquake (for example) does not suffer further damage.
With this introduction that I have made, the reason for this email is to ask you if you know (due to your experience in Japan or in other parts of the world), if there are any guidelines, protocols or standards of adaptation of seismic monitoring centers, which has already been endorsed, approved or already applied in a real seismological center.
In other words, these guidelines should list those best practices to adapt critical seismic monitoring equipment.
For example, that the entrance to the "Seismic Center" should has an access control, a surveillance system, a cooling system, etc. In addition, simpler things, such as not treating this place as a warehouse, obstacles that can fall and damage equipment, anchor furniture or server racks to fixed surfaces, etc. etc.
So, we would like to know if there is already a better elaborated document, where all these requirements are concentrated.

3) To wait for the update of tsunami system, SeisComP, at CATAC to start the discussion on the mutual backup issue. See the below description in **the Target 2**.

II. Data and information acquisition including cooperation with CATAC (Category 5)

1. Promoted DGOA to share any information with CATAC (Target 2)

Status

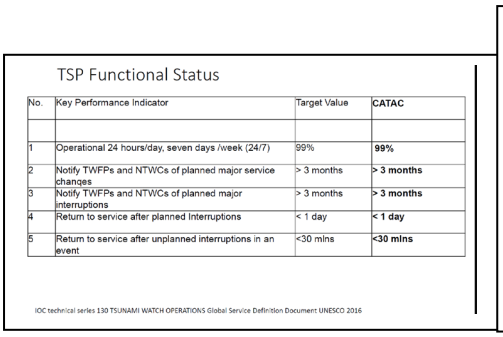
"Draft minutes of the virtual meeting with CATAC held on 04Mar22ver3", "**Memo for the talk via email as of 13Mar22**", and "**Draft minutes of the seminar with CATAC held on 07Feb23 as of 12Feb23**" show the status of the target 2. As mentioned in **the draft minutes of the seminar on 07Feb23**,

1) MARN and CATAC has discussed the below items proposed from CATAC:
   Item 1 To exchange "seismic and tsunami processing results" in real time
   Item 2 To unify processing parameters and definition of common event bulletin in a short time after the occurrence of earthquakes[2]
   Item 3 To install a permanent voice and video connection
   Item 4 To establish satellite internet connection between CATAC and MARN
   Item 5 To define that MARN could be the backup of CATAC in case of impact of earthquake or other events at CATAC.
2) MARN has finished updating the tsunami system, SeisComP, but CATAC has not yet finished it due to the budgetary issue for some software license.
3) CATAC has not received permission from the IOC to enter the official operation. But a sort of "full-scale test operation" has been started. And CATAC has shown its reliability to MARN.
4) CATAC has started series of webinars with the countries that CATAC should cover. MARN has been invited to one of the webinars held on 21Feb23.

Challenges.

At the seminar held on 07Feb23, MARN and CATAC have discussed, and its results shows as follows:

1) **As for Items 1 – 3 in the Status,** we have discussed with CATAC how to handle them. And we have agreed to discuss the issues further. Namely regarding item 1, we should make the below issues clear: the "specifications" of a) "getting them from CATAC in real time" and b) "providing them from MARN in real time" (Note: Specifications = Contents, Timing, Stability, Method's reliability, and its cost). Regarding item 2, it might be necessary to establish the procedures to unify seismic parameters through seeing the full spec trial of CATAC. Regarding item 3, we have tested Skype and WhatsApp and should develop the procedures on how to use them..
2) We have agreed to annually have a joint tsunami drill and a workshop to review the drill.
3) As for Item 4 in the Status, MARN has no budget to handle the establishment of the satellite internet connection, https://www.starlink.com/, between CATAC and MARN. But MARN has reconsidered it and has thought it might become an economical connection in the future.
4) As for Item 5 in the Status, MARN and Expert has been considering the conditions to be cleared for becoming "CATAC backup" as shown in **the below columns**.



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 changes	> 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 mins	**<30 mins**

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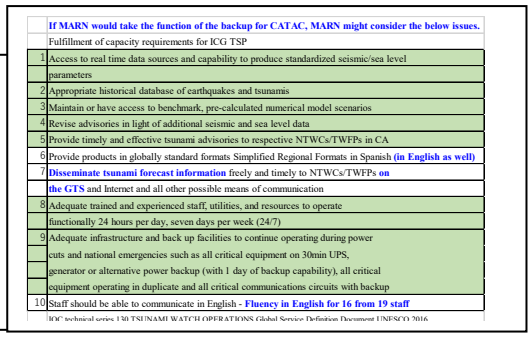

	If MARN would take the function of the backup for CATAC, MARN might consider the below issues.
	Fulfillment of capacity requirements for ICG TSP
1	Access to real time data sources and capability to produce standardized seismic/sea level parameters
2	Appropriate historical database of earthquakes and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

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[2] About unifying the parameter, MARN has mentioned that about 20 years ago, Nicaragua and El Salvador issued different magnitude independently that made confused the people. So, it might be better for us to consider the issue positively.

(Descriptions with blue letters should be handled further even after finishing this project.)

Then Expert has prepared the document, "**Backup of CATAC from Memo for the talk via email on 13Mar22 as of 22Aug22**" and has proposed the idea to DG of MARN on 23Aug22 at 10:11 AM JST with the agreement from the Colleagues. **See the below column**. Then, we have

Dear Director General of MARN (CC: Manuel),
Today MORI should report about cooperation with CATAC through defining that MARN should be the backup of CATAC. The issue is described in the attached document. And the essence of the proposal from MORI is as shown below.

How to handle becoming the backup for CATAC

1. Responsibility
   INETER should be responsible for the issuance of the "CATAC tsunami advisories", even if they take the action with the backup from MARN.
2. Works to be covered
   MARN should cover only the works that MARN can handle with the resources they have now.
   So, MARN would provide CATAC with the information issued from MARN.
   But MARN would also do passively with the results obtained from the MARN's SeisComP4.

Background explanation
In our JICA seismic and tsunami project, we have the target that it should be promoted that DGOA should share any information with CATAC. Therefore, we have been talking with CATAC through remote meetings about the "Cooperación entre CATAC y el MARN en el campo de sismología y tsunami". In the talks CATAC has proposed us several items as follows:

Item 1 To exchange "seismic and tsunami processing results" in real time
Item 2 To unify processing parameters and definition of common event bulletin in a short time after the occurrence of earthquakes
Item 3 To install a permanent voice and video connection
Item 4 To establish satellite internet connection between CATAC and MARN
Item 5 To define that MARN could be the backup of CATAC in case of impact of earthquake or other events at CATAC.

The above issue is the Item 5.

The proposal would not change the current duties of MARN. Further, when we should consider our SeisComP system should be connected to CATAC, we should explain you about how to manage the issue, particularly security issue. So, may we proceed with our talk with CATAC through following the above idea described in the attached document? If you think that MORI should explain the idea, would you please tell me?
Regards,
Shigeo MORI

Based on **the below challenges**, the below idea could be proposed.
Responsibility: INETER should be responsible for the issuance of the "CATAC tsunami advisories", even if they take the action with the backup from MARN.
Works to be covered: MARN should cover the works of CATAC that MARN can handle with the resources they have now. So, MARN would provide CATAC with the information issued from MARN and passively with the results obtained from the MARN's SeisComP4 by using the new feature in messaging system that handles exchanging parameter messages between different SeisComP modules during runtime.
Steps to become the backup:
Based on the above ideas, the below may be the practical steps:
Step 1 (Timing: soon) To install a permanent voice and video connection such as grouping in WhatsApp
Step 2 (Timing: after finishing the migration of SeisComP at CATAC) To try to exchange "seismic and tsunami processing results" in real time
Step 3 (Timing: after finishing Step 2) To try to cope with the information in the tsunami advisories
We should finish the Step 3 by the end of the Phase 2 project (at the end of March ,2023).
In the future beyond: To try to unify processing parameters and definition of common event bulletin in a short time after the occurrence of earthquake

3. Challenges
If we become CATAC itself as the CATAC backup, we should clear the conditions that should be our challenges. But if we become a CATAC supporter as the CATAC backup, we should just know the conditions to support CATAC more properly. And it should be better for us to understand **the User's Guide on the CATAC (Guía de Usuario)**. The latest version might be **"Draft vs. 20211125"**.

(Descriptions with blue letters should be handled further even after finishing this project.)

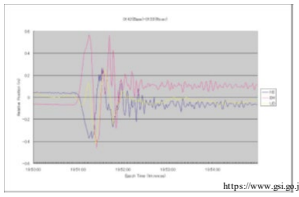
proposed the idea (see **the above column**.) to CATAC at the seminar on 07Feb23, and CATAC has approved the idea there. So, we should take the steps mentioned in the above column.

2. Use of the real time data of the GPS stations in the system in order to get accurate Mw earlier through observing W-phase with the data (Target 4-1)

Status

As for usage of GPS, we have considered to get the seismic waveform as seen in **the right column** with real-time GPS data from the stations #1 & #2 in **the below list.**

Ground displacement of the 2003 M8.0 Tokachi-Oki earthquake on September 26, 2003, observed by kinematic GPS with 1Hz sampling . It clearly shows static crustal displacements (offsets between 19:50 and 19:52) as well as long -period seismic waves.



https://www.gsi.go.jp/common/000040737.pdf

Then, we have been asking the Topcon dealer in El Salvador to provide us with the quotation to establish the sophisticated GPS system using the existing two GPS receivers. Further, we have been informed by Mexican professors and Chilean professors about the issue.

Expert should consider how to get real-time data from the stations #1 and #2.

Parámetros de estaciones GPS El Salvador (2018-2019-2020)

No.	COD-ID	Estation	Antenna Type	Receiver Type	How to get the data	Ref.	Sampling rate	Memory capacity in the receiver	Processing	Surveying type	positioning
1	LNUB	Las Nubes	TPSCR.G5	Topcon NetG3A	**Internet**	JICA	30 sec (1Hz can be used.)	15 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
2	ALAR	Lomas de Alarcón	TPSCR.G5	Topcon NetG3A	**Internet**	JICA	30 sec (1Hz can be used.)	15 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
3	ACAJ	Puerto de Acajutla	TRM41249.00	Trimble NetRS	**Internet**	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
4	SNJE	San José	TRM41249.00	Trimble NetRS	**Internet**	UW	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
5	CNR1	Centro Nacional de Registro	TRM41249.00,	Topcon GB1000	**Internet**	UW	30 sec (1Hz can be used.)	100 Mb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
6	SSSV	San Salvador	SEPCHOKE_B3E6	SEPT POLARX5	**Internet**	JPL	1Hz (resampling to 30 sec)		Real Time and post-processing	Static (kinematic can be used)	DGPS or Absolute
7	AIES	Aeropuerto Internacional El Salvador	TRM41249.00	Trimble NetRS	On site	UW	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
8	LALI	Puerto de La Libertad	TRM41249.00	Topcon GB1000	On site	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
9	SVCI	San Vicente	TPSCR.G5	Trimble NetRS	On site	JICA	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
10	VMIG	Volcán de San Miguel	TRM 57971-00	Trimble Net R9	On site	UW	30 sec (1Hz can be used.)	4 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
11	PATI	Patio de Finca Santa Isabel	TRM41249.00	Trimble R7	On site	MARN	30 sec (1Hz can be used.)	100 Mb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
12	PMON	Piamonte	TRM41249.00,	Topcon GB1000	**Internet**	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute

Challenges

1. The Topcon dealer in El Salvador has provided us with the quotation to establish the "prioritized idea (see **the below column**.). But the cost estimated was far higher than our estimated cost. So, we have sent the message like as follows:

From: MORI Shigeo mori@jmbsc.or.jp / Sent: Friday, December 9, 2022 3:44 PM / To: 'Survey 3g' survey3g@hotmail.com / Subject: Gracias de nuevo: sowfart de monitoreo El salvador (MARN)

Estimado Jorge (CC: MARN colegas),

Gracias de verdad por su información adicional. / Si volviéramos a considerar el problema en el futuro, parece que el costo es demasiado alto para manejar el problema que estamos considerando.

------(English)

Thank you indeed for your additional information. / If we should consider the issue in the future again, it seems that the cost is even now too expensive to handle the issue we are considering.

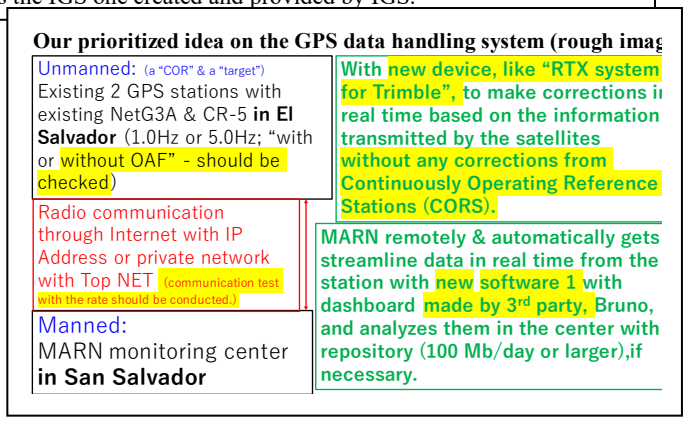
---

2. Expert has asked a GPS specialist in Japan, Prof. Kato. The response from him was wrapped up as shown below (see the below column.). And Expert has emphasized to consider the cooperation with the countries in the Central America on the issue.

After Prof. Kato who is a specialist on GPS handling (23Jan23 Prepared by MORI)
(Note: He once visited Costa Rica around 25 years ago with JICA's technical cooperation and cooperated in the establishment of a GPS observation network there.)
1. Regarding warning tsunamis using CMT analysis or W-phase with GPS observation, he has no experience on the issue, but thinks it is quite a challenging issue because GPS is much less sensitive to ground motions than seismographs. Even if it is possible to estimate the epicenter process in real time, a network of observation points like GEONET is required, so he thinks it may be very difficult only with two observation points in El Salvador.
2. The Geospatial Information Authority of Japan (GSI) is developing a system called the "Real-time GEONET Analysis system for Rapid Deformation Monitoring (REGARD)", which estimates focal mechanism in real time using GEONET's 1Hz sampling data. This uses inverse analysis from the ground surface displacement associated with the earthquake. With this, it seems that the magnitude of the epicenter and the amount of slippage can be estimated in real time almost in real time even for an inland M7 class earthquake. In the case of El Salvador, he thinks the following is necessary:
1) The number of observation points should be increased to, preferably, several tens ~ 100 observation points,
2) For real-time analysis, Position estimation should be performed in real time by RTKLIB or by others that allows a real-time kinematic analysis using phase data of 1Hz sampling obtained from these observation points. Since precise position data of GPS satellites is required to obtain the highest accuracy, it is necessary to acquire the Precise Ephemeris of International GNSS Service (IGS) via the Internet separately and use it for analysis. "**Our prioritized idea on the GPS data handling system (rough image)**" is also good, because the receiver itself has a function that can obtain the Precise Ephemeris of the satellite, and you can get a precise positioning solution directly from the receiver (although the receiver is more expensive accordingly).
3. In any case, he thinks that considerable technical training is required to produce proper results. developed this method and is still actively challenging tsunami prediction by real-time analysis.)

Note 1: GEONET is the acronym for the GNSS Earth Observation Network System operated by the Geospatial Information Authority of Japan (GSI). That is an observation system that aims to establish a high-density and high-precision survey network consisting of electronic reference points installed at approximately 1,300 locations nationwide and the GEONET Central Station (Tsukuba City, Ibaraki Prefecture) and to monitor crustal movements over a wide area.
GNSS (Global Navigation Satellite System) is the general term for satellite positioning systems such as GPS in the United States, Quasi-Zenith Satellite (QZSS) in Japan, GLONASS in Russia, and Galileo in the European Union.
Note 2: https://www.gsi.go.jp/denshi/denshi65009.html
Note 3: The method was developed by Prof. Yusaku Ohta of Tohoku University, who is still actively challenging tsunami prediction by real-time analysis. https://irides.tohoku.ac.jp/eng/organization/ohta_yusaku.html
Note 4: RTKLIB is that, for RTK (Real Time Kinematic)-GPS, a concise and highly portable RTK-GPS positioning calculation library written in C language, and a collection of application programs using it.
RTK is one of the measurement methods called "relative positioning". It is a technology that receives signals from four or more satellites with two receivers, a fixed station, and a mobile station, and by exchanging information between the two receivers and correcting the misalignment, it is possible to obtain position information with higher accuracy than single positioning. The biggest feature of RTK is that it can be kept to within a few centimetres, although there is some error.
Note 5: The Precise Ephemeris is more accurate satellite orbit information than the broadcasted Ephemeris. Currently, the most used Precise Ephemeris is the IGS one created and provided by IGS.

3. On the other hand, regarding the GPS processing in real time, MARN has sent an e-mail to the professor Timothy Melbourne (tim@geology.cwu.edu) at the Central Washington University (CWU) some months ago regarding this topic. MARN will try to contact the professor again.
-> Based on the results studied until today, Expert should tell as follows:



(Descriptions with blue letters should be handled further even after finishing this project.)

a) The merit of GPS is no saturation with gigantic events.
b) The merit of W-phase is early determination of Mw.
c) To get “real time seismic waveform” from GPS, we need “real time data” from tens or 100 of GPS stations.
d) To get “real time data” from GPS stations in order to get any seismic waveform, we need some amount budget, if we order it to any “commercial” company.

So, as for the W-phase, we should use Broadband seismometer.
As for GPS, we will continue to collect information until the necessary budget is secured.
Also, as for the budget, priority is given to acquiring "real-time data" from our own station (currently two stations). And we should consider exchanging GPS real-time data in cooperation with neighbouring countries.

3. EEW by Swiss (EWBS)

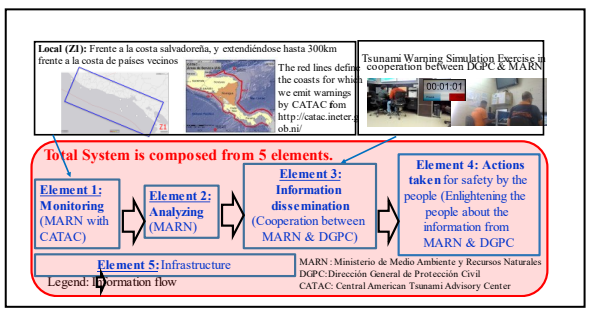
Status

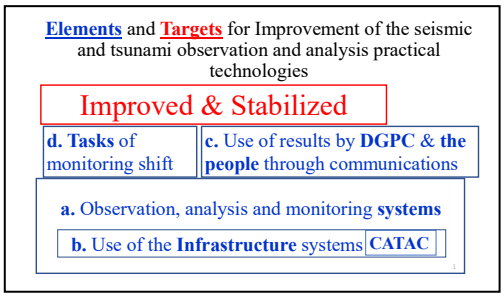
The function established until today on EEW is used in the tsunami monitoring duties as a reference in the work.

Challenges

With the information, Expert should watch the progress of the Swiss project further to use the function properly and effectively in the tsunami warning procedures. The project will finish in 2024.
By the way, it is said that banner of EWS could internally appear on TV of the "Channel 10", because the information is being sent to the TV company.

Appendix What are “Elements”?





Period

(Descriptions with blue letters should be handled further even after finishing this project.)

7_Guideline for introduction of the additional technologies in monitoring tsunamis and earthquakes as of 20Mar23.docx

Guideline for introduction of the additional technologies that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance

Prepared by the Expert on 20Mar23
Approved by MARN on 20Mar23

1. Introduction

The "**target 4**", shown in **the below column**, in our project tells that we should **"**establish **the guideline for introduction of the additional technologies** that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance**"**. And the project plan shows the 11 items **in the below Table 1** as the "additional technologies".

Target 4
Established **the guideline for introduction of the additional technologies** that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance
4-1 Use of the real time data of GPS stations to get accurate Mw earlier through observing W-phase with the data
4-2 Grasping the distribution of amount of slips on the seismic source fault surface by analyzing the seismic waves
4-3 Making displaying moment rate function to understand the actual seismic magnitude earlier
4-4 Any other technologies
4-4-a Initial motion analysis for grasping focal mechanisms
4-4-b Tools for evaluating the underestimate of Magnitude
4-4-c DD method on enhancement of hypocenter determination for inland seismic activities
4-4-d IPF method for enhancement of automatic hypocenter analysis against multi-occurrence of earthquakes
4-4-e Station weighting/correction for enhancement to hypocenter determination
4-4-f Segmentation of coasts in tsunami warning to make it elaborate
4-4-g Development of safe & effective system in the tsunami observation by humans at coasts without tide gauges
4-4-h Consideration on the guideline for updating the seismic microzoning maps of El Salvador

Table 1 Items in the Target 4

Further we can put them in the 7 categories established in this project as shown **in the below Table 2**.

Element					Category	Items in Target 4
1	Monitoring *with CATAC* (419)	d	Tasks of monitoring shift	Human resources	7 self-training	
2	Analyzing	a	Observation, monitoring and analysis systems	Systems	1 seismic and tsunami monitoring (419)	4-4-e Station weighting/correction for enhancement to hypocenter determination
						4-4-bTools for evaluating the underestimate of Magnitude
						4-4-c DD method on enhancement of hypocenter determination for inland seismic activities
						4-4-d IPF method for enhancement of automatic hypocenter analysis against multi-occurrence of earthquakes
					2 CMT and Mw monitoring (419)	4-3 Making displaying source time function to understand the actual seismic magnitude earlier
						4-4-a Initial motion analysis for grasping focal mechanisms
						4-2 Grasping the distribution of amount of slips on the seismic source fault surface by analyzing the seismic waves
					3 tsunami handling (419)	
						4-4-f Segmentation of coasts in tsunami warning to make it elaborate
						4-4-g Development of any safe & effective system in the tsunami observation by humans at coasts without tide gauges
3	Information dissemination (419)	c	Use of results by DGPC and the people through communications	Systems	6 issuance tsunami advisory for disaster prevention including cooperation with DGPC	
4	Actions taken for safety by the people			Users	(7)	
						4-4-h Consideration on the guideline for updating the seismic microzoning maps of El Salvador
5	Infrastructure (419)	b	Use of infrastructure system *with CATAC*	Infrastructure	4 recovery and backup	
					5 data and information acquisition including cooperation with CATAC	4-1 Use of the real time data of the GPS stations in the system in order to get accurate Mw earlier through observing W-phase with the data

Table 2 Categorizing of the items in the Target 4

(Descriptions with blue letters should be handled further even after finishing this project.)

In the Table 2, the items of "Target 4" in the white frame is handled in "**Plan on the technology transfer & the training**"[1] about the Elements or the Categories. On the other hand, those in the green frame should be handled in this document, "**Guideline for introduction of the additional technologies**".

2. Diagnosis of the latest performance of the seismic and tsunami monitoring system

The latest performance of the system related to the items to be handled are diagnosed in this chapter.

2.1 Analysing for seismic and tsunami monitoring (Category 1 in Element 2)

1) Tools for evaluating the underestimate of Magnitude (Sub-target 4-4-b)

As for gigantic earthquakes like larger than M8.0, M obtained from maximum amplitude has a feature of saturation. Further, the source process duration of the events is so long that we need long time to get the accurate Mw. So, in the early stage we sometimes underestimate Magnitude.

On the issue, MARN has got ISOLA that has the function of displaying source time function. Expert initially thought we might use it as the tool somehow. But Expert has understood that we were not able to use the function in real time.

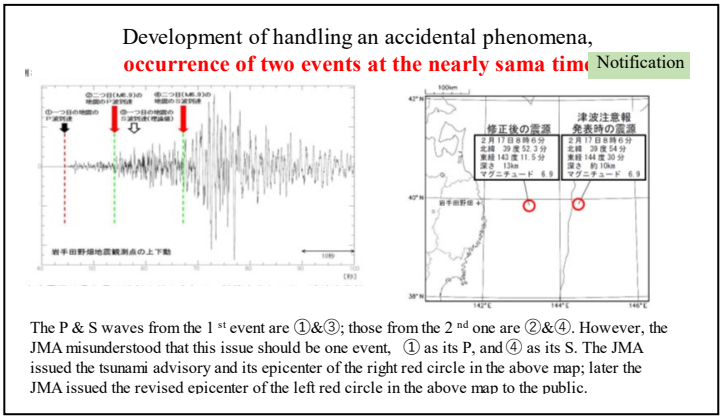
(Note: MARN has developed tsunami database[2]. It seems that the database handles M 8.0 as the largest. The "tsunami protocol in 2019"[3] has M larger than 8.7.)

2) DD method on enhancement of hypocenter determination for inland seismic activities (Sub-target 4-4-c)

As for inland disastrous earthquakes, the relation between the event and the faults existing at the epicentral area is essential to understand its feature like its cause. So, accurate aftershock-distribution or swarm-one should be important. On the issue, MARN doesn't have any tool to do so.

3) IPF method for enhancement of automatic hypocenter analysis against multi-occurrence of earthquakes (Sub-target 4-4-d)

As for multi-occurrence of earthquakes like the one shown **in the right column**, we should use only P-phases as the 1st step in the



[1] We have the following six documents of "Plans on the technology transfer & the training" like 1) Category 1, 2) Category 2, 3) Category 3, 4) Element 1(d) (Category 7), 5) "Element 3(c) (Category 6), and 6) "Element 5(b) (Category 4 & 5).

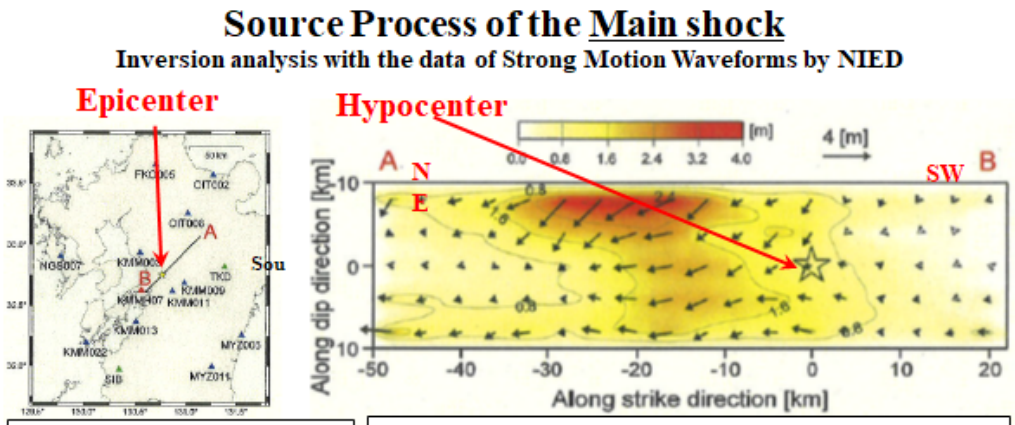
[2] The tsunami database has 561 scenarios modeled, using magnitudes from 7.0 to **8.0** in steps of 0.1 and three depth values for each of the 27 selected seismic sources. Wave heights to be forecasted are prepared at 71 points along the coast. To simplify the results, the results are tabulated at the municipality level (each municipality has several forecast points – where the highest value is taken) and the wave height values were associated in range (< 0.3 m, 0.3 - 1.0 m, 1.0 - 3.0m, > 3.0m). When an earthquake with tsunamigenic characteristics occurs, the module of the information dissemination platform checks the data obtained from SeisComP and extracts, from the database, the scenario that most closely resembles the earthquake that has just occurred.

[3] IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019

hypocenter calculation, if handling manually. But in automatic determination, it's not easy to handle the event. On the issue, MARN doesn't have any tool to handle it. (Note[4]: Some years ago, there was a distant earthquake whose S phase was wrongly taken by the system as the P phase of a second seismic event. The first and real event was automatically located near Ecuador coast and the second one was wrongly located at Costa Rica.)

2.2 Analysing for CMT and Mw monitoring (Category 2 in Element 2)
4) Grasping the distribution of amount of slips on the seismic source fault surface by analysing the seismic waves (Sub-target 4-2)

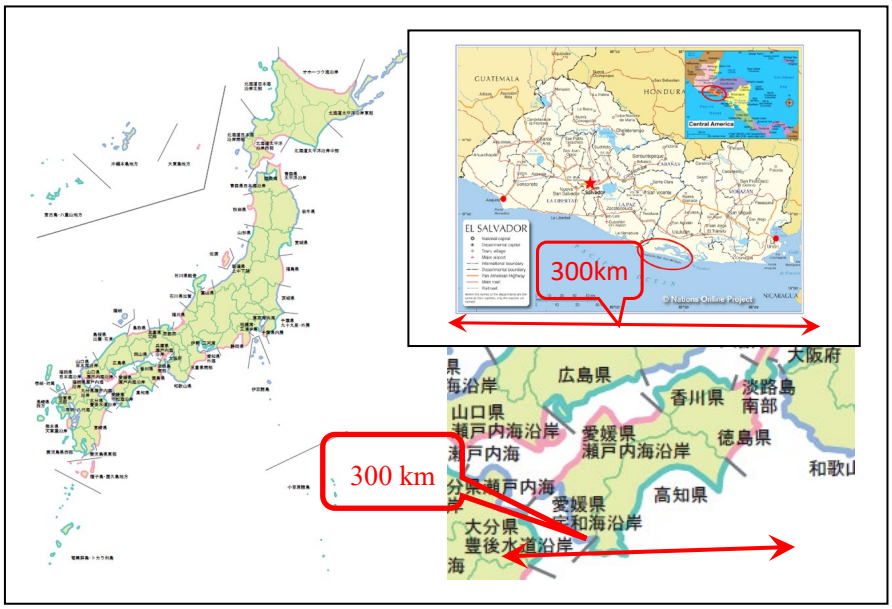
As for considering the disaster feature, the distribution of effects from strong motion and from tsunami should be the basic information. The distribution of them is closely related to the distribution of slips on the seismic source fault surface. So, it would be better for us to get the latter distribution of slips, if possible. Further, it would make us understand the feature of the earthquake in the seismic tectonics of the region. The feature would sometimes give us any hint about the future big earthquake to occur around the area. **See the below column** showing an example of the distribution.



Based on the page 10 in the
http://www.static.jishin.go.jp/resource/monthly/2016/2016_kumamoto_2.pdf

[4] The experience of Rodolfo's.

2.3 Analysing for tsunami handling (Category 3 in Element 2)
5) Segmentation of coasts in tsunami warning to make it elaborate (Sub-target 4-4-f)
JMA segments coasts **as shown in the right column.** Expert initially thought to propose any segmentation of the coats of El Salvador to elaborate the tsunami warning for the people to properly consider how to take actions with the information from MARN. But, even without the segmentation, MARN can issue the tsunami height estimation to each municipality with tsunami database. Namely MARN can issue tsunami warnings to "segmented" coasts. On the other hand, the current system cannot issue "cancellation" to "segmented" coasts.



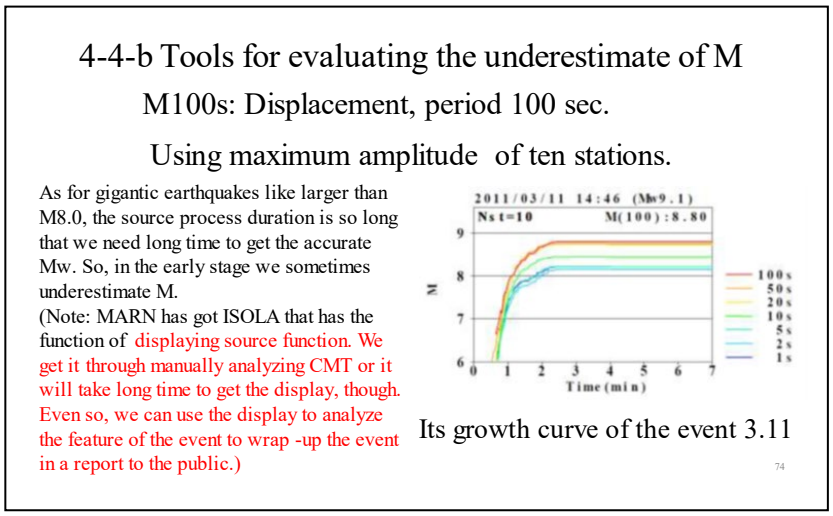
(Note: We initially thought, for the segmentation, the things like 1) Accuracy level of the tsunami database, 2) how to segment the coasts like a) administrative areas, b) topography, c) social conditions, and d) slope (steep or gentle) of beach[5], and 3) appropriateness for the people.)

6) Development of any safe & effective system in the tsunami observation by humans at coasts without tide gauges (Sub-target 4-4-g)
When tsunami warning has been issued, MARN makes telephone-calls to the people that MARN has requested beforehand to monitor the sea change in the "emergency situation". They should cover the coats that have no tide gauge.
But the monitoring by them should be carried out at the safety place. So, we should make the "safety issue" sure.

2.4 Actions taken for the safety by the people (Element 4)
7) Consideration on the guideline for updating the seismic microzoning maps of El Salvador (Sub-target 4-4-h)

[5] The ideas were proposed by Rodolfo. Steep group will have Isla de Mendez beach; Gentle group will have San Diego, Majahual and the rest of La Libertad beaches.

The Seismic Risk project by IDB has handled/updated the seismic microzoning maps of El Salvador.
Therefore, the Phase 2 project has nothing to do on the issue.



3. Introduction of the additional technologies

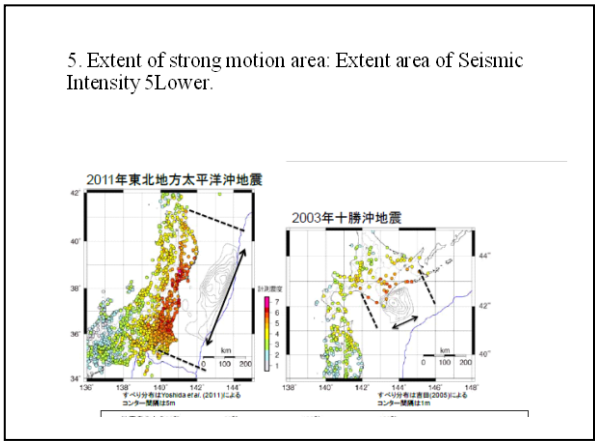
According to the above diagnosis, the below technologies should be considered to introduce into the system.

3.1 Analysing for seismic and tsunami monitoring

1) Tools for evaluating the underestimate of Magnitude

As for the issue against gigantic event larger than M8.0, JMA has the tools that can be used within 3 minutes after the occurrence as follows:

1. M100s: Displacement, period 100 sec. **See the column in the previous page.**
2. Mhara: Short period seismic waveform continuation time, displacement.
3. Long Period: 100 - 500sec period.
4. Mwi: Epicenter distance 150km-200km, average of instrumental seismic intensities.
5. Extent of strong motion area: Extent area of Seismic Intensity 5Lower. **See the right column.**



From the above 5 tools, the items 4 and 5 might not be suitable for the "tsunami earthquake" like the 2012 Usultan event. Among the remained 2 tools, the 1st tool (M100s) might be the best solution to be introduced into the monitoring system due to its simplicity.

As for the tsunami database that handles M 8.0 as the largest for the Z1 zone, the event larger than 8.0 shown in the tsunami protocol in 2019 is covered by categorising then into one "scenario" like "Very High Tsunami Threat / Emergency". As for the Z2 and the Z3 zones, they are covered with PTWC, if necessary.

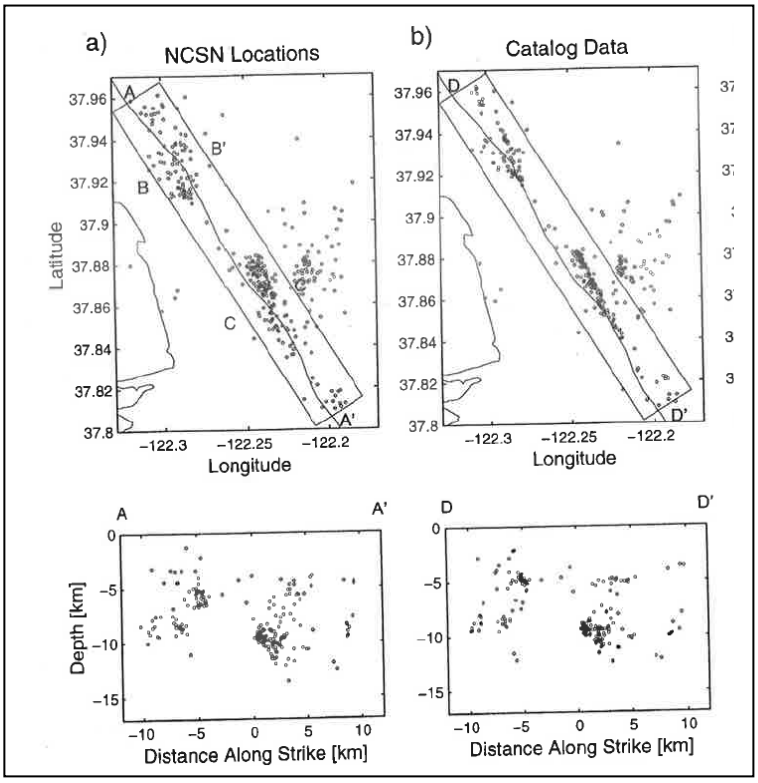
Excerpt from the Tsunami Protocol

Table 1 Scenarios and Magnitude to determine the action in case of Tsunami threat based on historical information.

Magnitude	Local earthquake (Z1)	Regional earthquake (Z2)	Distal earthquake (Z3)
	Located in the Pacific basin and with Profundidad < 100 km away		
<6.5	No threat	No threat	No threat
6.5-7.0	Mild tsunami threat / Pre-warning	No threat	No threat
7.1-7.5	Moderate tsunami threat / Warning	No threat	No threat
7.6-7.9	High Tsunami Threat / Alert	Possible mild tsunami threat/ Pre-warning / assessed according to PTWC data	No threat
8.0 -8.6	Very High Tsunami Threat / Emergency	Possible moderate tsunami threat/ Warning / assessed according to PTWC data	Possible mild tsunami threat/ Pre-warning / assessed according to PTWC data
= 8.7		Possible high tsunami threat / Alert / assessed according to PTWC data	Possible moderate tsunami threat/ Warning/ is assessed according to PTWC data

2) DD method on enhancement of hypocenter determination for inland seismic activities

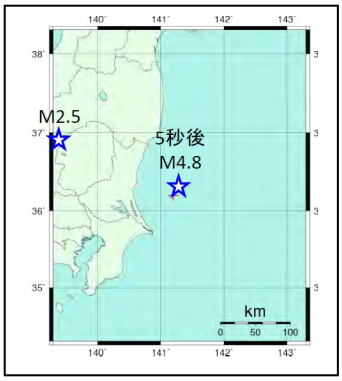
For the purpose to get accurate aftershock-distribution or swarm-one, Expert proposed the Double-Difference Hypocenter Locations method in the Phase 1. **See the figures in the next page column.** They show earthquakes distribution on the maps. **The left** is the results from standard hypocenter calculation. And **the right** is those from DD method. We can see that the vague distribution becomes clear somehow. MARN has told that SeisComP4 had the function, so MARN could use it, if necessary. (Note: We can also use the free software of DD method, if necessary.)



3) IPF method for enhancement of automatic hypocenter analysis against multi-occurrence of earthquakes

(Descriptions with blue letters should be handled further even after finishing this project.)

For the purpose to properly handle any multi-occurrence of earthquakes, Integrated Particle Filter (IPF) method could contribute somehow.
The method uses 1) an algorithm that combines multiple data and methods with Bayesian inference, 2) an identification algorithm that considers the uncertainty of the hypocenter using trigger time and amplitude. The event shown **in the right column** was well handled with the method. It might be better for us to consider its introduction into EWS in the future through studying the method further.



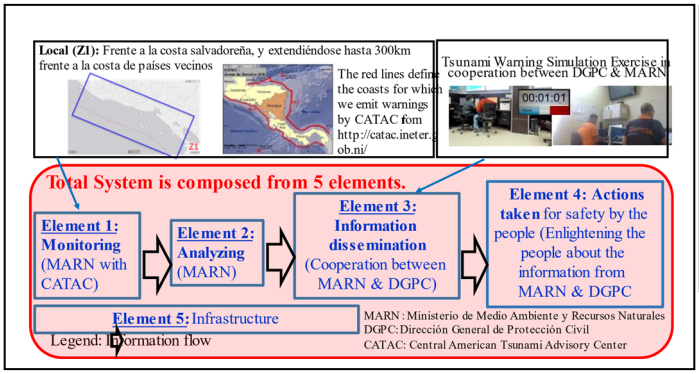
Date	Time	Epicenter	Lat.	Lon.	Dep.	Mag.
2011/03/19	06:18:48	NW Gunma Pref.	36.9	139.4	10km	2.5
	06:18:53	E Off Ibaraki Pref.	36.2	141.2	40km	4.8

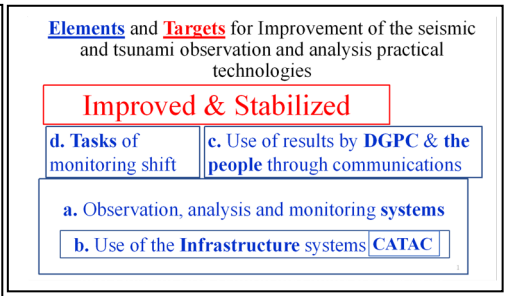
3.2 Analysing for CMT and Mw monitoring
4) Grasping the distribution of amount of slips on the seismic source fault surface by analysing the seismic waves
If necessary, we should learn the various tools to introduce the function into our monitoring system.

3.3 Analysing for tsunami handling
5) Segmentation of coasts in tsunami warning to make it elaborate
On the other hand, the current system cannot issue “cancellation” to “segmented” coasts. This issue should be considered further through conducting regular tsunami drills.

6) Development of any safe & effective system in the tsunami observation by humans at coasts without tide gauges
As for monitoring sea change by humans, we should develop the system to keep the safety of the monitoring people requested by MARN to do so.
(Note: One idea proposed by Rodolfo is to construct a tower of more than 10 meters high at San Diego in La Libertad.)

Appendix What are “Elements”?





Period

(Descriptions with blue letters should be handled further even after finishing this project.)

Guía de Sismos y Tsunamis

2023

GOBIERNO DE EL SALVADOR

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES

Guía de Sismos y Tsunamis

2023

Guía de sismos y tsunamis 2023

Ministerio de Medio Ambiente y Recursos Naturales (MARN) El Salvador,
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Dirección del Observatorio de Amenazas y Recursos Naturales

Edición y diagramación Unidad de
Comunicaciones

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San Salvador, marzo 2023

Con el asesoramiento técnico del experto japonés asignado por la Agencia de Cooperación Internacional del Japón (JICA)

Ministerio de Medio Ambiente y Recursos Naturales (MARN)

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Prefacio

El Ministerio de Medio Ambiente y Recursos Naturales (MARN) de El Salvador tiene como misión recuperar el entorno estratégico ambiental salvadoreño y reducir los riesgos socioambientales, a través de la promoción de una cultura ciudadana y coordinación interinstitucional bajo principios institucionales.

La información sobre sismos, tsunamis y prevención a desastres emitida por el MARN es para salvaguardar la vida de la población en riesgo, por tanto, debe ser comprendida y utilizada adecuadamente por las instituciones del Sistema de Protección Civil y de la población en general.

La presente Guía sobre sismos y tsunamis brinda información general referente a estos fenómenos, los procedimientos y tiempos requeridos en la emisión de la información, los medios oficiales de divulgación; los criterios para emitir aviso por amenaza de tsunami y el tipo de información que se divulga para la población bajo amenaza; los instrumentos de registro, las escalas de medición, comportamientos históricos, entre otra información.

Contenido

I. Terminología

Términos relacionados a los sismos[1]

Enjambre sísmico: serie o grupo de sismos de magnitud similar que ocurren en el mismo lugar en un periodo de tiempo relativamente corto (días, semanas e incluso meses). El MARN hace difusión pública del enjambre cuando el número de sismos es mayor o igual a 25 en menos de 24 horas.

Epicentro: es el punto en la superficie de la tierra verticalmente arriba del hipocentro (o foco).

Falla: es una fractura a lo largo de la cual los bloques de la corteza se han movido uno con relación al otro en paralelo a la fractura.

Hipocentro: es el punto dentro de la Tierra donde comienza la ruptura de un sismo. Este se encuentra directamente debajo del punto en la superficie de la tierra llamado epicentro (o foco).

Intensidad sísmica: es un número (escrito como un número romano) que describe la severidad de un sismo en términos de sus efectos en la superficie de la tierra, en los humanos y sus estructuras. La intensidad de un sismo depende de dónde se encuentre la persona que lo percibe, a diferencia de la magnitud, que es única para cada sismo. Una de las escalas de intensidad más utilizadas es la escala Modificada de Mercalli (MM).

1 Algunos términos han sido adaptados de: https://earthquake.usgs.gov/glossary/earthquake-hazards-program

I. Terminología

Magnitud: generalmente expresada con "M", es una medida cuantitativa del tamaño de un sismo en términos de la energía sísmica liberada. Se mide en una escala logarítmica, de tal forma que cada unidad de magnitud corresponde a un incremento de raíz cuadrada de 1000, o de aproximadamente 32 veces la energía liberada. Por ejemplo, un sismo de magnitud 8 es 32 veces más grande que uno de magnitud 7; 1000 veces más grande que uno de magnitud 6; 32,000 veces más grande que uno de magnitud 5, y así sucesivamente. Para calcular "M" se utiliza la máxima amplitud de las formas de onda registrada por los sismómetros. Para calcular la magnitud también se utiliza el momento sísmico, el cual es una cantidad proporcional al área de ruptura y al deslizamiento ocurrido en la falla geológica y se expresa como "Mw" en lugar de "M".

Profundidad focal: se refiere a la profundidad del hipocentro del sismo.

Réplicas: sismos que siguen al choque más grande de una secuencia sísmica. Son más pequeños que el sismo principal y se encuentran a una distancia de 1 a 2 longitudes de ruptura del sismo principal. Las réplicas pueden continuar durante un período de semanas, meses o años; en general, cuanto mayor sea el sismo principal, más grandes y numerosas serán las réplicas, y por más tiempo continuarán.

Región de origen: se piensa que el rápido deslizamiento dentro de la tierra -que es la causa directa de los terremotos (movimientos sísmicos)- es causado por la fractura de las rocas. La región donde ocurrió esta ruptura se llama región de origen. En grandes terremotos, la región de origen varía entre varias decenas y cientos de kilómetros; no es razonable considerar esto como un solo punto, sin embargo, con los valores observados de los tiempos de llegada de las ondas sísmicas en varios lugares, si calculamos como un punto el lugar donde se generaron las ondas sísmicas, se determinará un punto sin ningún inconveniente. Este punto se denomina hipocentro y es el lugar donde ocurrió la ruptura por primera vez, a menudo se encuentra más cerca del borde que del centro de la región de origen.

I. Terminología

Serie sísmica: serie de sismos ocurridos en un periodo de tiempo corto, en un área determinada. Si en la serie ocurre un sismo con magnitud mayor que el resto, a la serie se le da el nombre de "series de réplicas y premonitores", dependiendo de si ocurren antes o después del sismo principal. Cuando en la serie de sismos no se distingue ningún sismo principal, a la serie se le denomina "enjambre sísmico".

Shakemap: mapa del movimiento del suelo en términos de intensidad instrumental en la escala de Mercalli Modificada.

Sismo: es un movimiento de la tierra, que puede ser generado por el deslizamiento repentino en una falla, actividad volcánica o magmática, u otras fuentes.

Solución del mecanismo focal: es una forma de mostrar la falla y la dirección de deslizamiento de un sismo, usando círculos con dos curvas que se cruzan y que parecen pelotas de playa. También se llama una solución de plano de falla.

I. Terminología

Términos relacionados a los tsunamis[2]

Altura de inundación: o altura de tsunami, es la elevación alcanzada por el agua del mar; es la suma de la profundidad del agua y la altitud topográfica local. Esta se mide en relación al nivel medio del agua o el nivel del agua en el momento de la llegada del tsunami en una distancia de inundación específica.

Amplitud del tsunami: normalmente determinada por un registro de nivel del mar, es: 1) el valor absoluto de la diferencia entre un seno o un valle particular del tsunami y el nivel normal del mar en reposo a la hora indicada, 2) la mitad de la diferencia entre un seno y un valle sucesivos, corregida por el cambio de marea entre ellos. Representa la verdadera amplitud de la onda del tsunami en algún punto del océano, sin embargo, es a menudo modificada de alguna forma por la respuesta del mareógrafo.

Datum: sistema geométrico de referencia empleado para expresar numéricamente la posición geodésica de un punto sobre el terreno. Cada datum se define en función de un elipsoide y por un punto en el que el elipsoide y la Tierra son tangentes.

Fuente del tsunami: punto o área de origen del tsunami. Normalmente es el lugar en el que un terremoto, erupción volcánica o deslizamiento de tierras ha causado un rápido desplazamiento de agua a gran escala dando origen a las ondas del tsunami.

2 La mayoría de términos han sido tomados de: Comisión Oceanográfica Intergubernamental. Glosario de tsunamis, cuarta edición, 2019. Colección Técnica de la COI, 85. París, UNESCO, 2019; https://unesdoc.unesco.org/ark:/48223/pf0000188226_spa/PDF/188226spa.pdf.multi

I. Terminología

Intensidad del tsunami: medición del tamaño de un tsunami basada en la observación macroscópica del efecto de sus olas en los seres humanos y objetos, como embarcaciones de diferentes tamaños y edificios. La escala original fue publicada por Sieberg (1923) y posteriormente modificada por Ambraseys (1962) para crear una escala de seis categorías.

Papadopoulus e Imamura (2001) propusieron una escala de intensidad de 12 grados que fuera independiente de la medida de los parámetros físicos como la amplitud de la ola, susceptible a las pequeñas diferencias en los efectos de un tsunami, y lo suficientemente detallada para cada grado como para abarcar los distintos tipos de impacto de un tsunami que pudieran existir sobre los seres humanos y la naturaleza.

Magnitud del tsunami: medida para determinar el tamaño de un tsunami basado en la medición de sus ondas por mareógrafos y otros instrumentos. La escala, originalmente descriptiva y más similar a la de intensidad, cuantifica el tamaño usando mediciones de la altura de las olas o de *runups* de tsunami. Lida et ál. (1972) describió la magnitud (m) como el logaritmo en base 2 de la altura máxima de la ola medida sobre el terreno y que corresponde a una magnitud que va de -1 hasta 4

$$\mathbf{m = \log_2 Hmax.}$$

Posteriormente, Hatori (1979) extendió esta escala conocida como Imamura-Lida para los tsunamis de campo lejano incluyendo la distancia en la fórmula.

Mareógrafo: también conocido como mareómetro, sensor del nivel de mareas o estación de nivel del mar. Es un instrumento utilizado para medir y registrar el nivel del mar.

Peligro de tsunami: la probabilidad de que un tsunami de una determinada magnitud impacte en una zona de la costa en particular.

I. Terminología

Runup: diferencia entre la elevación de penetración máxima de un tsunami (línea de inundación) y el nivel del mar en el momento del tsunami. En términos prácticos, el *runup* sólo se mide en la costa en la que hay clara evidencia de inundación.

Tiempo de arribo: Es el tiempo estimado que un tsunami tardará en llegar a un lugar específico luego de su generación, lo cual es determinado por medio de la velocidad y la refracción de las olas del tsunami a medida que viajan desde su origen. La velocidad de la ola del tsunami es controlada por la profundidad del agua, cuando la profundidad del mar es mayor a los 6,000 m, las olas de un tsunami pueden viajar a velocidades de hasta 800 km/h. La velocidad es mucho menor en aguas costeras, donde la altura de la ola comienza a incrementarse dramáticamente.

Tsunami: término japonés que literalmente significa "ola en puerto" (*tsu*: puerto, *nami*: ola). Serie de ondas de longitud y período sumamente largos, normalmente generados por perturbaciones asociadas con sismos que ocurren bajo el fondo oceánico o cerca de él. También llamado "ola sísmica" y, de manera incorrecta, "ola de marea". Asimismo, las erupciones volcánicas, los deslizamientos de tierra submarinos, los derrumbes costeros de montañas, y el impacto en el mar de un meteorito de gran tamaño, también pueden dar origen a la generación de un tsunami.
Las ondas de un *Tsunami* pueden alcanzar grandes dimensiones y viajar por toda la cuenca oceánica perdiendo energía; se propagan como olas de gravedad normales con un periodo típico de entre 10 a 60 minutos. Al acercarse a aguas someras, o poco profundas, las ondas de tsunami se amplifican y aumentan en altura, inundando áreas bajas, y donde la topografía submarina local provoca amplificación extrema de las olas, éstas al llegar a la playa pueden causar daños importantes. Los tsunamis no guardan relación con las mareas.

I. Terminología

Siglas

CATAC: Centro de Asesoramiento de Tsunamis para América Central
DGPC: Dirección General de Protección Civil
MARN: Ministerio de Medio Ambiente y Recursos Naturales
PTWC: Centro de Alerta contra los Tsunamis en el Pacífico (*Pacific Tsunami Warning Center*)
USGS: Servicio Geológico de los Estados Unidos (*United States Geological Survey*)
UTC: Tiempo Universal Coordinado (UTC=tiempo de El Salvador + 6 horas)

II. Advertencia e información ante desastres

Procedimiento de emisión de información

La advertencia de tsunami e información relacionada es remitida a la Dirección General de Protección Civil (DGPC) y a la población, en los tiempos establecidos, de acuerdo a los procedimientos operativos estándar a través de los medios de comunicación institucionales como las redes sociales (Twitter, Facebook), sitio web, correo electrónico, radio y fax. Ver detalles en la Figura 1 y 2

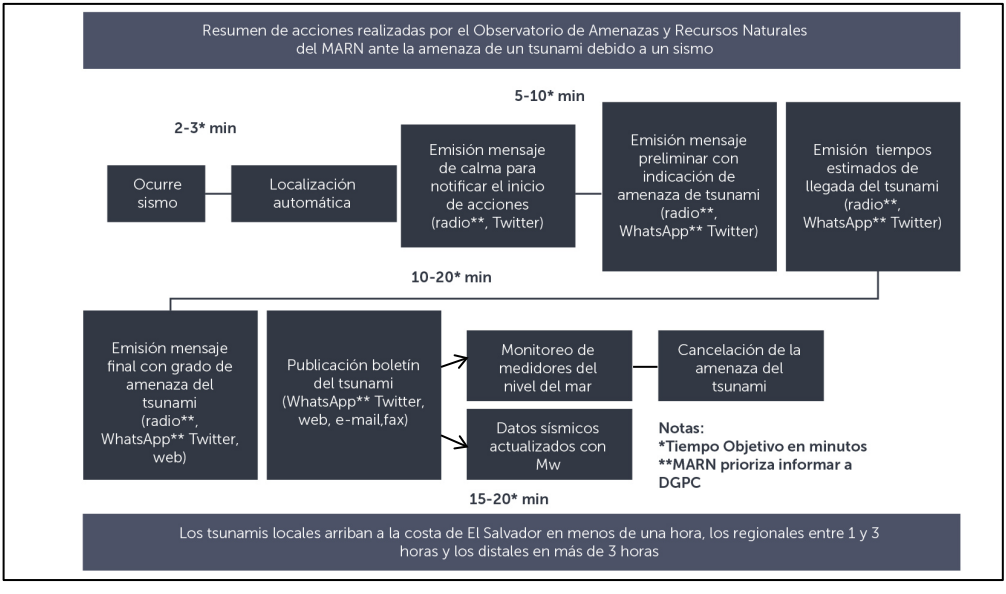

Figura 1. Acciones realizadas por sismo con amenaza de tsunami

<table>
<tr><td rowspan="2">Tiempo transcurrido desde la detección del sismo</td><td></td><td colspan="2">Herramientas</td><td>Radio</td><td>WhatsApp</td><td>Fax</td><td>Twitter</td><td>Web</td></tr>
<tr><td>Acciones</td><td colspan="2">Hacia</td><td>DGPC y autoridadess locales</td><td>DGPC y autoridadess locales</td><td>DGPC</td><td>Público</td><td>Público</td></tr>
<tr><td>0 min</td><td colspan="3">Ocurre sismo</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">2-3 min</td><td colspan="3">Localización automática</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Emisión de mensaje de calma para notificar el inicio de acciones</td><td rowspan="3">Primero</td><td rowspan="3">Segundo</td><td rowspan="3">Copia de redundancia para WhatsApp</td><td rowspan="3">Segundo</td><td></td></tr>
<tr><td rowspan="2">5-10 min</td><td colspan="3">Emisión de Mensaje Preliminar con indicación de amenaza de tsunami</td><td rowspan="2">Tercero</td></tr>
<tr><td colspan="3">Difusión de los tiempos estimados de llegada del tsunami (ETA)</td></tr>
<tr><td rowspan="4">10-20 min</td><td colspan="3">Emisión del mensaje final con grado de amenaza de tsunami</td><td rowspan="4"></td><td rowspan="4">Primero</td><td>Segundo (Junto con emal)</td><td rowspan="3" colspan="2">Tercero</td></tr>
<tr><td colspan="3">Emisión y difusión del Boletín de Tsunami con parámetros s ísmicos, grado de amenaza de tsunami, ETA, y de altura estimada de tsunami</td><td rowspan="3">Copia de redundancia para WhatsApp</td></tr>
<tr><td colspan="3">Los datos emitidos por PTWC y CATAC son evaluados y divulgados.</td></tr>
<tr><td rowspan="2">15-20 min</td><td colspan="3">Parámetros sísmicos actualizados con Mw, en caso de ser necesario</td></tr>
<tr><td colspan="3">Difusión de mapas de intensidad instrumental (ShakeMap)</td><td></td><td></td><td></td><td colspan="2"></td></tr>
</table>

Figura 2. Herramientas y medios utilizados en la emisión de información

Mensajes de calma, preliminares, finales y boletín

Ejemplos de los mensajes de calma, preliminar, final y boletín divulgados en twitter (Figura 3, 4, 5 y 6, utilizados internamente en el ejercicio de simulación de tsunami en 2021). **El mensaje de calma** se emite aproximadamente dentro de los 2-3 minutos posteriores a la ocurrencia del sismo para informar que ha sido percibido o sentido por las personas cercanas al epicentro (Figura 3). **El preliminar** tiene los datos del sismo evaluado aproximadamente dentro de 5-10 minutos para informar si el evento sísmico tiene potencial de generar un tsunami (Figura 4). Posteriormente, **el mensaje final** tiene los datos recalculados utilizando nueva información disponible para una mejor precisión en la evaluación del nivel de amenaza y las alturas estimadas de tsunami (Figura 5). **El boletín** tiene datos e información provisional más detallada sobre el tsunami (Figura 6). este informe es actualizado a medida que el evento evoluciona.

Figura 3. Ejemplo de mensaje de calma publicado en twitter

Figura 4. Ejemplo de información sísmica preliminar publicada en twitter

Figura 5. Ejemplo de información sísmica final publicada en twitter

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES
GOBIERNO DE EL SALVADOR

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Dirección General del Observatorio Ambiental
Gerencia de Geología – Área de Sismología
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BOLETIN 1

TOMAR ACCIÓN

CON BASE EN LA INFORMACIÓN DISPONIBLE HASTA ESTE MOMENTO, EXISTE POSIBLE AMENAZA DE TSUNAMI MUY ALTA PARA EL SALVADOR, POR SISMO FRENTE A LA COSTA DE LA LIBERTAD. MAGNITUD PRELIMINAR: 7.8

Fecha y hora de emisión: viernes 5 de noviembre del 2021, Hora local: 15:35

Parámetros preliminares del sismo

Fecha (local)	05-11-2021
Hora origen (local)	15:15:00
Magnitud preliminar	7.8
Coordenadas	12.464724 N, -89.475383 O
Profundidad	10.0 km
Localización	Frente a la Costa de La Libertad

Evaluación del Tsunami

Con base a las características preliminares del sismo, se estima que por el momento existe una posible amenaza de tsunami MUY ALTA para la costa de El Salvador.

Una amenaza de tsunami MUY ALTA indica un escenario para el que se prevén fluctuaciones en el nivel del mar MAYORES de 3 metros con respecto al nivel de la marea. Estas variaciones constituyen un riesgo sumamente importante, implicando un máximo grado de evacuación para toda la costa de El Salvador, con el fin de proteger las vidas de la población amenazada,.

Tomar en consideración que el fenómeno aún está bajo evaluación, por lo que el grado de amenaza y nivel de impacto podrían ser actualizados tan pronto se tenga mayor información.

Nivel de impacto esperado: SEVERO

Representa un peligro a la vida humana. Corresponde a una destrucción casi completa de estructuras costeras como puertos y muelles, e infraestructuras de las zonas costeras bajas como viviendas, restaurantes y hoteles.

Recomendaciones y acciones a tomar

~ Evacuación de las playas y los puertos de TODA LA COSTA salvadoreña, movilizándose hacia partes altas.
~ Si se encuentra en la playa y observa que el mar retrocede, ALÉJESE a un lugar seguro en altura.
~ Siga las rutas de evacuación ante tsunami y DIRÍJASE hacia una zona segura (un lugar elevado) determinado por su municipalidad.
~ Evite el pánico durante la evacuación y SIGA las indicaciones que proporcionan las autoridades.
~ Alejarse de ríos y esteros, ya que las olas del tsunami pueden penetrar kilómetros tierra adentro.
~ NO regrese a la zona de costa afectada por tsunami hasta que autoridades indiquen que es seguro y se haya cancelado la amenaza.
~ Restricción en actividades de recreo tales como: natación, pesca, buceo, surf y navegación en barcos.
~ A las pequeñas y medianas embarcaciones abstenerse de zarpar durante las siguientes horas después de ocurrido el sismo.

Actualización e información adicional

El siguiente boletín será emitido posteriormente se obtenga una revisión de la magnitud del sismo.

En el siguiente boletín se mostrará una estimación de los tiempos de arribos y alturas de ola por un posible tsunami, sobre ciertos sectores específicos de la costa salvadoreña.

El MARN dará seguimiento a este evento sísmico para informar oportunamente a la población sobre la evolución de este fenómeno. Se recomienda atender las indicaciones emitidas por las autoridades de la Dirección General de Protección Civil y no prestar

atención a rumores o a información no oficial acerca de esta situación.

Kilómetro 5½ Carretera a Santa Tecla, Calle y Colonia Las Mercedes,
Edificio MARN No. 2 (anexo al Edificio ISTA), San Salvador, El Salvador, Centroamérica.
http://www.snet.gob.sv

Kilómetro 5½ Carretera a Santa Tecla, Calle y Colonia Las Mercedes,
Edificio MARN No. 2 (anexo al Edificio ISTA), San Salvador, El Salvador, Centroamérica.
http://www.snet.gob.sv

Figura 6. Ejemplo de boletín del tsunami.

Información sobre la intensidad sísmica

La intensidad de un sismo disminuye con la distancia, debido a la capacidad del suelo de amortiguar las ondas sísmicas a medida se alejan de su fuente.

En la Figura 7 se muestra un ejemplo del mapa de intensidad sísmica instrumental (*ShakeMap*) que se publica en el sitio web del MARN después de la ocurrencia de un sismo. El siguiente mapa es una representación gráfica del movimiento del terreno y los posibles efectos causados por un sismo (niveles de intensidad sísmica instrumental), con base a la escala de Mercalli Modificada.

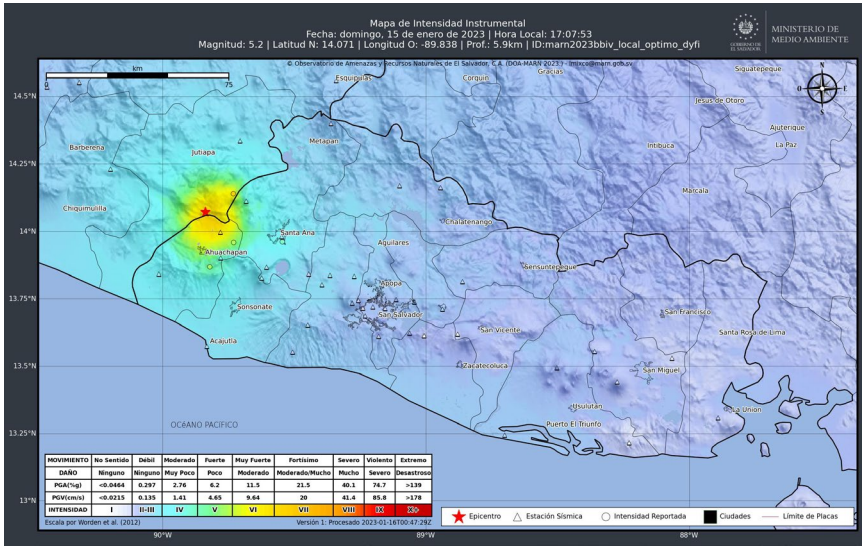


Figura 7. Mapa de intensidad sísmica (ShakeMap)

II. Advertencia e información ante desastres

Información web de sismos sentidos

En el sitio web del MARN se encuentran publicados los datos de los sismos que han sido reportados como sentidos por la población desde el año 2002. Los últimos 10 sismos sentidos se encuentran en http://www.marn.gob.sv/ultimos-10-sismos/. Para una búsqueda de los sismos por fecha de ocurrencia, se utiliza la opción de mapa dinámico http://www.marn.gob.sv/mapa-dinamico/ donde se pueden generar mapas y listados de sismos (Figura 8).

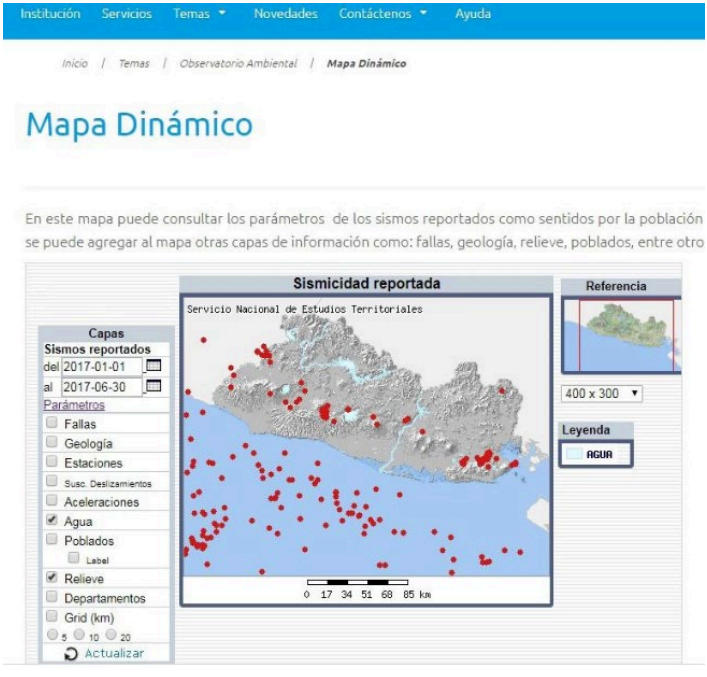


Figura 8. Datos de sismos sentidos disponibles en la web del MARN

Cálculo de hipocentro y magnitud del sismo

El hipocentro sísmico es el punto en el interior de la tierra donde inicia la ruptura que genera el sismo. La proyección del hipocentro sobre la superficie de la tierra es el epicentro. La magnitud está relacionada con la energía sísmica liberada. Para el cálculo de estos parámetros se requiere de los datos registrados por los sismógrafos. Se realizan varios cálculos (proceso iterativo) hasta obtener información lo suficientemente precisa para ser emitida a la Dirección General de Protección Civil y a la población. En la Figura 9 se muestra un ejemplo de todos los epicentros calculados para un mismo sismo.

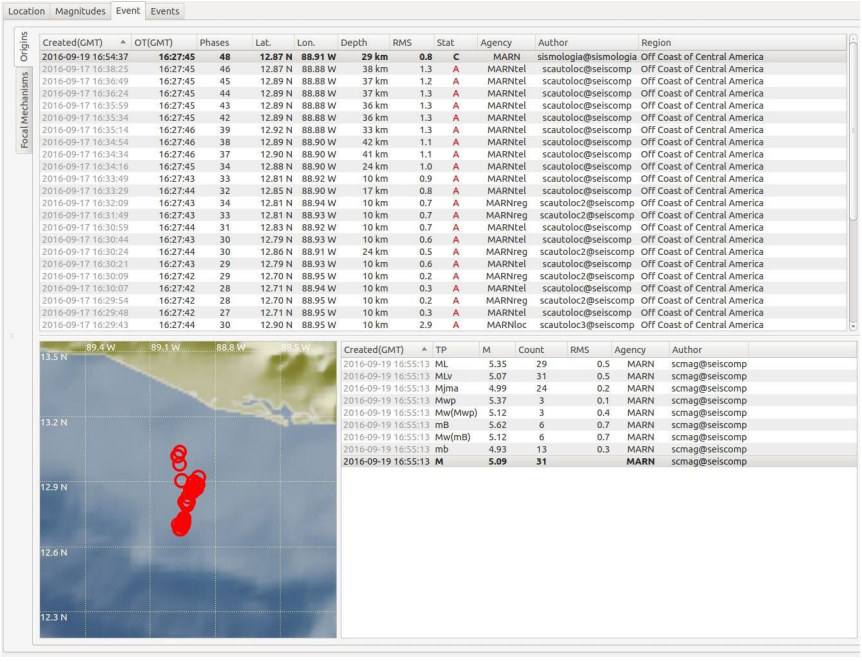


Figura 9. Todas las ubicaciones realizadas para un mismo sismo, hasta obtener la mejor precisión posible

III. Acciones en el monitoreo de sismos y tsunamis

Monitoreo de aceleraciones

Para registrar las aceleraciones generadas por los sismos, se tiene una red de acelerógrafos distribuida en todo el país. Con los datos registrados se puede conocer la respuesta del suelo ante el paso de las ondas sísmicas. En la Figura 10 se muestra un ejemplo de la aceleración registrada en función del tiempo en los componentes vertical, norte-sur y este-oeste por un acelerógrafo ubicado a un metro de profundidad (superficie) y otro a una profundidad de 17 metros (fondo), nótese como la amplitud del registro es afectado por el espesor del suelo, por ejemplo en la componente vertical el equipo en superficie registró una aceleración de 3.006 cm/seg^2 cm/s y el equipo en fondo una aceleración de 1.366 cm/seg^2.

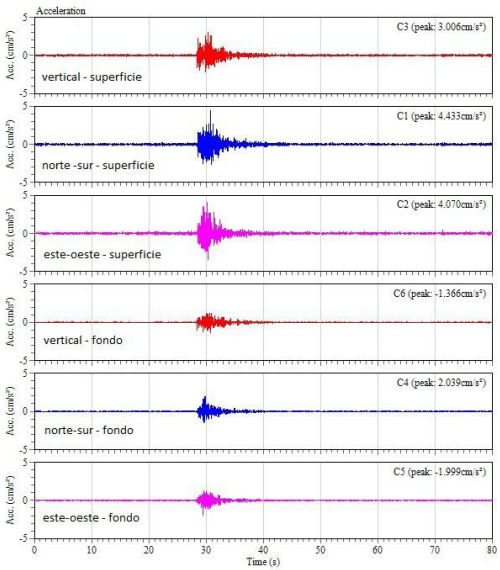


Figura 10. Aceleración sísmica registrada en las componentes vertical, norte-sur, este-oeste por equipo ubicado en superficie (trazas superiores) y equipo ubicado a 17 metros de profundidad (trazas inferiores). En cada traza sísmica se indica el valor de aceleración pico en cm/seg^2

III. Acciones en el monitoreo de sismos y tsunamis

Método de juicio para emitir aviso por amenaza de tsunami

Para emitir un aviso por amenaza de tsunami, se evalúan datos como localización, profundidad y magnitud del sismo; así como el tiempo de arribo y altura del tsunami. El tiempo de arribo se refiere a lo que tarda el tsunami en viajar desde la localización del sismo hasta la costa salvadoreña. En la Figura 11 y Figura 12 se muestran los criterios utilizados.

Magnitud	Sismo local (Z1) Desde Guatemala - hasta Nicaragua	Sismo regional (Z2) Desde México - hasta Colombia	Sismo distal (Z3) Toda la cuenca del Pacífico
	Ubicados en la cuenca del Pacífico y con profundidad < a 100 km		
<6.5	No amenaza	No amenaza	No amenaza
6.5-7.0	Amenaza de tsunami leve / Pre-aviso	No amenaza	No amenaza
7.1-7.5	Amenaza de tsunami moderada / Aviso	No amenaza	No amenaza
7.6-7.9	Amenaza de tsunami alta / Alerta	Posible amenaza de tsunami leve/ Pre-aviso /se evalúa acorde con dato PTWC	No amenaza
8.0 -8.6	Amenaza de tsunami muy alta / Emergencia	Posible amenaza de tsunami moderada/ Aviso / se evalúa acorde con dato PTWC	Posible amenaza de tsunami leve/ Pre-aviso /se evalúa acorde con dato PTWC
≥ 8.7		Posible amenaza de tsunami alta / Alerta / se evalúa acorde con dato PTWC	Posible amenaza de tsunami moderada/ Aviso/ se evalúa acorde con dato PTWC

Figura 11. Escenarios y Magnitud para determinar la actuación en caso de amenaza de Tsunami

Tipo de información	Amplitud de la ola del tsunami (metros)	Nivel de impacto esperado	Acciones recomendadas	Palabra clave para el informe
AMENAZA DE TSUNAMI	> 3.0	Severo	vacuación de toda la costa salvadoreña.	Tomar acciones para toda la costa
	1.0 -3 0	Significativo	vacuación de las playas y los puertos en zona amenazada.	omar acciones para algunos lugares de la costa
	0.3 -1.0	Medio	Restricción en actividades de recreo en zona amenazada tales como natación, pesca, buceo, navegación, etc.	Estar preparados y seguir las instrucciones de los encargados de emergencias
	< 0.3	Bajo	Precaución para el desarrollo de actividades marinas.	Estar informados
POSIBLE AMENAZA DE TSUNAMI	1.0 -3 0	Significativo	vacuación de las playas y los puertos en zona amenazada. [1]	omar acciones para algunos lugares de la costa
	0.3 -1.0	Medio	Restricción en actividades de recreo en zona amenazada tales como natación, pesca, buceo, navegación, etc.[1]	Estar preparados y seguir las instrucciones de los encargados de emergencias
	< 0.3	Bajo	Precaución para el desarrollo de actividades marinas.[1]	Estar informados
NO AMENAZA DE TSUNAMI				in embargo, mantenerse informados sobre la evolución del fenómeno

[1] Se recomendará esta acción siempre que el grado de amenaza haya sido confirmado con información del PTWC).

Figura 12. Niveles de impactos y recomendaciones para la población

Estimación de la hora de llegada y altura del tsunami

Cuando ocurre un sismo tsunamigénico se elabora un mapa que muestra líneas de tiempo de arribo del tsunami. Estas son calculadas desde la localización del sismo hacia diferentes puntos del litoral (Figura 13).

La altura del tsunami para cada uno de los municipios costeros de El Salvador se obtiene de una base de escenarios previamente calculados y se presentan usando diferentes rangos de magnitud (de 0.1 a 0.3, de 0.3 a 1.0, de 1 a 3 y mayor a 3 metros) tal como se muestra en la Figura 14.

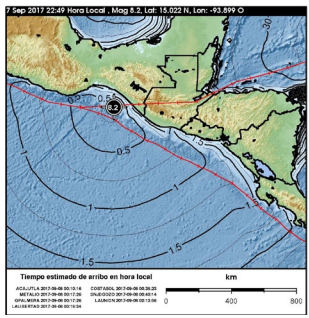


Figura 13. Ejemplo de tiempos de arribo de un tsunami

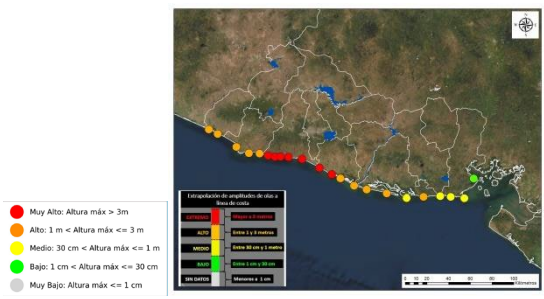


Figura 14. Ejemplo de altura de ola estimada para un tsunami

IV. Observación de sismos y tsunamis

Red de observación de sismos

Se dispone de diversos equipos sísmicos distribuidos en todo el país (Figura 15 y 16), para detectar la sismicidad generada por el proceso de subducción de la placa de Cocos bajo la placa del Caribe; así como la sismicidad producida por el reacomodo de las fallas geológicas locales y la actividad volcánica. Los datos obtenidos se transmiten a la central de procesamiento por medio del uso de diversos medios de comunicación (radio, internet, señal microonda y satélite).

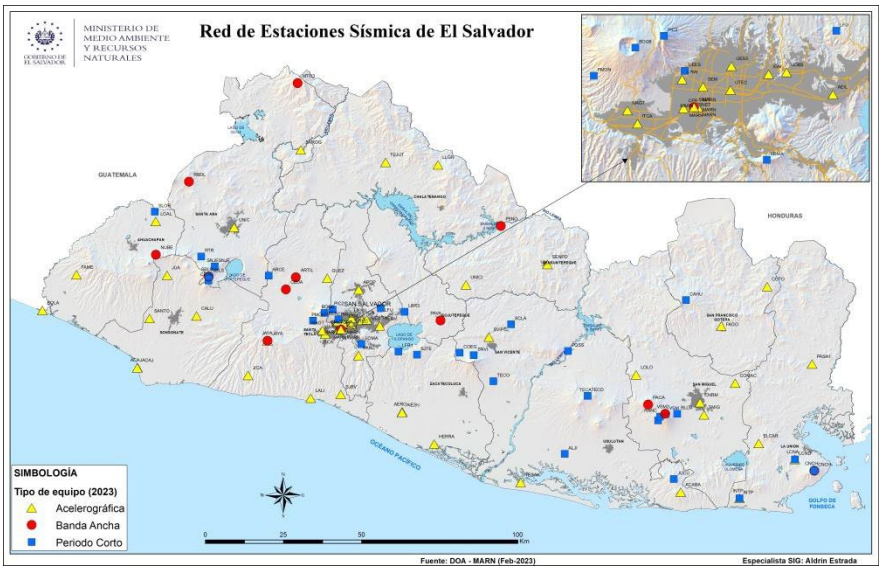


Figura 15. Ubicación y tipo de estaciones sísmicas

Tipo de equipo sísmico	Cantidad
Periodo corto analógicas	14
Periodo corto digitales	19
Banda Ancha	13
Acelerográficas (modelo Etna)	6
Acelerográficas (modelo SMA1-Retrofit)	5
Acelerográficas (modelo Basalto)	21
Acelerográficas (modelo Fortimus)	25
Total	103

Figura 16. Tipo de equipos sísmicos

Red de observación de tsunamis

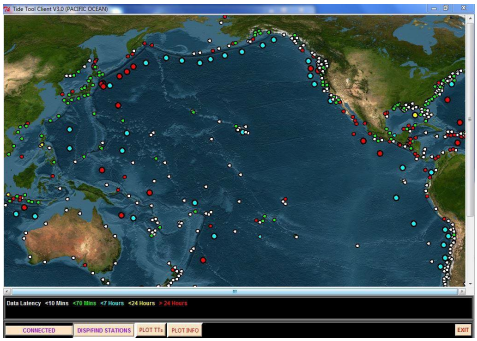
El monitoreo de tsunamis en la costa salvadoreña se realiza a través de tres estaciones mareográficas ubicadas en los puertos de Acajutla, La Libertad y La Unión (Figura 17a). Adicionalmente, se cuenta con dos cámaras ubicadas en los puertos de Acajutla y La Libertad.

IV. Observación de sismos y tsunamis

Se realiza mediciones del nivel del mar cada minuto y se transmiten los datos cada 5 o 15 minutos vía satélite a través de *Global Telecommunication System* (GTS). Las cámaras realizan la transmisión de datos vía internet, para visualizar los datos del nivel del mar de toda la cuenca del Pacífico, se utiliza el software TIDE TOOL (Figura 17b). El registro del nivel del mar se muestra a través de un gráfico en el cual, en su eje vertical, presenta la altura y en su eje horizontal el tiempo, siendo los valores extremos de la curva la pleamar (marea alta) y bajamar (marea baja), ver Figura 17c.

a)

b)



c)

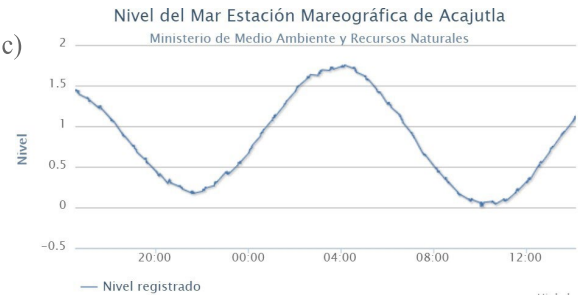


Figura 17. (a) Estaciones de monitoreo del nivel de mar en El Salvador, (b) Estaciones visualizadas con el software Tide Tool, (c) Ejemplo de registro del nivel del mar

IV. Observación de sismos y tsunamis

Red de medición de la deformación de la corteza terrestre (red de GPS)

La red está integrada por 11 GPS de precisión milimétrica, con el propósito de medir la velocidad de la deformación de la corteza terrestre (Figura 18 a). Con los GPS móviles se desarrollan mediciones en todo el país, para complementar el monitoreo, y estudiar la deformación volcánica. Los datos de estas mediciones son la base para implementar el sistema de alerta temprana ante un tsunami. La Figura 18b muestra los vectores de velocidad de deformación de la corteza terrestre obtenidos en diferentes puntos de observación para el año 2013. En este caso, las mayores velocidades de deformación se identifican en el occidente de El Salvador.

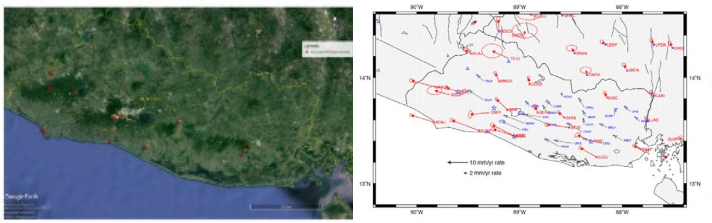


Figura 18. a) Ubicación de las estaciones de GPS permanentes y b) vectores de velocidad de deformación de la corteza (representados por su tamaño y orientación)

Sensores sísmicos (banda ancha, periodo corto, acelerógrafos)

El MARN usa los modelos Trillium Compact Trillium 120P y STS2 como sensores de banda ancha; los modelos Episensor, Titan, Fortimus y T-Sensor como acelerómetro o sensores de movimiento fuerte. Algunos de los digitalizadores usados con los sensores arriba indicados son:

Q330, Centaurus, Earthdata, Basalt. Como periodo corto se utilizan los sensores SS-1, S-13 y Sixaola (sensor + digitalizador), ver Figura19.

Los instrumentos de periodo corto se usan para registrar la microsismicidad en zonas de enjambres y volcanes activos; los datos registrados con banda ancha son de utilidad para el cálculo de sismos de gran magnitud (magnitud Mw, tensor de momento sísmico); los datos registrados con los acelerógrafos son para determinar la característica del movimiento del terreno en el sitio (factores de aplicación, periodos predominantes).

En la Figura 20 y 21 se muestra un esquema e imágenes de la instalación de los equipos sísmicos en campo, en donde se puede observar que en una estación sísmica, además del equipo sísmico, se requiere de un sistema de alimentación (baterías + paneles solares o energía comercial), un GPS para sincronizar el tiempo del registro sísmico y un sistema de comunicación (radios + antenas, *router*, etc.)

Equipo sísmico utilizado en el MARN		
Sensores de banda ancha		
		
Trillium 120P	Trillium	STS2

Acelerómetros y acelerógrafos		
		
Fortimus	Titan	Basalt
Digitalizadores		
		
Centaur	EarthData	Q-330
Sensores de periodo corto		
		
SS-1	Sixaola	S-13

Figura 19. Equipo sísmico utilizado en el MARN

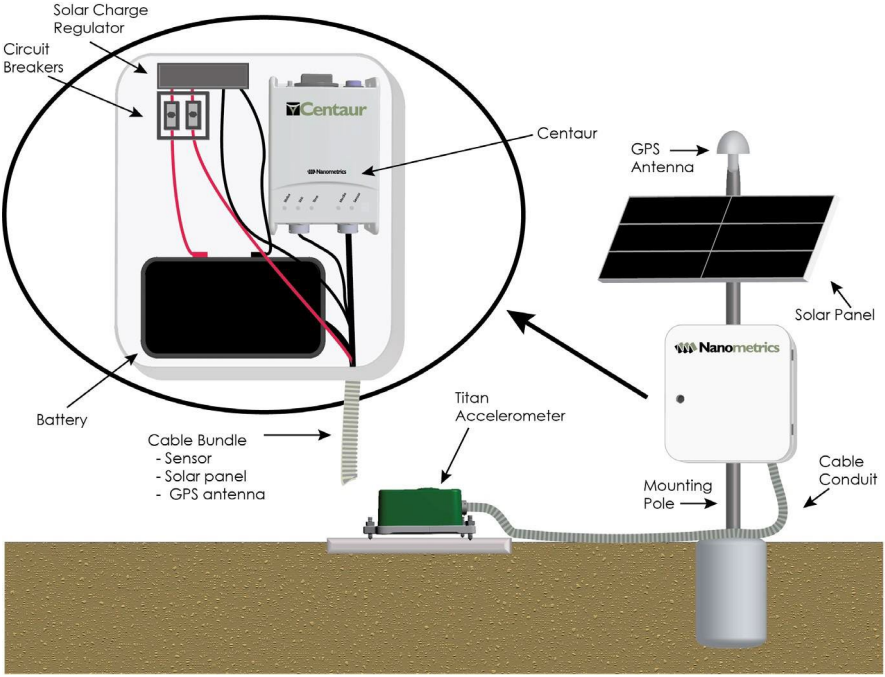


Figura 20. Esquema de la instalación de los equipos sísmicos en campo[3]

3 Nanometrics. Product Overview, Centaur Digitizer.

Figura 21. Equipos sísmicos y de GPS del MARN instalados en campo

Indicador de marea y cámara

Las Figuras 22, 23 y 24 muestran parte de los equipos desplegados en campo para registrar el comportamiento del nivel del mar. Las estaciones transmiten los datos en tiempo real al Centro de Monitoreo Integrado de Amenazas para su respectivo procesamiento.

Figura 22. Estación mareográfica ubicada en el puerto de La Libertad. La estación cuenta con un sensor de ultrasonido

Figura 23. Cámara web en puerto de La Libertad

Figura 24. Estación mareográfica en puerto de Acajutla

Observación de sismos. Ejemplo 1: Series sísmicas

Serie sísmica ocurrida en el Área Metropolitana de San Salvador (AMSS), entre los municipios de Antiguo Cuscatlán y San Salvador, durante el 6 de abril al 2 de mayo de 2017 (Figura 25). Esta serie se caracterizó por desarrollarse en tres episodios sísmicos no consecutivos.

El primer episodio se generó únicamente el 06 de abril, con un total de 10 sismos, de los cuales 2 fueron sentidos. El segundo, inició el 09 abril y finalizó el 18 del mismo mes, con un total de 532 sismos, de los cuales 53 fueron sentidos; en este período ocurrió el sismo de mayor magnitud (M 5.1), el 10 de abril. El tercer episodio fue entre el 22 de abril y el 2 de mayo, con un total de 80 sismos, de los cuales 15 fueron sentidos. En total, para esta serie se registraron 622 sismos, de los cuales 70 fueron reportados como sentidos por la población.

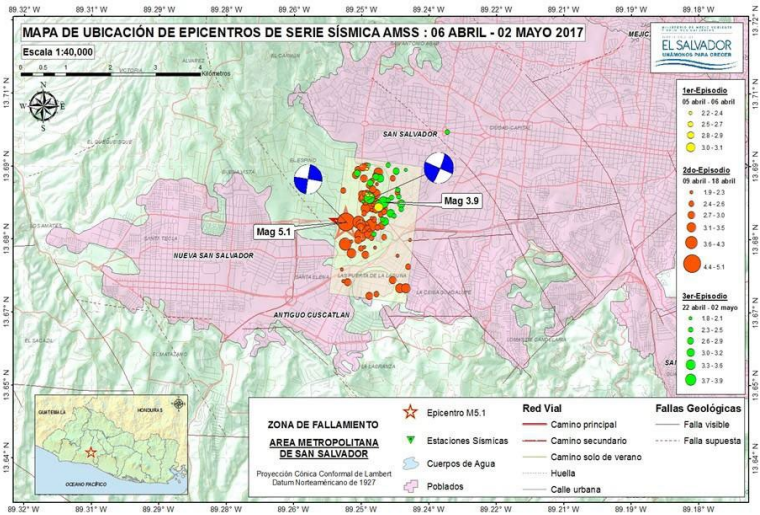


Figura 25. Localización de la serie sísmica en el AMSS

La Figura 26 corresponde al registro sísmico del 10 de abril de 2017 en la estación Piamonte (PMON), ubicada a unos seis kilómetros al oeste-noroeste del área epicentral de la serie sísmica ubicada entre los municipios de Antiguo Cuscatlán y San Salvador (Figura 25).

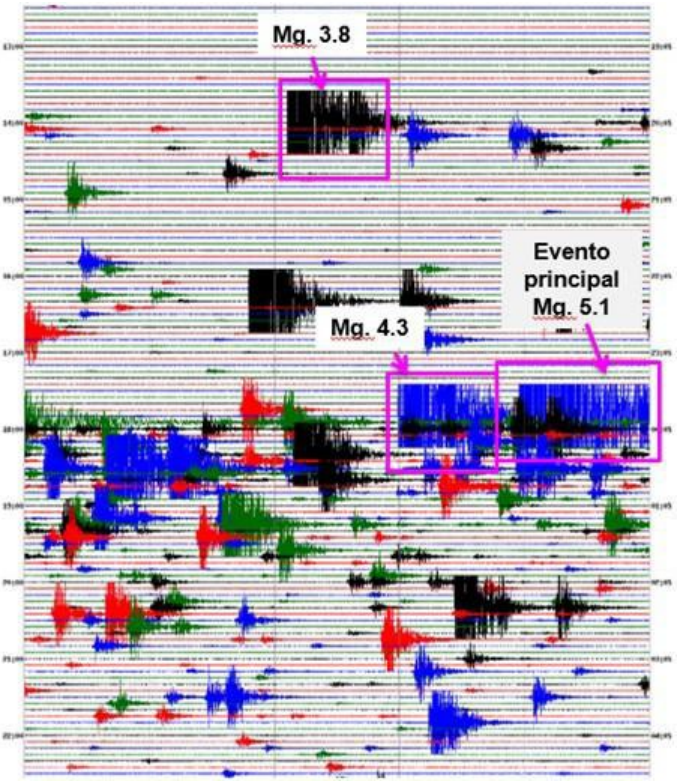


Figura 26. Registro sísmico, 10 de abril de 2017, estación Piamonte, municipio de Colón

Observación de sismos. Ejemplo 2: Un año de sismicidad

Localización de los epicentros, profundidades (Figura 27) y magnitudes (Figura 37) de los sismos registrados por la red sísmica del MARN con magnitud (M) mayor o igual a 3.0 durante el año 2022. El tamaño de los símbolos está relacionado con la magnitud y los colores con la profundidad de los hipocentros de los sismos.

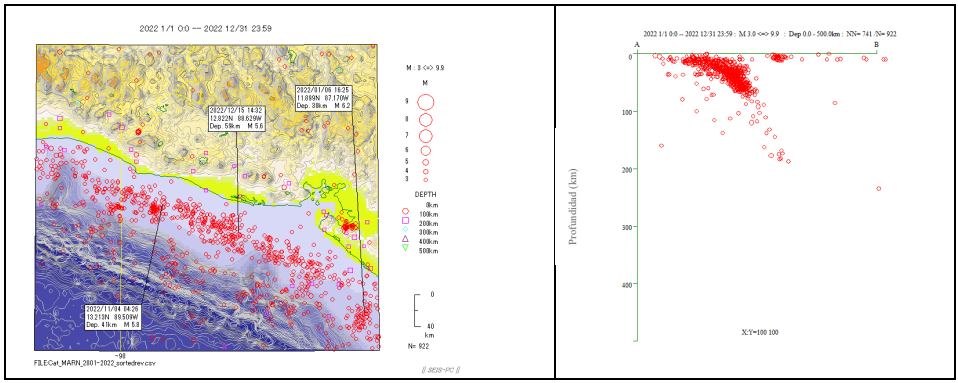


Figura 27. Ubicación (izquierda) y profundidad (derecha) de los sismos ocurridos en 2022[4]

4 Las figuras 27, 28, 37 y 40 fueron elaboradas con el software SEIS-PC.

Observación de sismos. Ejemplo 3: Réplicas

El terremoto M 7.3 que ocurrió el 27 de agosto UTC en 2012 tuvo réplicas notables cuya área de ocurrencia cubre 63 km x 31 km, estas réplicas se muestran con círculos en azul al sur del departamento de Usulután (Figura 28).

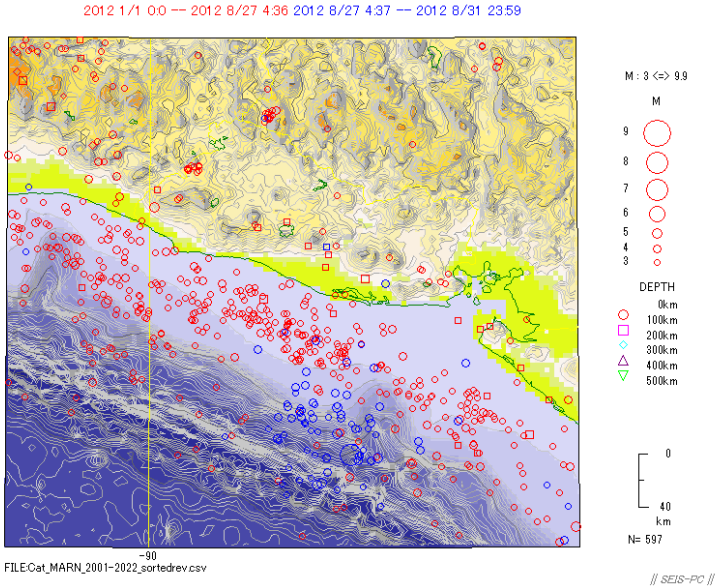


Figura 28. Sismos mayores o iguales a M4.0 registrados por la red de observación sísmica del MARN. Los círculos en rojo corresponden a epicentros ocurridos entre el 1 de enero y 27 de agosto de 2012, los círculos en azul son las réplicas del sismo de M7.3 del 27 de agosto

V. Actividad tectónica, sísmica y entorno geológico

Marco tectónico[5]

Desde un punto de vista tectónico, El Salvador se encuentra en el norte de Centroamérica, en el margen activo del noroeste de la placa Caribe (Figura 29). Enmarcado en el límite entre las placas Coco y Caribe, caracterizado por la subducción de la primera bajo la segunda a una velocidad que supera los 70 mm/año. Esta convergencia se traduce, a su vez, en la existencia de un sistema de fallas de desgarre en el continente, alineadas con la cadena volcánica. La velocidad de la Zona de Fallas de El Salvador (ZFES) que atraviesa al país de este a oeste, y la mayor de este sistema de fallas, alcanza los 14 mm/año.

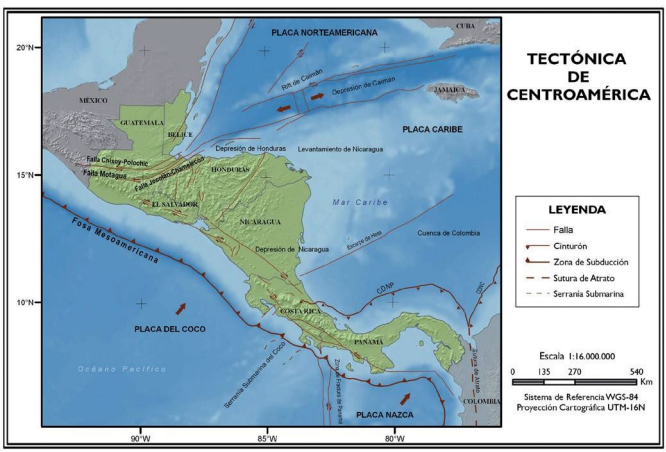


Figura 29. Tectónica de Centroamérica[6]

5 Adaptado de: Staller Vásquez, A. (2014). Modelización de las deformaciones en El Salvador (Centroamérica) mediante la integración de datos geodésicos (GPS), geológicos y sismológicos. Tesis doctoral. Universidad Politécnica de Madrid.

6 Benito, M.B., Lindholm, C., Camacho, E., Climent, A., Marroquín, G., Molina, E., Rojas, W., Talavera, E., Escobar, J.J. (2009). Marco Sismotectónico. En Benito, M.B. y Torres, Y. (Eds.), Amenaza sísmica en América Central. Madrid: Entinema

V. Actividad tectónica, sísmica y entorno geológico

Experiencia de fuertes terremotos

La interacción entre las placas Coco y Caribe es la principal fuente sísmica que afecta a El Salvador, la cual puede generar sismos con magnitud superior a siete. Ejemplos recientes han sido los sismos del 13 de enero de 2001 (Mw=7.7), 26 de agosto de 2012 (Mw=7.3), 13 de octubre de 2014 (Mw=7.3).

Sin embargo, los sismos con mayor potencial de destrucción son los que ocurren en el eje volcánico, debido a profundidades focales menores a 10 km y cercanía con los centros de población (Figura 30). El ejemplo más significativo es el sismo ocurrido el 10 de octubre de 1986, en San Salvador, con magnitud 5.7 (Mw) y 8 km de profundidad. Este sismo causó 1,500 muertos y pérdidas económicas entre 1.5 y 2 billones de dólares. Cerca del hipocentro del evento de 1986, tuvimos otro evento desastroso que ocurrió el 3 de mayo de 1965, que supuestamente podría haber debilitado los edificios. Finalmente, otro de los sismos importantes ha sido el del 13 de febrero en San Vicente, con una magnitud de 6.6 (Mw)

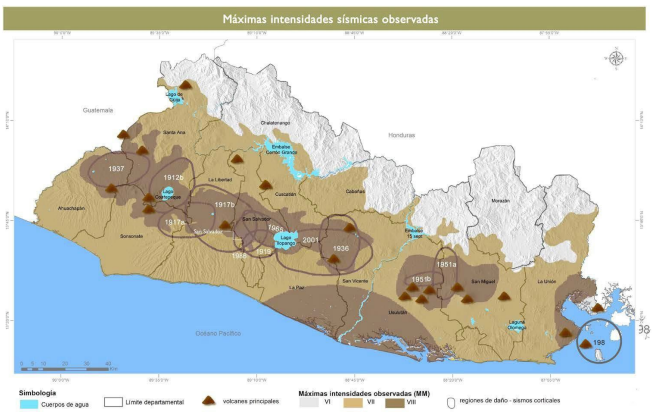


Figura 30. Máximas intensidades sísmicas observadas y regiones con daños por sismos en el eje volcánico

V. Actividad tectónica, sísmica y entorno geológico

Ambiente geológico y distribución de volcanes[7]

El Salvador está constituido por las siguientes unidades geomorfológicas: montaña fronteriza, fosa o graben central, cadena volcánica joven, cadena costera y planicie costera. Cada unidad forma una banda de orientación este-oeste (E-O) que se extiende por el país paralelamente a la costa (Figura 31). Las unidades tienen un marcado control tectónico en su origen, pues su desarrollo está condicionado por una combinación entre la tasa de subducción elevada y una intensa actividad sísmica y volcánica.

En la parte sur del graben central se elevan los volcanes cuaternarios, formando el eje volcánico que atraviesa el país de este a oeste.

La mayor parte del territorio salvadoreño está ocupado por materiales Plio-Cuaternarios y de origen volcánico (Figura 32). Se trata de rocas efusivas de composición riolítica, dacítica, andesítica y basáltica, así como materiales piroclásticos.

En El Salvador se reconocen cuatro familias de fallas principales con orientaciones noroeste-sureste (NO-SE), nor noroeste-sur sureste (NNO-SSE), nor noreste-sur suroeste (NNE-SSO) y este-oeste (E-O), siendo esta última la de mayor importancia, debido a que atraviesa todo el territorio a lo largo del eje volcánico.

7 Copiado de: Canora Catalán, C. (2011). Análisis sismotectónico, neotectónico y paleosísmico de la zona de falla de El Salvador, Centro América. Tesis doctoral, Universidad Complutense de Madrid, España

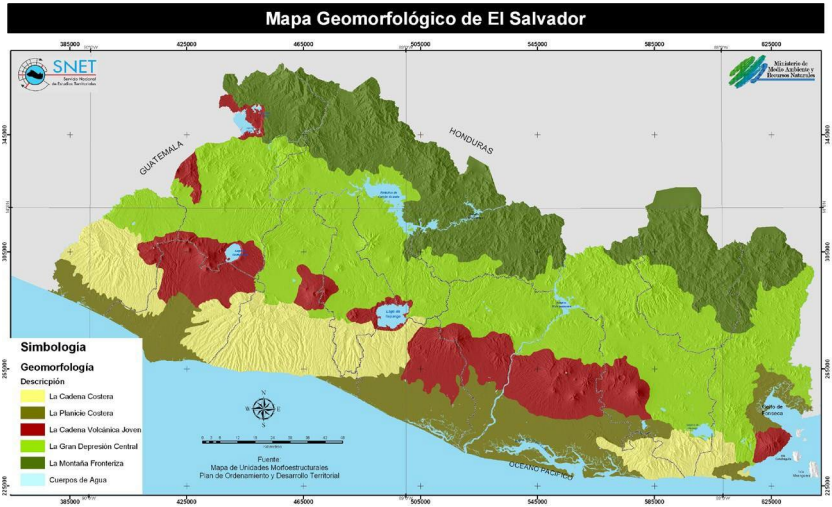


Figura 31. Mapa geomorfológico

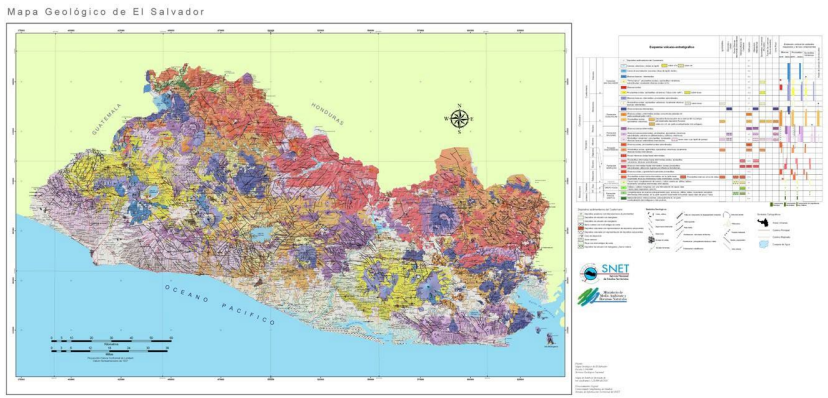


Figura 32. Mapa geológico

VI. Cooperación internacional

Cooperación internacional para la vigilancia de tsunamis

El Centro de Alerta de Tsunamis del Pacífico (PTWC), con sede en Hawái, Estados Unidos, desde 1965 emite alertas internacionales de tsunamis a los países de la cuenca del océano Pacífico. Estas alertas se realizan con el propósito de apoyar en la evaluación de la amenaza por tsunami en sus costas.

Posterior a la ocurrencia de un sismo con potencial de generar un tsunami, el PTWC ofrece productos de texto y gráficos con los datos pronosticados del tsunami a los puntos focales identificados en cada país. En el caso de El Salvador, el punto focal que recibe la información del PTWC es el Observatorio Ambiental del MARN.

Los productos de texto son recibidos por correo electrónico y fax, estos contienen información preliminar de los parámetros del sismo tales como: las costas con pronóstico de amenaza, los rangos de altura de ola esperados, los tiempos estimados de arribo, recomendaciones, entre otros.

Los productos gráficos recibidos son varios mapas que muestran la direccionalidad prevista de la energía del tsunami, la posición prevista de la onda inicial a lo largo del tiempo y las amplitudes de onda esperadas en alta mar y en la costa (Figura 33). Los rangos de altura de ola utilizados para el pronóstico en la costa son: menor a 0.3, de 0.3 a 1.0, de 1.0 a 3.0 y mayor a 3 metros.

En 2023, el Centro de Asesoramiento de Tsunami para América Central (CATAC), con sede en Managua, Nicaragua, ha comenzado su etapa de prueba. El MARN dará seguimiento a su progreso para utilizar en el futuro la información de CATAC como respaldo para emitir alertas de tsunami en El Salvador.

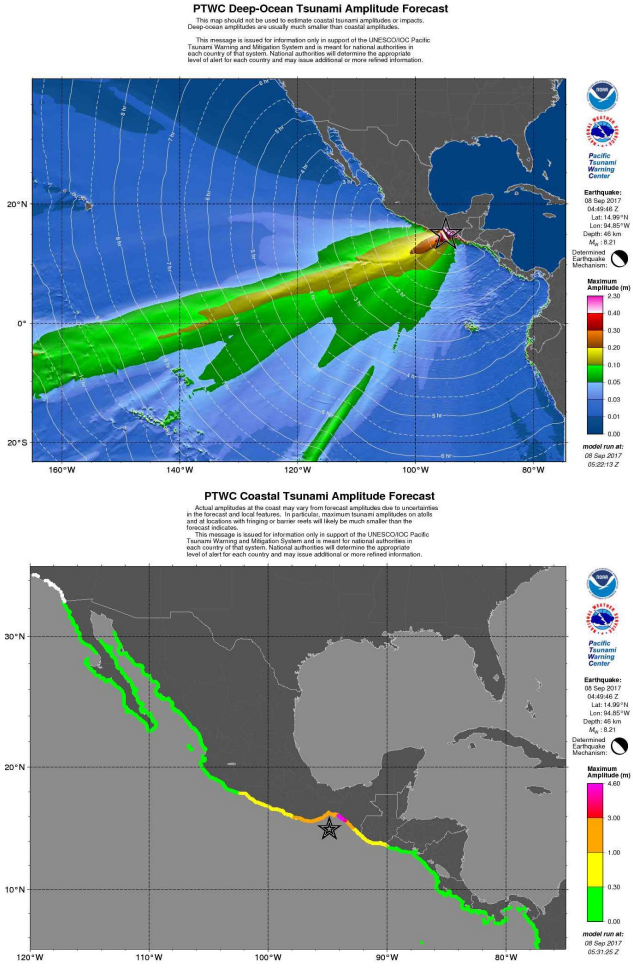


Figura 33. Ejemplo de los productos gráficos emitidos por el PTWC. En la imagen superior la dirección prevista de la energía del tsunami, amplitud en alta mar y tiempo de viaje. En la imagen inferior la amplitud máxima esperada del tsunami en la costa

VII. Información adicional

Tsunamis observados en la costa salvadoreña

En la costa salvadoreña se han registrado u observado 24 tsunamis en el período 1859-2022 (Figura 34 y 35). De ellos, ocho tuvieron su fuente en la costa de El Salvador. El tsunami del 26 de febrero de 1902 ha sido el más devastador, afectó a la zona occidental del país, en Barra de Santiago y Garita Palmera. Causó 185 muertes y daños materiales importantes, abarcó 120 kilómetros de costa aproximadamente.

DATOS DEL SISMO			DATOS DEL TSUNAMI EN EL SALVADOR	
Fecha (UTC)	**Magnitud**	**País**	**Lugar de El Salvador donde se registró u observó**	**Altura del agua en El Salvador (m)**
25/08/1859	6.2	**El Salvador**	La Unión	Tsunami probable
09/12/1859	7.0	**El Salvador**	Acajutla	Tsunami probable
26/02/1902	7.0	**El Salvador**	Barra de Santiago	Tsunami probable
			Acajutla	Tsunami probable
			Barra de Santiago y Garita Palmera	Tsunami probable
31/01/1906	8.8	Ecuador	Los Negros	Tsunami definitivo
25/05/1906		**El Salvador**	Los Negros	Tsunami cuestionable
07/09/1915	7.9	**El Salvador**	Barra de Santiago	Tsunami muy dudoso
05/10/1950	7.7	Costa Rica	La Libertad	0.09
			La Unión	0.10
23/10/1950	7.5	**Guatemala**	La Unión	0.10
04/11/1952	9.0	Rusia	La Libertad	0.58
09/03/1957	8.6	Estados Unidos	Acajutla	0.50
			La Unión	0.03
22/05/1960	9.5	Chile	La Unión	0.53
28/03/1964	9.2	Estados Unidos	Acajutla	0.20
			La Unión	0.10
19/09/1985	8.0	México	Acajutla	0.29
13/01/2001	7.7	**El Salvador**	Acajutla	0.25
26/12/2004	9.1	Indonesia	Acajutla	0.16
27/02/2010	8.8	Chile	Acajutla	0.25
11/03/2011	9.1	Japón	Acajutla	0.48
			La Unión	0.05
27/08/2012	7.3	**El Salvador**	Península San Juan del Gozo	6.3
			Acajutla	0.10
			La Unión	0.03
07/11/2012	7.3	**Guatemala**	Acajutla	0.10

14/10/2014	7.3	**El Salvador**	La Unión	0.02
16/09/2015	8.3	Chile	Acajutla	0.17
			La Unión	0.07
24/11/2016	6.9	**Nicaragua**	La Libertad	0.08
			Acajutla	0.03
08/09/2017	8.2	México	Acajutla	0.58
			La Libertad	0.38
			La Unión	0.06
15/01/2022	Erupción volcánica	Tonga	Acajutla	0.26

Figura 34. Tsunamis que han sido observados o registrados en El Salvador, según datos del National Centers for Environmental Information NGDC/WDS Global Historical Tsunami Database, 2100 BC to present. Recuperado el 13/02/2023 en https://www.ngdc.noaa.gov/hazard/tsu_db.shtml

Figura 35. Ubicación de sismos que han generado tsunamis y han sido registrados u observados en costa de El salvador

Sismicidad registrada durante 2022

Durante el año 2022, la red sísmica del MARN registró un total de 3,520 sismos, de los cuales 314 fueron reportados como sentidos por la población salvadoreña. Del total de sismos registrados, 1,167 fueron generados por las fallas geológicas en el territorio salvadoreño y 2,353 por la interacción de las placas tectónicas Coco y Caribe, o en fallas geológicas de los países vecinos. En la Figura 36 se presenta la distribución de la sismicidad por mes y en la Figura 37 la ubicación de los sismos con magnitud mayor o igual a 4.0.

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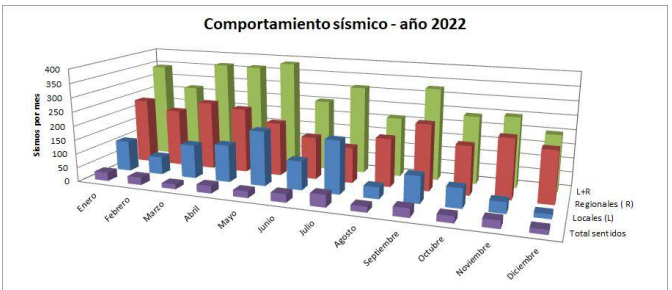
El sismo de mayor intensidad en territorio salvadoreño durante el año 2022, ocurrió el 3 de noviembre a las 10:26 p.m. (4 de noviembre a las 04:26 UTC), con epicentro frente a la costa de La Libertad, con magnitud de 5.8 (Mw), a una profundidad de 41 km, con una intensidad en San Salvador de IV-V en la escala de Mercalli Modificada.

Durante el 2022 se reportaron solamente tres enjambres sísmicos, uno en el municipio de Berlín, entre el 20 y 28 de mayo, compuesto por 61 sismos, de los cuales, solo uno fue reportado como sentido, con magnitud 2.7. El segundo fue en el municipio de Chinameca entre el 23 y 26 de junio, compuesto por 54 sismos, de los cuales cinco fueron reportados como sentidos, la máxima magnitud fue de 3.4. El tercero tuvo su epicentro entre los municipios de Ahuachapán, San Lorenzo y Atiquizaya, entre el 15 y 25 de julio, con 151 sismos; de ellos 20 fueron sentidos y la máxima magnitud fue de 4.4 (Figura 37).

Durante este año también registramos un pequeño tsunami el día 15 de enero, debido a la erupción del volcán Hunga Tonga-Hunga Ha'apai, ubicado a más de 10,000 km de El Salvador, en donde el mareógrafo de Acajutla registró una altura máxima de 26 cm.



	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre
Total sentidos	30	27	17	27	23	30	43	20	31	23	27	16
Locales (L)	109	64	120	132	194	102	187	41	94	69	39	16
Regionales (R)	235	205	245	232	191	151	126	171	233	171	210	183
L+R	344	269	365	364	385	253	313	212	327	240	249	199

Figura 36. Actividad sísmica 2022

VII. Información adicional

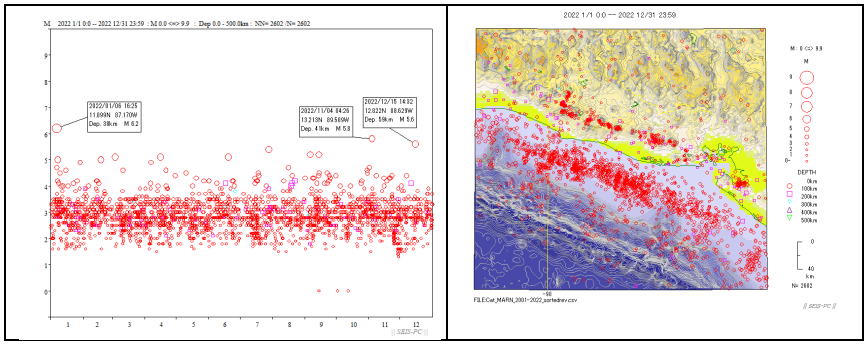


Figura 37. Magnitud y ubicación de los sismos ocurridos en 2022. La ubicación y profundidad de los sismos con magnitud ≥ 3.0 se encuentran en la Figura 27.

Sismicidad 2001-2022

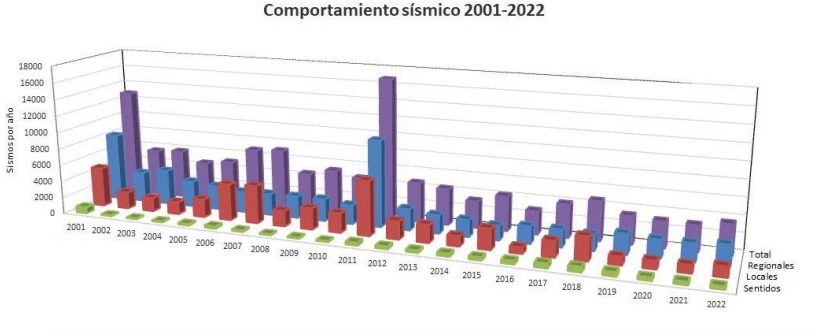
Miles de sismos son registrados cada año por la red sísmica del MARN. La Figura 38 muestra la distribución anual de sismos por año y los clasifica en: sismos sentidos por la población salvadoreña, sismos locales (generados por fallas geológicas en el territorio salvadoreño) y sismos regionales (generados por el proceso de subducción de la placa tectónica de Coco bajo la placa del Caribe, o en fallas geológicas de los países vecinos).

Durante el 2001 – 2022, el mayor porcentaje de la sismicidad registrada se clasifica como regional y corresponde al 57% y la sismicidad local es el 43 %. Del total de sismos registrados, aproximadamente el 5% fue reportado como sentido por la población. Tal como se evidencia en la Figura 38. En algunos años, la sismicidad local ha sido superior a la regional (años 2006, 2007, 2015 y 2018).

La mayoría de la sismicidad localizada anualmente, para el periodo en análisis, tiene magnitud menor a 4.0 (se encuentra entre el 91% y 96 %). En

la Figura 39 se hace una comparación de los sismos por rango de magnitud localizados entre las coordenadas de 12° a 15° latitud norte y de -91° a -87° longitud oeste, por ser la zona de influencia sísmica para El Salvador.

En la figura 40 se presentan los epicentros de todos los sismos, también se muestra un filtrado de los sismos con magnitud mayor o igual a 5.5, por ser sismos que en la mayoría de los casos son fuertemente sentidos por la población. En dicha Figura también podemos apreciar que solo cuatro sismos han sido mayores o igual a magnitud 6.9, estos ocurrieron en los años 2001, 2012, 2014 y 2016, y dos de ellos (2012 y 2016) fueron generadores de tsunamis, tal como se indica en la Figura 34. También se presenta en la Figura 40 los mecanismos focales de los cuatro sismos con magnitud mayor o igual a 6.9.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Sentidos	739	107	100	106	174	259	159	84	105	114	326	299	272	321	326	368	502	573	449	322	324	314
Locales	4729	1996	1618	1459	2149	4364	4499	1849	2521	2303	6464	2130	2091	1188	2432	717	1857	2755	935	924	888	1167
Regionales	8099	3572	4177	3102	2858	2485	2576	2617	2647	2257	10332	2535	2193	1991	1690	2007	2046	1866	2351	2104	2093	2353
Total	12828	5568	5795	4561	5007	6849	7075	4466	5168	4560	16796	4665	4284	3179	4122	2724	3903	4621	3286	3028	2981	3520

Figura 38. Comportamiento actividad sísmica 2001-2022

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Año	Mag. ≥ 0.1	Mag. ≥ 4	Mag. ≥ 5	Mag. ≥ 6	Mag.≥ 6.9
2001	8394	329	30	5	1
2002	2215	121	6	0	0
2003	3286	175	12	1	0
2004	2665	160	13	1	0
2005	2649	138	20	1	0
2006	2578	149	21	0	0
2007	2813	120	17	1	0
2008	2432	148	11	1	0
2009	2380	125	11	1	0
2010	2427	131	8	0	0
2011	2938	146	14	0	0
2012	2505	233	18	1	1
2013	2057	110	10	2	0
2014	2240	137	11	2	1
2015	1989	115	9	0	0
2016	1980	166	17	1	1
2017	2510	150	21	2	0
2018	2598	184	27	1	0
2019	2546	186	18	2	0
2020	2191	135	9	0	0
2021	2500	190	23	1	0
2022	2598	130	11	0	0
TOTAL	60491	3478	337	23	4

Figura 39. Sismos por rango de magnitud. Los datos de 2001 – 2019 han sido tomados de la base seisan y los del periodo 2020-2022 de la base de seiscomp del MARN

VII. Información adicional

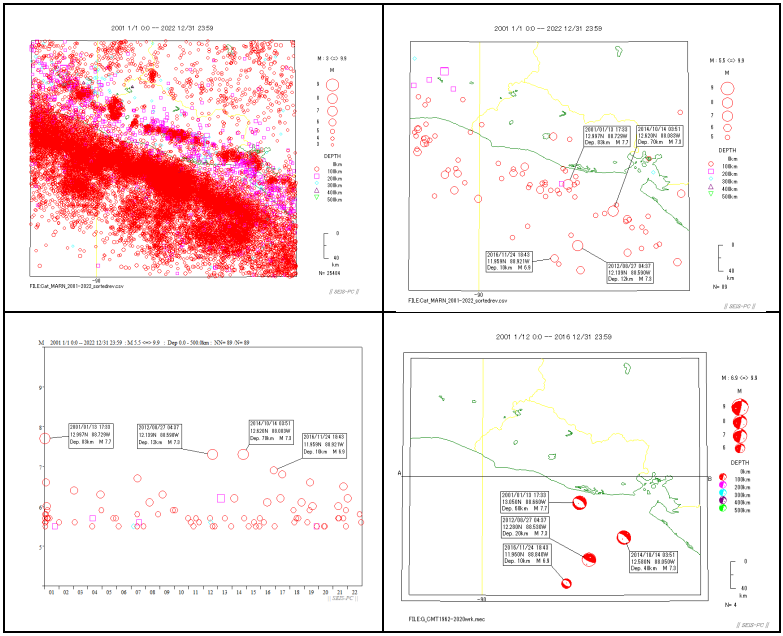

Figura 40. Comportamiento actividad sísmica 2001-2022. En la Figura superior izquierda se muestran todos los epicentros, en la imagen superior derecha solo los epicentros con magnitud ≥ 5.5 resaltando lo del mayor magnitud, en la Figura inferior izquierda las magnitudes ≥ 5.5 con respecto al tiempo y en la imagen inferior derecha los mecanismos focales de los cuatros sismos de mayor magnitud.

VII. Información adicional

Parámetros de una falla

El movimiento de una falla, representada por el movimiento entre dos bloques, se define por tres parámetros: *acimut* o *strike*, buzamiento o *dip*, desplazamiento o *rake* (Figura 41).

El acimut o *strike* (Φ), es el ángulo que forma la traza de la falla con el norte geográfico, puede tener valores entre 0 y 360 grados. El buzamiento o *dip* (δ), es el ángulo que forma el plano de la falla con el plano horizontal, puede tener valores entre 0 y 90 grados. El desplazamiento o *rake* (λ), es el ángulo entre la dirección del vector de deslizamiento (*slip*) o dislocación y la horizontal, medido sobre el plano de falla, puede tener valores entre -180 y 180 grados.

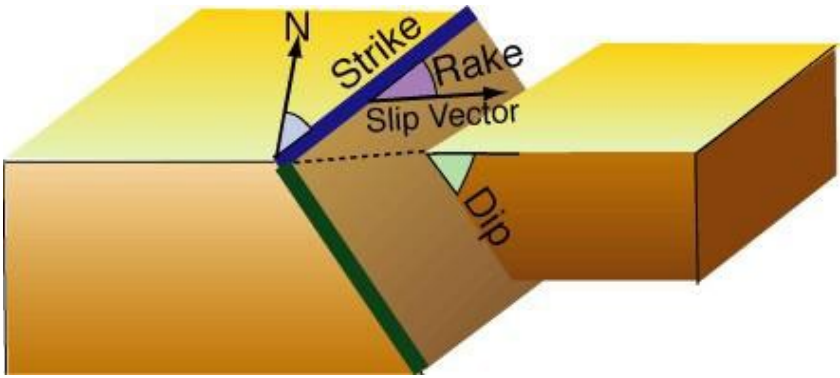

Figura 41. Parámetros que definen el movimiento de una falla[8]

8 https://igppweb.ucsd.edu/~gabi/sio15/supps/fault.gif

VII. Información adicional

Escala de intensidad sísmica Mercalli Modificada[9]

En 1931, en los Estados Unidos, H.O. Wood y F. Neumann recopilaron los trabajos de Mercalli, Cancani y Sieberg, y publicaron la escala que se ha llegado a conocer como Mercalli Modificada (MM). Una nueva versión de la escala MM fue presentada por C.F. Richter en 1956. Esta escala, compuesta de niveles crecientes de intensidad, que van desde sismos imperceptibles hasta destrucción catastrófica, se designa con números romanos (Figura 42). Estas no tienen una base matemática, es una clasificación arbitraria basada en los efectos observados.

Intensidad	Descripción/Daños
I	No sentido.
II	Sentido por personas en posición de descanso, en pisos altos o situación favorable.
III	Sentido en el interior. Objetos suspendidos oscilan. Vibraciones similares al paso de un camión ligero. Duración apreciable. Puede no ser reconocido como un terremoto.
IV	Objetos suspendidos oscilan. Vibraciones similares al paso de un camión pesado o sensación de sacudida como de un balón pesado golpeando las paredes. Los automóviles parados se balancean. Ventanas, platos, puertas vibran. Los cristales tintinean. Los objetos de barro se mueven. En el rango alto de IV, los tabiques y armazones de madera crujen.
V	Sentido al aire libre; se aprecia la dirección. Las personas que están durmiendo se despiertan. Los líquidos se agitan, algunos se derraman. Objetos pequeños inestables desplazados o volcados. Las puertas se balancean, se cierran y se abren. Contraventanas y cuadros se mueven. Los péndulos de los relojes se paran, cambian de período.
VI	Sentido por todos. Muchas personas se asustan y salen al exterior, caminan inestablemente. Ventanas, platos y objetos de vidrio se rompen. Adornos, libros, etc. se caen de las estanterías. Los cuadros se caen. Los muebles se mueven o vuelcan. Los revestimientos débiles y las construcciones de tipo D se agrietan. Las campanas pequeñas suenan (iglesias, colegios). Árboles, arbustos sacudidos visiblemente.

9 Copiado de: Bommer, J. (1994). Sismología para Ingenieros. Papeles técnicos UCA, serie: fundamentos. Universidad Centroamericana José Simeón Cañas

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VII	Difícil mantenerse en pie. Sentido por los conductores. Objetos suspendidos tiemblan. Muebles rotos. Daño a edificios del tipo D incluyen grietas. Las chimeneas débiles se rompen a ras del tejado. Caída de cielos rasos, ladrillos sueltos, piedras, tejas, cornisas, también antepechos no asegurados y ornamentos de arquitectura. Algunas grietas en edificios de tipo C. Olas en estanques, agua enturbiada con barro. Pequeños corrimientos y hundimientos en arena o montones de grava. Campanas grandes suenan. Canales de cemento para regadío dañados.
VIII	Conducción de los carros afectada. Daños en edificios del tipo C; colapso parcial. Algún daño a construcciones de tipo B; nada en edificios de tipo A. Caída de estuco y algunas paredes de mampostería. Giro, caída de chimeneas, rimeros de fábricas, monumentos, torres, depósitos elevados. Las estructuras de las casas se mueven sobre los cimientos si no están sujetas; trozos de pared sueltos, arrancados. Ramas de árboles quebradas. Cambios en el caudal o temperatura de fuentes y pozos. Grietas en suelo húmedo y pendientes fuertes.
IX	Pánico general. Construcciones del tipo D destruidas; edificios C seriamente dañados, algunas veces con colapso total; edificios tipo B con daños importantes. Daño general en los cimientos. Estructuras de armazón, si no están sujetas, desplazadas de los cimientos. Armazones arruinados. Daños serios en embalses. Tuberías subterráneas rotas. Amplias grietas en el suelo. En áreas de aluvial, eyección de arena y barro, aparecen fuentes y cráteres de arena.
X	La mayoría de las construcciones y estructuras de armazón destruidas con sus cimientos. Algunos edificios bien construidos en madera y puentes destruidos. Daños serios en presas, diques y terraplenes. Grandes corrimientos de tierras. El agua rebasa las orillas de canales, ríos, lagos, etc. Arena y barro desplazados horizontalmente en playas y tierras llanas. Carriles torcidos.
XI	Carriles muy retorcidos. Tuberías subterráneas completamente fuera de servicio.
XII	Daño prácticamente total. Grandes masas de rocas desplazadas. Visuales y líneas de nivel deformadas. Objetos proyectados al aire.
Para evitar ambigüedades de lenguaje, la calidad de la construcción, ladrillo u otro material, se especifica por las siguientes letras:	
A	Estructuras de acero y concreto reforzado, bien diseñadas, calculadas para resistir fuerzas laterales. Buena construcción, materiales de primera calidad.
B	Estructuras de concreto reforzado, no diseñadas en detalle para resistir fuerzas laterales. Buena construcción y materiales.
C	Estructuras no tan débiles como para fallar la unión de las esquinas, pero no reforzadas ni diseñadas para resistir fuerzas horizontales. Construcción y materiales corrientes.
D	Construcciones de materiales pobres, tales como el adobe; baja calidad de construcción. No resistente a fuerzas horizontales.

Figura 42. Escala de intensidad sísmica Mercalli Modificada

VII. Información adicional

Leyes de escalamiento sísmico

Existen relaciones entre la magnitud del sismo (M), la longitud de ruptura (L) en kilómetros y el desplazamiento (U) en metros de la falla que genera el sismo. Por ejemplo en Utsu (2001)[10] se presentan las siguientes relaciones:

Log U(m)=0.5 M -3.1
Log L(km)=0.5M -1.85

En la Figura 43 se presentan los valores de longitud de ruptura y desplazamiento en la falla para sismos con magnitudes entre 5 y 9.1

M	U (m)	L (km)	M	U (m)	L (km)	M	U (m)	L (km)
5	0.25	4.47	6.4	1.26	22.39	7.8	6.31	112.20
5.1	0.28	5.01	6.5	1.41	25.12	7.9	7.08	125.89
5.2	0.32	5.62	6.6	1.58	28.18	8	7.94	141.25
5.3	0.35	6.31	6.7	1.78	31.62	8.1	8.91	158.49
5.4	0.40	7.08	6.8	2.00	35.48	8.2	10.00	177.83
5.5	0.45	7.94	6.9	2.24	39.81	8.3	11.22	199.53
5.6	0.50	8.91	7	2.51	44.67	8.4	12.59	223.87
5.7	0.56	10.00	7.1	2.82	50.12	8.5	14.13	251.19
5.8	0.63	11.22	7.2	3.16	56.23	8.6	15.85	281.84
5.9	0.71	12.59	7.3	3.55	63.10	8.7	17.78	316.23
6	0.79	14.13	7.4	3.98	70.79	8.8	19.95	354.81
6.1	0.89	15.85	7.5	4.47	79.43	8.9	22.39	398.11
6.2	1.00	17.78	7.6	5.01	89.13	9	25.12	446.68
6.3	1.12	19.95	7.7	5.62	100.00	9.1	28.18	501.19

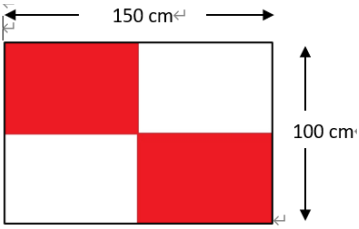
Figura 43. Longitud de ruptura (L) y desplazamiento (U) en las fallas con el uso de leyes de escalamiento, para diferentes magnitudes (M)

10 Utsu T (2001) Jishingaku 3rd edn. KyoritsuShuppan (en japonés)

Apéndice 1 Bandera del tsunami

La "Bandera del Tsunami" se ha introducido en Japón para salvar a las personas nadando, bañándose o jugando en el mar de los abruptos ataques del tsunami.
Al usar la Bandera del Tsunami, podemos notificar 1) a las personas con discapacidad auditiva y 2) a las personas que nadan que tienen dificultades para escuchar el sonido debido al sonido de las olas o el viento.

JICA proporcionó 5 banderas de 150 x 100 cm sobre un máximo de 2 metros, que se utilizaron en el simulacro el 22 de noviembre de 2022. Se requiere una varilla de aluminio de 2 metros como asta para izar.



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国内遠隔業務結果報告書

（エルサルバドル国　地震・津波情報の分析能力強化 Phase 2、2021～2023 年）

令和 3 年 6 月 26 日

JMBSC 森　滋男

1. 作業日程実績

当初のワークプランに従い、一部手直しして作業を実施した。その実績は、付録２に示した。なお、プロジェクト全体の日程概要を付録１に示した。

2. 成果

2.1 ワークプラン[1] に示した作業目標と作業手順

下に作業目標一覧を示した。また、下の図１と２に作業手順を示した。

上位目標

MARN の DGOA をカウンターパート（以下、「C/P」）機関とし、地震・津波監視及び警報発令業務の実施能力の向上

目標とする成果

成果１：フェーズ1で導入・提案した内容が適切に実践される。

成果２：CATACから発出される津波情報がDGOAの津波予測システムに適切に反映され、両者間の情報共有が促進される。

成果３：DGOAがDGPCと共有する津波予警報のためのガイドライン・プロトコルが改善される。

成果４：地震・津波監視システムの高度化に資する技術が紹介され、システムの高度化に向けた今後の指針が定まる。

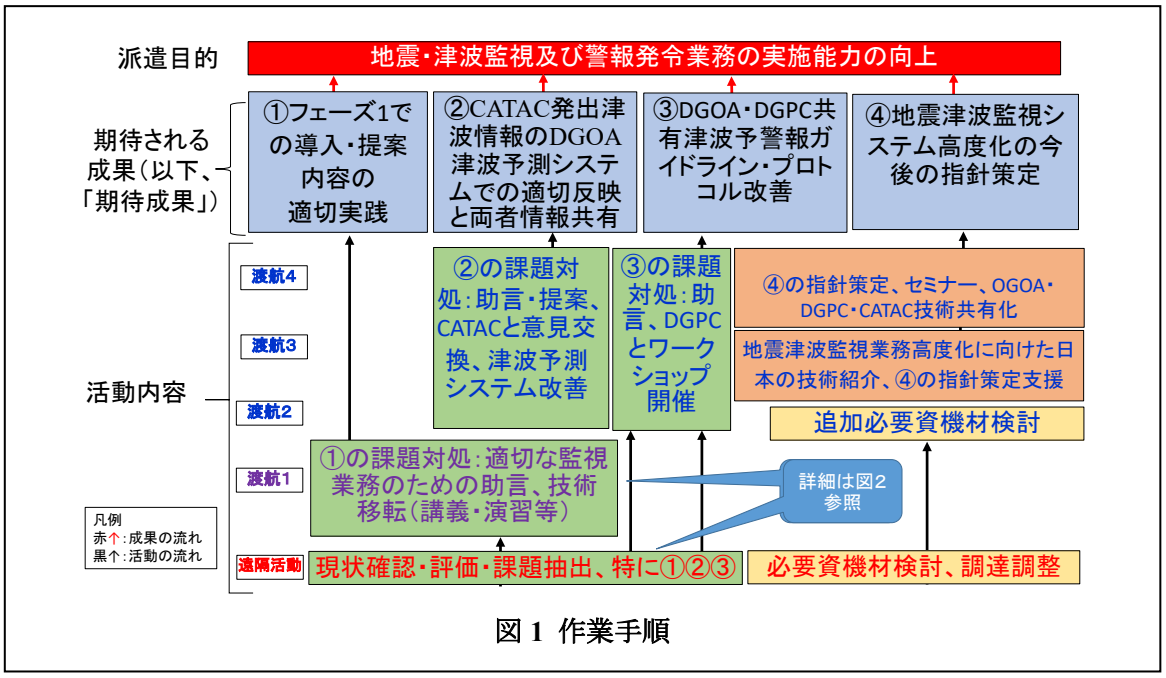


図 1 作業手順

[1] Work Plan of the Short-term Expert Dispatch to MARN in El Salvador as of 09Jun21

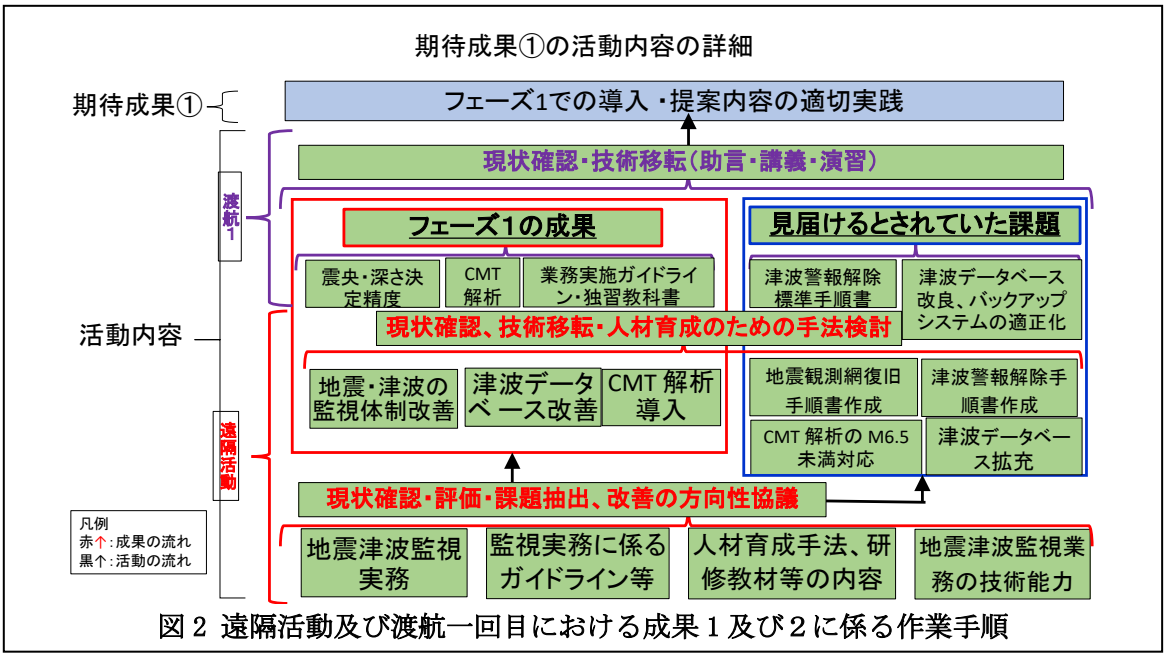


図２ 遠隔活動及び渡航一回目における成果１及び２に係る作業手順

2.2 遠隔活動における目標の詳細と達成状況

遠隔活動で扱うべき目標をその達成状況と共に下表に整理した。

遠隔活動での優先順位	目標とする成果の型	監視		広報			遠隔活動での成果達成状況
	遠隔活動における目標の優先順位の意味 1：できるだけ達成に近づける 2：同上 3：着手する 4：特に扱うことはしない	業務	手引書	情報処理	市民防災	一般国民	
1	目標とする成果１						
1	1) フェーズ１での導入内容の現状確認・評価						
1	a) 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	○					活動結果の整理
1	b)発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	○					同上
2	c) その他						
2	c-1) 津波監視手引書		○				作業中
2	c-2) 津波監視現業体制での技術レベル：維持・改善研修体制確立		○	○			同上
1	2) 見届けることとしていた課題						
1	a) CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	○					活動結果の整理
1	b) 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	○					同上
1	c) 地震観測網復旧の効率的な取扱いのための道具：開発（地震観測網復旧の手順書作成）		○	○			作業中
1	d) 津波警報解除手順書：作成		○		○		同上
1	e)バックアップシステムの適正化：対応			○			同上
3	f) その他						
3	f-1)現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立		○				作業中
3	f-2) MARNガイドブック：確立		○		○	○	活動結果の整理
3	f-3)e-mailの公式利用、FAX点検の日課への導入：確立		○	○	○		作業中
3	f-4) 異常地震活動対応標準手順：確立		○				同上
3	f-5) 津波警報解除後の注意喚起情報：導入検討	○	○		○	○	同上
3	f-6) 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	○	○				同上
3	f-7) 津波実況監視手段Tide Tool の利用：現業者での利用推進	○	○	○			活動結果の整理
3	f-8) 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討（目標とする成果 1-1 c-2参照）			○			作業中
1	目標とする成果 2						
1	CATACとの情報の共有化の促進	○	○	○			作業中
1	目標とする成果 3						
1	DGPCの津波警報利用：適切化		○		○		作業中

2.3 遠隔活動におけるその他の目標の詳細と達成状況

遠隔活動で扱うべきその他の目標をその達成状況と共に下表に整理した。

遠隔活動での優先順位	目標とする成果の型	監視			広報		遠隔活動での成果達成状況
	遠隔活動における目標の優先順位の意味 1：できるだけ達成に近づける 2：同上 3：着手する 4：特に扱うことはしない	業務	手引書	情報処理	市民防災	一般国民	
3	目標とする成果4						
3	今後の業務改善に向けた提言						
3	1) GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）／津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定			○			調査中
3	2) 地震波形を用いた解析による震源断層の滑り量分布の把握			○			作業中
3	3)モーメントレート関数表示機能（震源時間関数の把握）			○			同上
4	4) その他						
4	地震波初動解析による発震機構把握			○			作業中
4	マグニチュード過小評価手法 / 日本の地震・津波監視業務に関し、過去事象の教訓・課題・改善共有			○			
4	内陸地震活動の震源分布推定の精度向上のためのDD手法			○			
4	複数地震同時発生への自動震源解析の信頼性向上のためのIPF手法			○			
4	震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入			○			
4	津波警報の精緻化のための海岸を分割した警報発表手法			○			
4	津波観測測器がない海岸のボランティアによる監視安全・効率化			○			
4	エルサルバドルの地震マイクロゾーニング地図の更新のためのガイドラインの検討			○			調査中
1	機材						
1	機材調達						作業中
4	他の国際協力機関の関連活動の状況把握						
4	ユネスコによるTsunami Readyプロジェクト						作業中
4	スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW）開発						同上
4	米州開発銀行（Inter-American Development Bank, IDB）による地震危険度評価プロジェクト						同上

3. 成果達成状況の詳細 [2]

3.1 目標 1-1 フェーズ 1 での導入内容の現状確認・評価

a) 地震発生検知～津波警報発表の時間：20 分以上を 3 年間で 5～10 分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）

これら改善結果が継続していることを以下に示すように確認した。但し、下に示すようにいくつかの課題も見出された。

1) 津波警報に係る「最終情報」の発出までに要する時間

- 見込んでいた通り数分短縮化された。即ち、下の表にあるようにフェーズ 1 終了時の 2017 年に 9.5～21.2 分であったものが、最近の 3 年間（2019～2021）では 8.0～17.4 分となった。なお、この表では、分と秒とで数字が表現されている。また、下の図 3 では日本の気象庁における津波警報の発出に要する時間の最近 60 年間の短縮経緯と比較してエルサルバドルの改善経過を示した。
- 今回の数分の短縮という改善の背景には、可能性として、残されていた対応が想定通りに実施されたことがあるのではと考えられる。

2) 「最終情報」発出に係る課題

- 「最終情報」のような緊急情報は安定して発出されなければならない。というのは、時によって救命に直接係る情報となるからである。また、安定して発出することは、MARN に対する国民の信頼の醸成につながるものでもある。このようなことから、最遅発出時間は可能な限り短くすることが肝要である。

[2] 青字で記述した内容は本プロジェクトで実施していく。

- 専門家は最近 3 年間における最遅である 27.0 分について検討する。但し、この地震はマグニチュードが 4.4 であり、津波警報に係るものではなかった。

経過時間 対象：M4.0以上の地震		フェーズ1							フェーズ2
		2014	2015	2016	2017	2019	2020	2021	評価結果
速報	平均	5:30			5:49	4:32	5:34	5:08	最善状況維持
	最遅	07:39 M4.2			09:00 M8.0	10:14 M4.2			同上
最終	平均	20:13 +/- 7:29 (12:44 – 27:42)			15:20 +/–05:52 (09:28 – 21:12)	10:45 +/- 01:47 (08:58 – 12:32)	13:57 +/- 03:26 (10:31 – 17:23)	12:44 +/- 02:47 (09:57 – 15:31)	さらに改善
	最遅	40:14 M4.2			35:43 M5.3	27:59 M4.4			同上

3) 速報発出に要する時間
これは最善状況が維持されていること確認された。即ち、2017 年では約 5.8 分であり、最近の 3 年間では 4.5~5.1 分程度であった。但し、これらは 2015 年における 5.5 分と同程度である。以上のことは上表に示してある。なお、この表では、分と秒とで数字が表現されている。

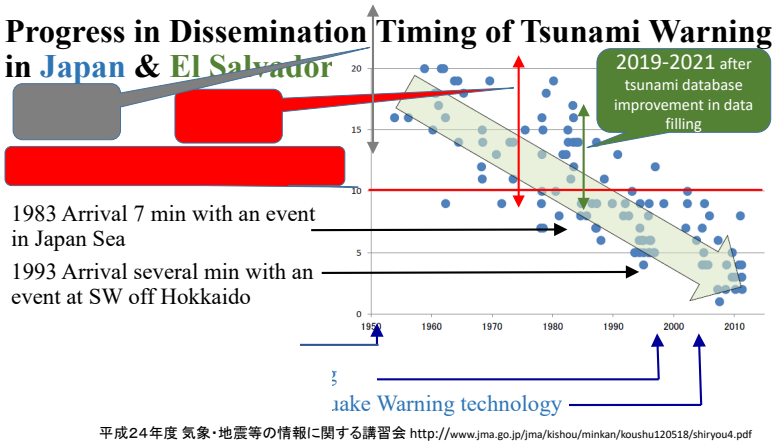


図 3 エルサルバドルの改善経過及び日本の気象庁における津波警報の発出に要する時間の最近 60 年間の短縮経緯

- 最近の 3 年間では、M4.0 未満の地震を含めると最遅は 30 分であった。この地震は小さいことから、発表すべきか（有感となったか）の判断[3]に時間を要したとのことであった。このことは、この判断を自動で行うという機能を導入することで解決できることから、MARN はそのような対応をするとしている。

4）速報発出における課題
- 速報も最終報と同様に安定して発出されなければならない。それは、最終報発出に直接係るためである。
- 平均発出時間は、将来において EEW 機能の導入後、これの成果を活用することで短縮化が図りうる可能性がある。
- 一方で、我々は、この発出時間を如何に短縮化させるか検討すべきである。

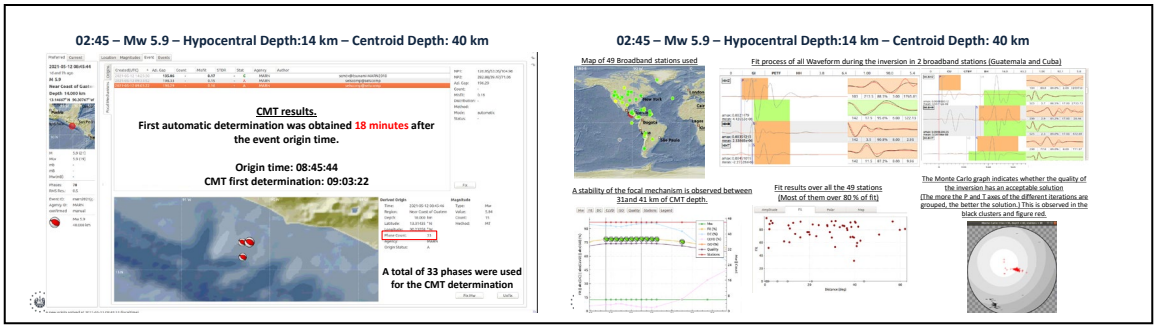
5）最終報の精度
これは改善状況が維持されていることが確認された。即ち、最終報に用いたデータの残差（観測値と計算値の差）の標準偏差は、下表に示すように、2014 ～ 2015 年では約 1.0 秒であったものが、2016 年以降最近の 3 年間も含めて約 0.5 秒であった。

残差の標準偏差(秒) 対象：M4.0以上の地震		フェーズ1							フェーズ2
		2014	2015	2016	2017	2019	2020	2021	評価結果
速報	平均					0.73	0.72	0.75	
	最遅					1.95 M4.0			
最終	平均	1.09 – 1.44	0.91 – 0.97	0.38 – 0.41	0.39 – 0.49	0.53	0.57	0.46	改善状況維持
	最遅	2.6 M4.2		1.7 M6.1		1.23 M4.2			同上

[3] MARN は有感地震のみを発表するという基準を設けている。

b) 発震機構と Mw の利用：地震発生後 15～30 分で監視業務で利用可能化（CMT 解析の導入；Mw はモーメントマグニチュード）

改善状況が維持されていることが確認された。下の図を参照。



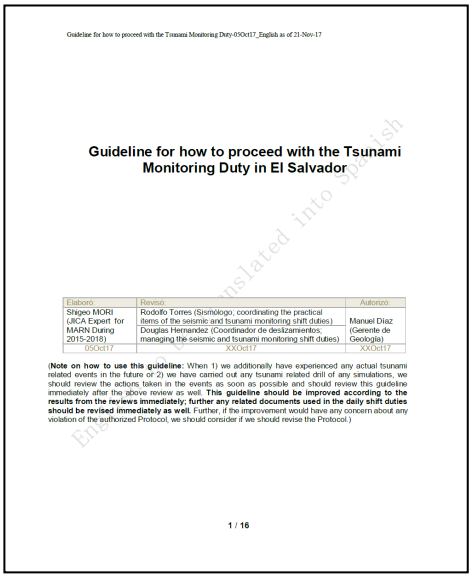
c-1) 津波監視手引書

この手引書は下のコラム欄に示す目的を有する。名称はガイドラインと呼ぶこともある。

目的：

1）大地震発生後 30 分までの時間経過に沿った詳細な作業手順を確立するものである。但し、公的な津波や地震への手順書（protocol）が整備されていることを前提としたものである。

2）市民防災局や一般国民に、海岸やその近傍に災害をもたらす可能性がある津波の発生について、その到着前に可能な限り早期に伝えるために用いるものである。


Guideline for how to proceed with the Tsunami Monitoring Duty-05Oct17_English as of 21-Nov-17

Guideline for how to proceed with the Tsunami Monitoring Duty in El Salvador

Elaboró:	Revisó:	Autorizó:
Shigeo MORI (JICA Expert for MARN During 2015-2018)	Rodolfo Torres (Sismólogo; coordinating the practical items of the seismic and tsunami monitoring shift duties) ; Douglas Hernandez (Coordinador de deslizamientos; managing the seismic and tsunami monitoring shift duties)	Manuel Díaz (Gerente de Geología)
05Oct17	XXOct17	XXOct17

(**Note on how to use this guideline:** When 1) we additionally have experienced any actual tsunami related events in the future or 2) we have carried out any tsunami related drill of any simulations, we should review the actions taken in the events as soon as possible and should review this guideline immediately after the above review as well. **This guideline should be improved according to the results from the reviews immediately; further any related documents used in the daily shift duties should be revised immediately as well.** Further, if the improvement would have any concern about any violation of the authorized Protocol, we should consider if we should revise the Protocol.)

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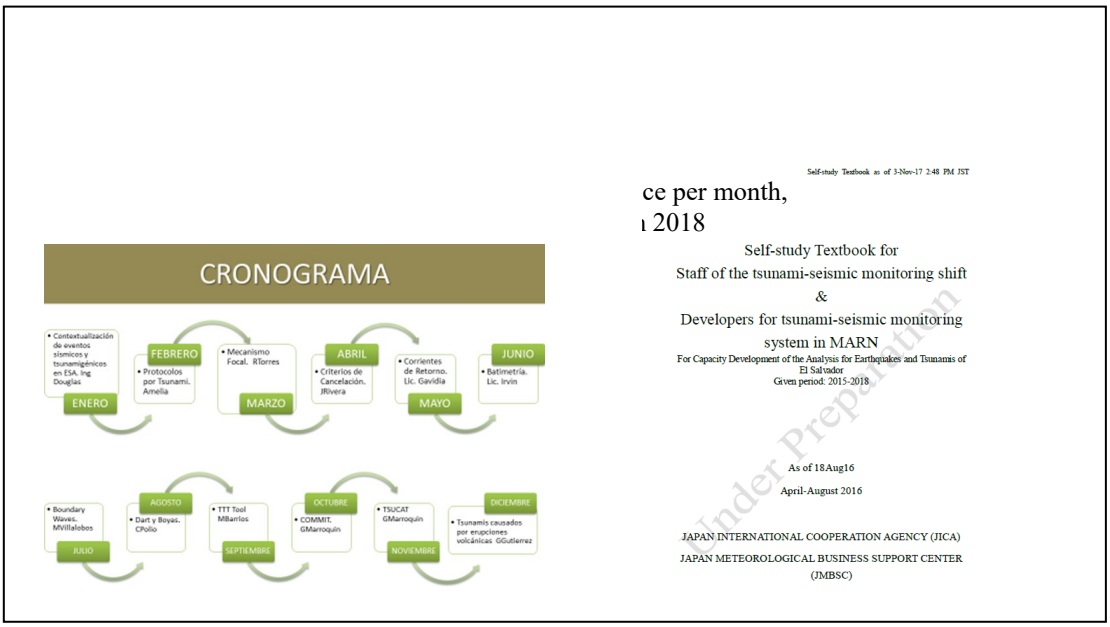
- このガイドラインはフェーズ１では、右に示すようなものが作られた。しかし、これは現在では使われておらず、MARN は替わりに別の物（以下、MARN 手順書と呼ぶ）を用いている模様である。
- このため、専門家は MARN 手順書の提供を受けて、この中において、以下に述べる事柄を確認することとする：
  1) マグニチュードや震源の選び方や CMT 分析から如何に Mw を得るかの記述の有無
  2) 公的手順書の“ANNEX 2 TABLES OF ACTIONS AND RESPONSIBILITIES”の考慮の有無
  3) エルサルバドル近傍に発生した地震についてのマグニチュードの大小に応じた作業シナリオについて、地震発生最初の 10 分間の作業がすべて同じであること
  4) 公的手順書の“Atender telefonos para brindar informacion preliminar”について、適切に対処すること
- 一方、津波警報発表訓練について、MARN 手順書が利用されることが要請されるが、訓練実施の現状は次の通りである：
  1) 2 月に一回程度実施。但し、昨年は CATAC 主導の訓練時での実施のみ。
  2) 2017 年に作成された訓練手順書はあるが、利用されていない、MARN はこれを見直してみる。
  3) 訓練の作業時系列は CATAC 主導での訓練におけるものと大きく異なるものではない。

c-2）津波監視現業体制での技術レベル：維持・改善研修体制確立
自己研修体制及び研修教材は、フェーズ１で確立した。目的は監視当番者の技術レベルを高いレベルに維持するためである。その研修体制及び研修教材の概要等は下の図に示した。これらは現在機能していない。

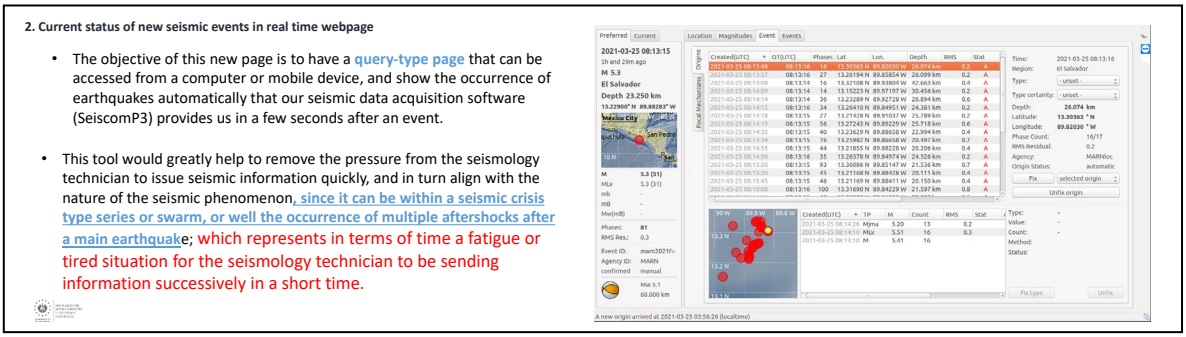


一方で、現業当番に必要な研修は仕事を体験しつつ実施されてきている（OJT）。但し、自主研修教材は作られていない。

- このことについて、専門家は、次のように対応することを考えている。
  1）自主研修教材については、簡素な教材として、震源計算、発震機構解析、地震走時表など基礎事項を扱うものを新たに作成
  2）自主研修体制については、現業当番者が、地震月報[4]の作成について、相互にその内容の改善に向けた対応をするという形で構築。そして、この対応において、上述の自主研修教材や「MARN ガイドブック」（目標 1-2 f-2 参照）を利用することを想定。

3.2 目標 1-2 見届けることとしていた課題

a）CMT 解析機能：M6.5 未満の地震をカバーするよう地域の地震波速度特性を取込んだグリーン関数データベース（GFDB）調達
このことは実施され、M6.5 未満の地震にも対応可能なことを確認した。前述の目標 1-1 b には、M5.9 で対応できていることを示している。



[4] 毎月 MARN はその月の地震活動の報告書を作成してきている。そして、それを Web サイトに掲示して一般国民の利用に供してきている。但し、現在は同サイトの改良中のため、この作成は 2017 年で停止している。

Improvement of the database in the Tsunami scenarios

We currently have 561 scenarios modeled (27x3x11=891?):

1) M: from 7.0 to 8.0 in 0.1 steps (11 scenarios?)
2) Depth: **three depth values for each of the 27 selected seismic sources (3x27=81 scenarios)**
3) Wave height: forecasted at 71 points along the coast
4) Results: tabulated at the municipality level to simplify the results (Note: a municipality can have several forecast points - where the highest value is taken)
5) Wave height values: associated in ranges, <0.3 m, 0.3 - 1.0 m, 1.0 - 3.0 m, and > 3.0 m
6) Earthquake with tsunamigenic characteristics: there is a module of the information dissemination platform that compares the data obtained from Seiscomp3 and the one drawn from the database scenario that most closely resembles the earthquake that has occurred.

(Note: the above was translated into English by the Expert with Google translation software from the email in Spanish sent from MARN.)

b) 津波データベース運用改善：地震パラメーター自動入力機能開発及び津波データベース改良

このことは、上の示した図と説明とに示すように達成されたことを確認した。

但し、専門家は、自動入力機能については実際の運用状況で、津波データベース改良については書き物で、それぞれ確認する。

c) 地震観測網復旧の効率的な取扱いのための道具：開発（地震観測網復旧の手順書作成）

MARN は、運営する様々な観測施設の障害を効率的に復旧させるための道具として観測施設の状態を地図に表示させるシステム（以下復旧用道具と呼ぶ）の開発をフェーズ 1 終了の時期に進めていた。この復旧用道具開発はその後中止された。しかし、また再開される見通しとのこと。専門家はその再開の進捗を継続的に注視していくこととする。

- 一方、地震観測網の稼働率は、下表のように近年は 86% 前後を維持してきている。但し、長期障害の観測施設を含めると 2020 年では 67% の稼働率となっている。長期障害の原因となっているのは、GPS 時計とデータ中継無線設備の障害である。

Tipo de alimentación	2015 (%dias funcionado)	2016 (%dias funcionado)	2017 (%dias funcionado)	2018 (%dias funcionado)	2019 (%dias funcionado)	2020 (%dias funcionado)
Promedio general	65%	74%	83%	82%	76%	67%
total estaciones	46	45	45	47	48	55
Estaciones no consideradas para promedio corregido (marcadas en amarillo) – ver justificación en notas	7	4	3	4	9	13
Promedio corregido	74%	81%	85%	88%	86%	84%

Consideraciones

1 El % de días de funcionamiento de cada estación se han obtenido contando los registros de data continua (archivos generados por día), independientemente si la estación funciono completamente las 24 horas del día.

2 Las estaciones de banda ancha tiene la capacidad de recuperar data, por lo tanto si un enlace se pierde por días, semanas o meses, el dato se recupera. Por lo tanto no tenemo control de la eficiencia real de la estación.

3 Debido que algunas estaciones se cerraron, movieron a otros sistios, se instalaron en direrentes periodos del año, su funcionamiento estuvo fuera de nuestro control. Se optó por calcular un promedio corregido, donde dichas estaciones no se han considerado.

------- (Translated from the above Spanish by the Expert) -------

Note for the above list:

1 The days of operation of each station have been obtained by counting the continuous data records (files generated per day), regardless of whether the station was fully operational 24 hours a day.

2 Broadband stations can recover data, therefore if a link is lost for days, weeks or months, the data is recovered. Therefore, we have no control of the actual efficiency of the station.

3 Because some stations were closed, moved to other sites, were installed in different periods of the year, their operation was out of our control. It was decided to calculate a corrected average, where these stations have not been considered.

- 専門家は、これらの障害を早期に回復させる手段はないか検討することとする。例えば、１）適量の予備品の整備、２）どのように障害に対処すべきかを助言するシステ

ム（例：対応の優先順位を示してくれるシステム）の確立。

d) 津波警報解除手順書：作成

津波警報解除の手順は、公式手順書（Protocol）に下のコラムに示すように記述されている。

The excerpt from the Protocol (Translated from Spanish by the Expert)

(Note: The below all conditions are the authentic cancellation conditions.)

Conditions that must be met to cancel tsunami threat

1) That the final parameters of the earthquake do not meet the threshold for generating a tsunamigenic event.
2) Do not observe changes or significant increases in sea level (less than 10 cm) in the tide gauges near the coast of El Salvador after the estimated time of arrival of the tsunami
3) That local conditions do not continue to produce strong water currents in canals or ports that require an extension of the tsunami alert status.
4) That the area has not been hit by harmful waves for at least two hours

About the issuance of the cancellation

Finally, Civil Protection is informed of the cancellation of the threat and the cancellation is disseminated through the different communication media and social networks, for this seen in annex 3 the cancellation message formats, in addition to including in the event closing report the cancellation of the threat.

但し、次のような課題がある。

- 市民防災局は、解除の判断にあたって、MARN の解除情報だけでなく、太平洋津波警報センター（PTWC）からの情報も利用している。
- Protocol の解除の条件の第 4)項に“two hours”とあり、その他“Decaimiento suficiente del tsunami después de un largo tiempo (al menos ***dos horas*** según PTWC después de los tiempos de arribo estimados)” & “Que el área no haya sido golpeada por olas dañinas al menos durante ***dos horas***”)とある。しかし、「2 時間」の根拠が明確でない。
- 専門家は、これら２つの課題をさらに検討することが必要である。

一方、解除においては、「津波の高さが小さくなってきた以降に襲来する大きな津波」（目標 1-2 f-6 参照）を考慮すべきである。このような津波は、2017 年のメキシコ近海で発生した[5]地震によるもの（右図参照）がある。公式手順書もこのことが考慮されている。下の図[6]では、この津波において、ラ・リベルタ海岸では、津波の第一波が観測されてから 11 時間経って最大波高（それまでの最大波高の約 3 倍）の津波が襲来したことを示している。この現象（第一波にかなり遅れてかなり高い津波が襲来）は、メキシコ沿岸からエルサルバドル沿岸まで海深が浅い部分が続いており、ここに津波エネルギーが閉じ込められ、かつ伝播速度が深い部分に比し遅いということから起こったと（その当時）推測された。

The internal document in MARN

Compilation of information and actions carried out by earthquake of magnitude 8.1, off the coast of Chiapas, Mexico, on September 7, 2017, at 22:49:21 (El Salvador time)

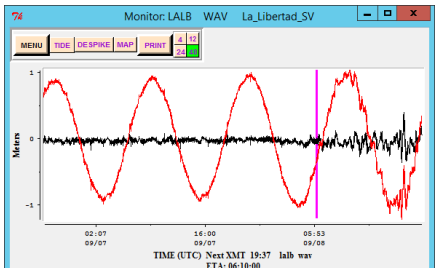
Unfortunately, there is no evidence of the times when the information on tsunami threat is disseminated by the radio of the **civil protection** system.

For the Sept. 7 earthquake, the first message via twitter, that there is a threat of a tsunami threat to the Salvadoran coast, is published at 00:20:39 after the earthquake occurred (Annex 8). For the earthquake on November 24, 2016, it was approximately 9 minutes after the earthquake occurred.

[5] The Mexican event occurred at 22:49 El Salvador Time on 07Sep17 off the coast of Chiapas, Mexico.

[6] ITIC の資料と MARN 資料から抜粋。後者では、地震発生～02:20:39 El Salvador Time の 4 時間余りの経緯が集められている。前者では、天文潮位を観測潮位から差し引き、津波が把握し易くされてある。なお、MARN もこの操作をＴＴソフトウェアー（目標 1-2 f-7 参照）で実施可能。

- 専門家は前述のコラム欄に示された 2016 年 11 月 24 日の地震での対応の様子を確認することとする。
- このような現象について、市民防災局に説明しつつ、解除の扱いを相談することとする。このような現象を考慮して、地震発生場所を踏まえつつ、MARN と DGPC と解除を同時に行えるようになることを目指す。また、公式手順書に右のコラム欄に示す記述があることにも考慮する。
- また、潮位観測運用責任者に「津波の高さが小さくなってきた以降に襲来する大きな津波」を発生させる可能性がある領域を予め推定するシミュレーションの実施を要請することとする。



Sobre la emisión de la cancelación
Finalmente se informa a Protección Civil de la cancelación de la amenaza y se difunde la cancelación por los diferentes medios de comunicación y redes sociales, para ello ver en anexo 3 los formatos de mensajes de cancelación, además de incluir en el informe de cierre del evento la cancelación de la amenaza.
-- (Translated from the above Spanish by the Expert) ---
About issuance of cancellation
Finally, Civil Protection is informed of the cancellation of the threat and the cancellation is disseminated through the different communication media and social networks, for this see in annex 3 the cancellation message formats, in addition to including in the event closing report cancellation of the threat.

e) バックアップシステムの適正化：対応
バックアップシステムは次のように適正化が維持されていることを確認した。
- 地震システムが設置され監視業務が実施されている建物：近年以前と同様の状態であり、耐震化されている。現在修理工事中であるが、耐震化とは関係がない。
- 地震システム：バックアップは別の建物に整備されている。但し、同システムのサーバーのうちの一台は、正副化が必要となっており、本プロジェクトの機材調達で要請がなされている。
- インターネット：輻輳は、地震回線優先化後は発生していない。一方で、SNS であるツイッターは、地震発生直後などアクセスが集中した際、動作が遅くなることが時折発生している。
- 地震処理システム SeisCOMP3：正副化してある。

但し、以下のことを引き続き注視していくことが必要となっている。
- 電源：UPS で利用しているバッテリーについて更新計画が策定されているかの確認。
- 建物からの退避時の対応：火災などでの退避時の対応策の検討。
- MARN 敷地からの避難時の対応：一つのアイデアとして、スマートホンによる「中米津波警報センターや太平洋津波警報センターからの情報の収集・分析、並びに津波警報の市民防災局や一般国への発出」というものがある。

f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立
この目標は、津波警報発表での手順（目標 1-1 c-1）の基本部分を、容易に見ることができるように表示する置物などを作成・利用することである。そのような物として、MARN からピラミッド型の置物の提案があった。右には専門家がフェーズ 1 終了直後作成したものを示し

Target 1-1 f-1 on going
Verified the actions on **Tsunami Monitoring materials** that were left in Phase 1 to be taken later on

An idea considered in Phase 1
To make the most of the contents in **the guideline** through setting **a pyramid-shape memo** with the tsunami handling timeline on the faces. The Expert had tried to make a prototypical item after the Phase 1 activities.

The three photos here are the one set on a table.

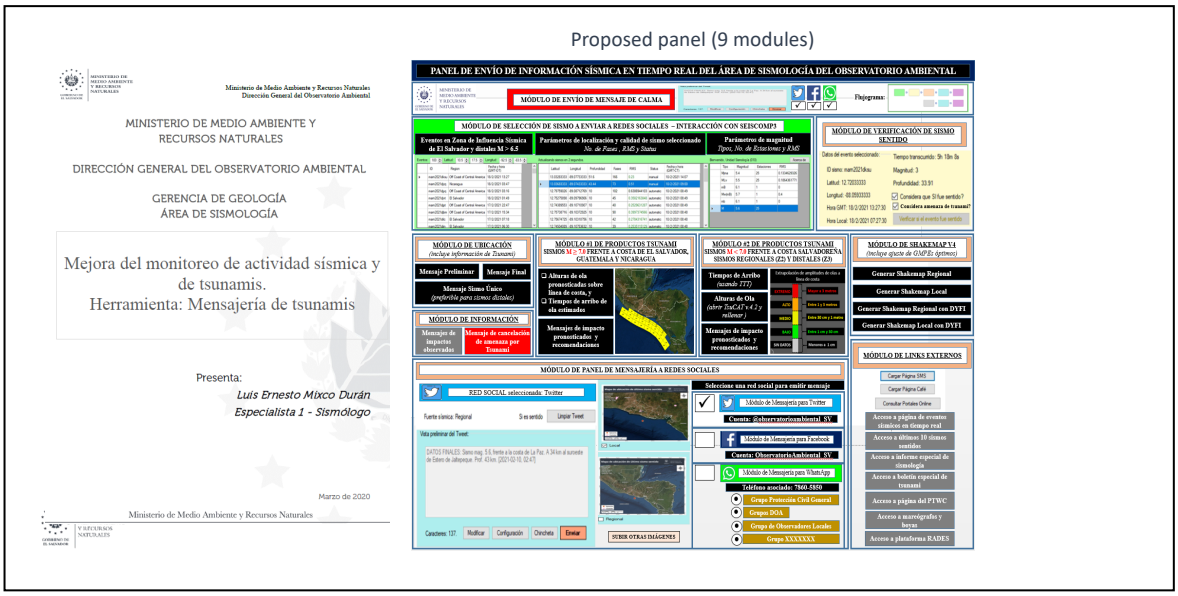
た。現在、MARN ではそのようなものを利用していない模様である。

- 専門家はこのことを確認し、検討する。

f-2) MARN ガイドブック：確立

この目標は、MARN が発出する情報を易しく説明した MARN ガイドブックと称するものを作成することであった。これを市民防災局や一般国民の手元に置いてもらい、MARN が発出する情報について、その内容、発出するタイミング、発出する道具などを、日頃から理解しておいてもらうものである。これによって、緊急時に適切に MARN 発出の情報を適切に利用してもらうことを目指したものである。2017 年に MARN が作成したものを右のコラムに示した。これは現在では、MARN の web サイトで見ることやダウンロードすることができる[7]。なお、このサイトは下のコラムに示すように改良が進められている。

- 専門家はこの改良状況を引き続き注視していく。その際、自主研修システムでの MARN ガイドブックの利用も考慮する（目標 1-1 c-2 参照）。



f-3) e-mail の公式利用、 FAX 点検の日課への導入：確立

このことは、目標３で説明する。

f-4) 異常地震活動対応標準手順：確立

手順は確立され、手順書が作成されている。

- 専門家はその内容を確認する。また、監視当番者の対応の様子を注視していく。

[7] https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/
Guía de sismos y tsunamis 2017 | CIDOC Virtual<https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/>

f-5) 津波警報解除後の注意喚起情報：導入検討

日本の気象庁は解除後の注意喚起情報等として、右のコラム欄に説明しているような「津波予報」と称する情報を発表してきている。フェーズ１の終了時点では、このような情報の導入について MARN で検討することとしていた。公式手順書では、このような用語は用いていないが、解除後に発出する情報にこの種の注意喚起をすることとしていることを付録に記述している。

Explanations on **Tsunami Forecasts** (http://www.data.jma.go.jp/svd/eqev/data/en/guide/tsunamiinfo.html)
Note: After an earthquake occurs, if no damage is expected, JMA issues Tsunami Forecasts.

Forecasted sea level changes	Message
No tsunami is expected	"No tsunami is expected." (To be included in Earthquake Information.)
Tsunami height less than 0.2 meters is expected	No damage is expected because sea level changes will be less than 0.2 m, and no special action is needed.
Slight sea level changes are expected to continue after Tsunami Warnings/advisories are cleared	Particular attention is needed when fishing, swimming or engaging in other marine activities because tsunami-related sea level changes have been observed and may continue for a while.

- この種の情報は解除後だけでなく、地震発生時、高さ 20cm 未満の津波を予想した場合など脅威となる津波の発生はないものの注意喚起が必要と判断した場合に発出することが適当と考えられる。このため、引き続きこの件については検討していく。

f-6) 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討

この目標については、目標 1-2 c に記述した。

f-7) 津波実況監視手段 Tide Tool の利用：現業者での利用推進

津波の実況監視のことは公式手順書でも取り扱われている。但し、Tide Tool(TT)という用語は明示されていない。専門家は、MARN 手順書（目標 1-1 c-1 参照）での扱いを確認する。

なお、TT は上記の目標 1-2 f-6 において、次のコラム欄に示すように利用されることになる。

(After the emails exchanged in MARN on the Tide Tool issue)
Q: We have been going over some things regarding the operation of the tide gauges. Is there any way to remove the tidal signal from the tidal gage monitoring graph? Can the tide gauge data be extracted for later processing?
A: The sea level height measurements from the tide gauges are stored on the MARN server. On previous occasions, the action has been asked to Elisha for them. Once the measurements have been downloaded, the tide would have to be subtracted to obtain the tidal residual. This is done by TIDE TOOL.

3.3 目標 2 CATAC との情報の共有化の促進

現在試験運用中の CATAC は、速報である地震パラメーターの情報だけを発出してきている。下の表からは最小 M4.0 となっている。また、この情報例を下のコラム欄に示した。さらに下の表には発出に要する時間（最遅 5 分（M5.6 の地震）、平均約 4 分）を整理した。この内容でこの時間（MARN の速報発出は平均 5 分前後。目標 1-1 c 参照。）であると CATAC の情報を MARN においてバックアップとして利用できるものである。

An example of the message that CATAC sent. (Translated partially into English by the Expert)

Instituto Nicarag?nse de Estudios Territoriales (INETER)
Centro de Asesoramiento de Tsunami en America Central
C A T A C
Informaci? preliminar de sismo
Hora de emisi?: Mayo 20,2021 9:08:04PM Hora local de America Central
: Mayo 20,2021 10:08:04PM Hora local de Panam?
PARAMETROS DEL SISMO
Tiempo de Origen : Mayo 20,2021 9:04:05PM Hora local de America Central
: Mayo 20,2021 10:04:05PM Hora local de Panam?
Epicentro : 12.686 N 89.013 O
Regi? : 66 Km al sur de Delta del Rio Lempa, El Salvador
Profundidad : 10 Km
Magnitud : 4.5
The parameters are calculated using data received in real time, with the contribution of seismic stations of seismological observatories in Central America (INSIVUHEH, MARN, COPECO, INETER, OVSICORI, ICG-UPA, ACP, RSN-UCR-ICE), and the global seismological network.
This is automatic information and may contain errors.
Please consult our website: http://catac.ineter.gob.ni/gaps/originlocatorview/

また、CATAC は昨年 2020 年 11 月 11 日に津波警報発表訓練を主導して実施した。MARN が専門家に共有してくれた資料（訓練の技術解説書、MARN の同訓練へのコメント）には津波警報発表手順が、下のコラム欄に示すようにあった。これを見ると、想定している作業手順と時間経過は、CATAC が本運用された場合において、バックアップとして利用できると理解できる。

Timeline of messages issued by CATAC

Tiempo después de OT (min)	Observación	Automático o manual	#Mensaje	Productos a enviar a los destinatarios en los países (NTWC, NTFP)
1	SeisComP3 (Virtual Seismologist) deriva epicentro (frente al golfo de Fonseca), profundidad, y magnitud ML 5,3. Evaluación: "No hay posibilidad de tsunami considerando la magnitud, la profundidad y la ubicación del sismo."	A	1	Texto: OT, Lat, Lon, Mag
3	Localización manual por ST. La magnitud derivada de Ondas S y/o superficiales llega a 6.8. Evaluación: "Existe una muy pequeña posibilidad de un tsunami local."	M	2	Texto: OT, Lat, Lon, M, Peligro
4	Shakemap (EEWD) presenta bajas aceleraciones desde El Salvador a Costa Rica.	A		
5	MT determina la magnitud de 7.8. Significa peligro para toda Centroamérica.	A		Texto: OT, Lat, Lon, M, Peligro

5	TOAST arroja los resultados de tsunami en correspondencia a estos nuevos valores M7.8. Se envían a los países "Advertencia de tsunami esta en efecto para las costas del Pacifico de El Salvador, Nicaragua, Honduras, Costa Rica y Guatemala." ST se sorprende que un terremoto de 7,8 no genere sacudida sísmica. Consulta con Director del CATAC. Interacción con sismólogo de turno del MARN/El Salvador. Se llega a la conclusión de que se trata de un terremoto lento	M	3	Texto: OT, Lat, Lon, M, Peligro Predicción de llegada y amplitudes máximas Graficos: amplitudes de tsunamis, tiempos de llegada, zonas de peligro
	Entran varias llamadas por teléfono y mensajes por Whatsapp durando de la magnitud del terremoto y de las predicciones de tsunami porque no se sintió el sismo fuertemente.	A		Interacción de los ST por Teléfono y Whatsapp con instituciones en los países explicando lo del terremoto lento
12	Entra el correo del PTWC que confirma la magnitud M7.8 del terremoto.			
45	Se obtienen registros en las estaciones mareográficas de El Salvador, Honduras, Nicaragua. Se envían a los países.	M	4	Texto: Horas de llegada y amplitudes de tsunamis en estaciones mareográficas de América Central - Ultimo mensaje -

Fecha	Hora de América Central	Hora de Panamá	Tipo de producto	Método de transmisión
11/11/2020	10:00	11:00	-Ocurre el Terremoto- Se envía Mensaje 0 (inicial)	Email
11/08/2020	10:01	11:01	Mensaje#1	Email
11/11/2020	10:03	11:03	Mensaje#2	Email
11/11/2020	10:05	11:05	Mensaje#3	Email
11/11/2020	10:45	11:45	Mensaje#4	Email

一方、CATAC の本運用（津波警報発出機能開始）について、照会したところ、下のコラム欄に示すような回答があった。即ち、本運用にあたっては、まず、中米作業グループ（Working Group on Central America、WGCA)の会合を開催するとしている。

- 専門家は、この会合の実施計画の動向を注視することとし、かつ CATAC の運用状況を引き続き見守ることとする。その際、津波警報において必須の Mw の発出の精度とタイミングについて特に注意する。

(Answer from CATAC)
We routinely only send earthquake messages. We give tsunami advice but in a non-routine way.
The seismologist on duty does but Emilio, Norwin or me. We are including many new stations in processing (EWARNICA and other projects), also GPS data. We also need to include more stations in Panama.
We have the tsunami database running now it is reviewing and comparing with TOAST. The idea is to start in the middle of the year sending messages on tsunami routinely and to propose to the PTWS on entering the regime CATAC routine. That would be at the latest at the ICG / PTWS meeting which will maybe celebrate next year in Japan.
All of this should be discussed soon at a meeting of the Working Group on Central America.

3. 4 目標 3 DGPC の津波警報利用：適切化

市民防災局（DGPC）の津波警報の利用の現状については、次のことが確認できた。

- 2017 年の合同勉強会（ワークショップ）では、右に示すような決議がなされた。即ち両者は 2017 年及びその先合同の津波訓練の実施を検討するとされた。ただ、その後両者はこの決議を参照することはしなかった。
- MARN は発出する情報を市民防災局へ公式に伝達する道具としては、下の表に整理したようなものを用いている。即ち、無線、ファックス、ツイッター（一般国民向けでも用いる）を用いる。加えて、電子メール（SMS）で特定の MARN 内の責任者や市民防災局

Acta de la Reunión del Taller

Título: TALLER DE CAPACITACIÓN MARN-DGPC sobre "Desarrollo de Capacidades para la Prevención de Riesgos ante Sismos y Tsunamis"
Fecha: martes 1 de noviembre de 2016
Objetivo: Mejoramiento de la comunicación entre el Ministerio del Medio Ambiente y Recursos Naturales (MARN) y la Dirección General de Protección Civil (DGPC) en relación a la información emitida al público sobre amenazas de Tsunamis.
Notificación: En el marco del primer Día Mundial de la Concientización sobre los Tsunamis, celebrado el 5 de noviembre, el cual fue autorizado por la ONU el año pasado.
Hora: 8:00-15:00
Lugar: Circulo Militar San Salvador en San Salvador
Moderador: Luis Mixco, Sismólogo del MARN
Asistentes: MARN 15 miembros del turno de monitoreo de tsunamis y otros (Incluyendo experto de JICA).
DGPC 6 miembros del centro de operaciones y otros (Incluyendo experta de JICA).
JICA 3 (Incluyendo dos intérpretes)
Agenda:

HORA	*TEMA*	*RESPONSABLE*
8:00	Preparación de la sala de reuniones y confirmando el programa	MARN y DGPC
8:30	Palabras de Apertura de Taller **(5min)**	**Celina Kattan** Directora del Observatorio Ambiental del MARN
8:35	Presentación sobre el Día Mundial de Concientización de los Tsunamis y experiencias vividas en Japón en el tema **(45min)**	**Shigeo Mori** Experto en Sismología de JICA
09:20	Charla introductoria sobre el rol del MARN en el tema de Tsunamis, incluyendo sus procedimientos, los sistemas y protocolos frente a una amenaza por Tsunamis **(15min)**	**Rodolfo Torres** Sismólogo del MARN
09:35	Charla introductoria sobre el rol del DGPC en el tema de Tsunamis, incluyendo sus procedimientos, sistemas y protocolos frente a una amenaza por Tsunamis **(15min)**	**Armando Vividor** Jefe de Unidad de Análisis de Riesgo, Cambio Climático y Alerta Temprana de DGPC
09:50	**Café (Descanso)**	
10:15	Foro de discusión sobre los roles que llevan a cabo ambas instituciones MARN y DGPC, frente a una amenaza por tsunamis. **(50min)**	Presidido por el MARN
11:05	Presentación sobre los resultados del ejercicio de simulación por amenaza de Tsunami, implementado internamente por MARN el 10 de octubre de 2016 **(40min)**	**Amelia García** Técnico en Monitoreo Sismológico del MARN
11:45	**Almuerzo**	
12:55	Presentación sobre los resultados del ejercicio de evacuación por Sismo Fuerte y Tsunamis, implementado por DGPC a nivel nacional el 10 de octubre de 2016 **(35min)**	**José Alfaro** Jefe de Operaciones en DGPC
13:30	Presentación del plan para el próximo año 2017, el apoyo futuro entre ambas instituciones en el desarrollo de un nuevo simulacro por tsunamis y la perspectiva del rendimiento del MARN en la emisión de avisos por amenazas de Tsunamis. **(25min)**	**Rodolfo Torres** Sismólogo del MARN
13:55	Presentación sobre la perspectiva en la optimización de la maniobrabilidad en la alerta de tsunamis en sus protocolos de actuación. **(20min)**	**José Alfaro** Jefe de Operaciones en DGPC
14:15	Discusión sobre presentaciones y discusiones anteriores entre MARN y DPGC, sobre el plan de los años siguientes, y la adopción de un acuerdo o confirmación sobre los resultados obtenidos de este taller. **(40min)**	Presidido por el MARN
	Confirmación de los resultados en un documento borrador (5min)	MARN y DGPC

Conclusiones:
1. Se debería realizar un ejercicio de simulación de tsunamis participando ambas instituciones en el año 2017, con fecha tentativa el 10 de octubre de 2017
2. Se debería continuar con la realización de ejercicios de simulación de tsunamis participando ambas instituciones, los años próximos, más allá del 2017.
3. Los puntos clave propuestos en el documento borrador sobre la Confirmación de los Resultados del taller, deben de examinarse más a fondo dentro de ambas instituciones.

DGPC (firmar, fecha) 22-11-16
MARN (firmar, fecha) 23/11/16

Tools to be used to communicate with DGPC

Feature	Veraval, mutual, speedy; one to one	Rich, figure; to one	Speedy, text, to specific, to many	Rich, to many, figure
Within	Radio	Fax	Email	SNS
10 min	Preliminary information of the earthquake obtained from the autonomous locator (5min)	None	None	1) a preliminary message indicating the degree of tsunami threat 2) message with probable arrival times
30 min	Communicate information after verifying data	Tsunami bulletin	None	1) estimated wave height 2) indication of that phenomenon is being evaluated Prepare tsunami bulletin 3) additional information with evaluated PTWC information
60 min	None	Continuar o finalizar de boltines de Tsunami	None	None

上の決議書に示された決議部分をここに抜粋した：

1. Se deberia realizar un ejercicio de simulacion de tsunamis participando ambas instituciones en el ano 2017, con fecha tentativa el 10 de octubre de 2017
2. Se deberia continuar con la realizacion de ejeercicios de simulacion de tsunamis participandl ambas instituciones, los anos prociimos , mas alla del 2017.
3. Los puntos clave propuestos en el documento borador sobre la Confirmacion de los Resultados del taller, deben de examinarse mas a fondo dentro de ambas instituciones.

の責任者等へ発出している。但し、市民防災局がこれら全ての手段から得られる情報を用いていることを MARN は承知しているものの、市民防災局がどの手段からの情報を公式情報として利用しているかは定かではない。

- 専門家は、市民防災局に係る様々な課題について、市民防災局と遠隔等での打ち合わせをするための資料案を作成し、その上で、上述の伝達手段の課題を見直しすることとする。一方、MARN はこの打ち合わせの日程調整を行うための市民防災局の窓口の職員を確認することとする。
- 専門家は、市民防災局に係る目標３について、どのように対応していくかの粗い計画案を下のコラム欄に示した。

Draft of the plan on the direction of the project to develop the capacity related to the DGPC
Target 3: Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC
Related targets 1 1) c-1: Establishment of the Tsunami Monitoring Manual
2) d: Establishment of tsunami warning cancellation procedures
2) f-2: Establishment of the “MARN guidebook”
Items to be handled
1. To collect “Document explaining the rough image/outline of webinar on 05Mar21 held by DGPC together with MARN (Note: “Presentation to DGPC: Tsunamis En El Salvador-Generación_ Medición y Mitigación-(1)” for March 2021)”
2. To have a talk with DGPC with the document that explains the comprehensive current communications tools between MARN and DGPC including the roles and the features of them
3. To have a talk with DGPC on the cancellation management
4. To collect additional information on the progress of the event that occurred on 07Sep17 off Mexico in order to consider the “cancellation handling together with DGPC”
5. To get the tidal gage data with the removal of the astronomical tide change
6. To check the event on 24Nov16 that is shown in the report on the event of 07Sep17 off Mexico

3.5 機材調達（データ伝送用無線機 1 対向、サーバー1 台)

MARN から機材調達について、予め要請があった。下には現時点での要請が整理されたものを示した（文書名：Marn-Procurement-28May2021_LMixco)。

EQUIPMENT DESCRIPTION	COMMENTS/JUSTIFICATION	QUANTITY	UNIT COST	TOTAL
Digital radios: Brand: Ubiquiti. Model: AF-5U Transfer capacity: 1.2Gbps Range: Greater than 100Km Frequency 5Ghz	Digital radios will serve to strengthen the seismic network as well as to create redundancy in the transmission lines of the seismic stations.	8.00	1500.00	12000.00
Workstation: Model: Precision 7920 Tower Chassis CL. Processor: Intel Xeon Bronze 3204 (1.9GHz, 6C, 9.6GT/s 2UPI, 8.25MB Cache, HT (85W)) DDR4-2133. Operating sytem: Windows® 10 Pro for Workstation (4 Cores Plus). Videocard: Radeon Pro WX 2100, 2GB, DP, 2 mDP (7X20T). Memory 32 GB RAM DDR4. Hard drive: 1 TB	The workstation will be used by one of the seismologists (Luis Mixco) to run specialized seismological and tsunami monitoring software.	1.00	3000.00	3000.00
Laptops: screen display size 13.3 Inches, max Screen Resolution 1920 x 1080 Pixels Processor 1.6 GHz i5 RAM 8 GB SDRAM Hard Drive 256 GB ssd Wireless Type 802.11ac	Laptops to be used in the field in the configuration and maintenance of the seismic network.	2.00	1000.00	2000.00
MatLab software and specific toolboxes (Perpetual Standard License)*	This software together with its complements will be used to be able to properly execute the ISOLA software, to determine the centroid moment tensor of a seismic event, its moment rate function and its slip distribution in a finite fault area; at a time after the event occurred. This application is more oriented to a scientific research field and to improve our results and justifications of tsunami generations, characterizing the seismic sources of tsunami.	1.00	8560.00	8560.00
				25560.00

** Research is still being done on the annual maintenance fee for the software. It is intended to communicate with MatLab Works personnel, so that they can provide more detailed information about said maintenance fee.*

3.6 目標 4 今後の業務改善に向けた提言

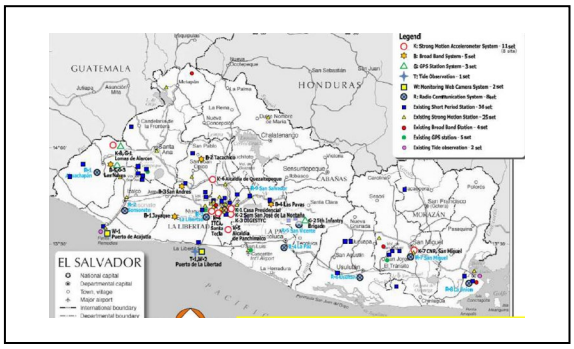
3.6.1 目標 4-1 GPS 観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用） / 津波地震や浅発地震を対象にした Wphase による Mw 及び発震機構推定

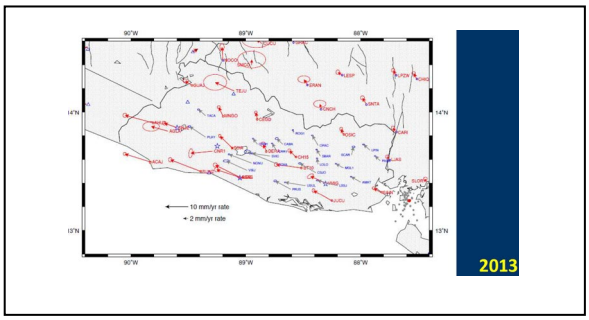
GPS を用いた測量施設は下表のように 12 か所現在ある。

Parámetros de estaciones GPS El Salvador (2018-2019-2020)

No.	COD-ID	Estation	latitude	Longitude	H antenna (m)	Antenna Type	Receiver Type	How to get the data
1	LNUB	Las Nubes	13.902209	-89.779916	0.3260	TPSCR.G5	Topcon NetG3A	Internet
2	ALAR	Lomas de Alarcón	13.998212	-89.780542	0.3290	TPSCR.G5	Topcon NetG3A	Internet
3	ACAJ	Puerto de Acajutla	13.575119	-89.833306	0.0667	TRM41249.00	Trimble NetRS	Internet
4	SNJE	San José	13.868300	-89.600700	0.287	TRM41249.00	Trimble NetRS	Internet
5	CNR1	Centro Nacional de Registro	13.670450	-89.289000	0.2873	TRM41249.00,	Topcon GB1000	Internet
6	SSSV	San Salvador	13.687416	-89.231663	0.1710	SEPCHOKE_B3E6	SEPT POLARX5	Internet
7	AIES	Aeropuerto Internacional El Salvador	13.447336	-89.050275	0.2876	TRM41249.00	Trimble NetRS	On site
8	LALI	Puerto de La Libertad	13.487239	-89.319579	0.0667	TRM41249.00	Trimble NetRS	On site
9	SVCI	San Vicente	13.639030	-88.793035	0.321	TPSCR.G5	Trimble NetRS	On site
10	VMIG	Volcán de San Miguel	13.396200	-88.304700	0.288	TRM 57971-00	Trimble Net R9	On site
11	PATI	Patio de Finca Santa Isabel	13.468860	-88.273552	0.450	TRM41249.00	Trimble R7	On site
12	PMON	Piamonte	13.7123167	-89.314394	0.0667	TRM41249.00,	Topcon GB1000	Internet

なお、フェーズ 1 の時点で専門家が承知していた情報は過去の事情を示している。そして、下の右の図は 2013 年に行った調査測量でのものであり、多くの場所には調査用に一時的に設置したものである。





3.6.2 目標 4-2，4-3，及び 4-4（発震機構）

右に示す目標 3 つは ISOLA ソフトウェアーで対応可能かもしれない。このソフトの調達経費は機材調達に示したが、下にも補助情報として示した。

2) 地震波形を用いた解析による震源断層の滑り量分布の把握
3)モーメントレート関数表示機能（震源時間関数の把握）
4) その他
地震波初動解析による発震機構把握

According to the latest ISOLA documentation, from 2020, the following toolboxes are required:

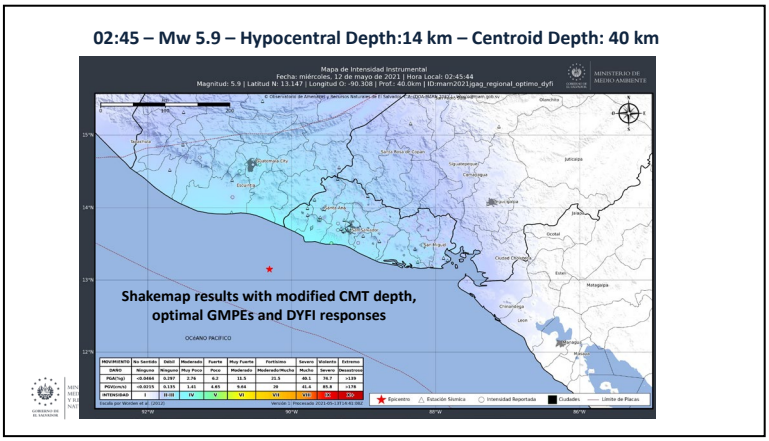
1. MatLab
2. Mapping Toolbox
3. Control System Toolbox
4. Signal Processing Toolbox
5. Statistics Toolbox
6. System Identification Toolbox

This information is in this documentation derived from the ISOLA course:
http://geo.mff.cuni.cz/~jz/for_Brasilia2020/b_installation.pdf
On the MatLab page an option appears to be able to observe the prices of the software and the toolbox (https://la.mathworks.com/pricing-licensing.html) Each of these Toolbox must be searched separately.
A small quote (at 17th May 2021) for a perpetual and annual license, both with the standard and education licenses: TOTAL Standard $8,560.00, $1,650.00; Education $3,424.00, $825.00

3.6.3 目標 4-4 エルサルバドルの地震マイクロゾーニング地図の更新のためのガイドラインの検討

地震マイクロゾーニング地図については、下の図で示した Shakemap の改善（Performance CMT-Tool-12May から抜粋）があり，新たな国際技術支援プロジェクト（Seismic Risk project、下の 3.6.4 項の 3）節参照）の下で、更新が進められている模様である。

- 専門家はこの進捗に注意を払うこととする。



3.6.4 その他

他の国際協力機関の関連活動として次のものがある：

他の国際協力機関の関連活動の状況把握
ユネスコによるTsunami Readyプロジェクト
スイス(Swiss Seismological Service, SED)によるEarthquake Early Warning(EEW)開発
米州開発銀行(Inter-American Development Bank, IDB)による地震危険度評価プロジェクト

1) Tsunami ready

専門家はその進捗を見守ることとする。その際、MARN の津波・地震防災や災害軽減の能力向上に向けたヒントを探ることとする。

2) EEW

現在の EEW の開発状況は、S 波による強震襲来の 8 秒前に警告できた実績がある。震源がこの時より遠い例では、15 秒の余裕があった。

専門家はその進捗を見守ることとする。その際、次のことを考慮する：

- EEW で得られる地震パラメーターは津波警報の作業で利用できるかもしれない。
- 日本の気象庁で運用している緊急地震速報での経験と改善とがこのプロジェクトの推進に役立つかもしれない。具体的には、a) 予測震度の誤り、b) ノイズが原因の誤情報発出、及び c) 複数の地震のほぼ同時の発生についての処理。最後の「c)」については目標 4-4 に係るものである。

3) Seismic Risk

このプロジェクトは、目標 4-4 の「エルサルバドルの地震マイクロゾーニング地図の更新」に係る可能性があるものであり、進捗を見守ることとする。

4. 次期渡航時実施すべき事項

以下に、今回の遠隔活動の進捗結果を踏まえて、MARN 又は専門家のどちらかが今後実施すべき事項、及び両者が協働して実施すべき事項を整理した。下のリストには各事項が目指す目標を右の欄に示した。また、この欄は想定される主な実施主体に応じて色分けした。茶色が専門家、緑色が MARN、青色が両者、色なしは終了したものをそれぞれ示す。なお、各章は当初の実施主体で分類してある。

4.1 当初主に MARNT が実施すべきであった事項

Legend for the pointed column
Ocher-color items: to need consideration of the Expert
Green-color items: to need actions conducted by MARN
Blue-color items: to need Meetings or actions conducted by both
No-color items: to be wrapped up

Actions	Priority	Target
Action to be taken MARN = to provide the Expert with any documents/data		
a) Tsunami procedures used by the shift staff	1	1-1 a 1-2 f-3
b) Data for checking the latest status of “the timing” & “the accuracy”	1	1-1-a
c) Document explaining the rough image/outline of webinar on 05Mar21 held by DGPC together with MARN	1	3
d) the log file of the CATAC tsunami drill	1	2
f) the current enhanced tsunami database showing the partition of depth, region, and magnitude.	1	1-1 a
k) The logs of twitter having the tidal data of the Mexican event	1	1-2 d
Action to be taken MARN = to ask DGPC/CATGAC to provide us with any information		
e) DGCP tsunami handling “manual”, if they have	1	3
i) the queries on the CATAC function like Query 1: When can we expect to get Mw from CATAC during the tsunami event handling processes? Query 2: When can we expect to get any seismic information from CATAC during the processes? Query 3: When can we expect to see the official CATAC function? ->The Expert should consider how to get the answer on the Queries 1 & 2	1	2
n) the date and the method of the CATAC meeting of the Working Group on Central America -> Waiting for the response from CATAC	1	2
Action to be taken MARN = to implement the analysis/review/check on		
g) the events, Mw5.6 and Mw5.9, with ISOLA	1	4-4
h) the drill procedures document made in 2017	1	1-1 c-1
j) whether any renewal plan of batterie has been made as a sort of "backup".	1	1-2 e
l) the latest operation rate of the seismic observation network -> The "platform establishment" issue should be watched.	1	1-2 c
m) MARN will introduce the automatic judgement, whether the event should be handled or not, function into the monitoring system in order to resolve the issue on the maximum 30 minutes lapse for the preliminary message issuance.	1	1-1 a

4.2 機材調達（両者で対応）

	Priority	Target
Equipment		
Equipment procurement 1) The radio transmission equipment is requested to this project, 2) the server is requested in this Project, 3) the other items are being requested. -> This issue has been informed to JICA by the Expert to get comments from JICA. -> MARN should consider the priority on the items and the quantity.	1	equipment

4. 3当初両者で対応すべきであった事項

Legend for the pointed column
Ocher-color items: to need consideration of the Expert
Green-color items: to need actions conducted by MARN
Blue-color items: to need Meetings or actions conducted by both
No-color items: to be wrapped up

	Priority	Target
Action to be taken by both = to consider how to enhance the current status on		
a) The task, the response to the telephone-call from supervisors, shown in the Protocol as one of the tasks to be conducted within 10 min <- The Expert should propose any idea on it.	1	1-1 c-1
b) The usage of a smart phone against the case that the entire MARN should evacuate from the premises in order to get information sent from CATAC/PTWC and to issue tsunami warning to DGPC/ the public. <- The Expert should propose any idea on it.	1	1-2 e
Action to be taken by both = to support the Expert's action		
c) to collect additional information on the progress of the event on 07Sep17 off Mexico on handling the cancellation properly including communication with DGPC and to get the tidal gage data with the removal of the astronomical tide change -> The Expert should make any document to tell DGPC to have a meeting virtually in order to exchange the views on the issues concerned	1	1-2 d
d) to make the document that explains the comprehensive current communications tools between MARN and DGPC including the roles and the features of them in order to improve them through discussing the issue among MARN and DGPC -> See the above.	1	2
e) to analyze the 2020 drill document including the timing of issuance of Mw from CATAC when the event is large and slow earthquake like the one treated in the drill. -> The Expert should wrap up the issue.	1	3
f) to get any information on initiation of the official CATAC function	1	2

4.4 当初専門家が対応すべきであった事項

Legend for the pointed column
Ocher-color items: to need consideration of the Expert
Green-color items: to need actions conducted by MARN
Blue-color items: to need Meetings or actions conducted by both
No-color items: to be wrapped up

	Priority	Target
Tsunami protocol (cancellation, DGPC, drill)		
Action to be taken the Expert = to evaluate/check the current status		
a) to evaluate the tsunami monitoring procedures on the timeline, the cancellation, and the documents to be used by the shift staff -> we should wait for the document mentioned in the MARN Action a.	2	1-1 c-1 1-2 d 1-2 f-1 3
b) to check if DGPC will officially use all the information sent with radio, fax, email, twitter/SNS from MARN -> we should wait for the document mentioned in the MARN Action e.	1	1-1 c-1 1-2 d 1-2 f-1 3
c-1) to check the cancellation management through communicating with DGPC-> we should wait for the document mentioned in the MARN Action e.	1	1-1 c-1 1-2 d 1-2 f-1 3
c-2) to check the event on 24Nov16 that is shown in the report on the event of 07Sep17 off Mexico	1	1-1 c-1 1-2 d 1-2 f-1 3
d) tsunami warning supporting issues like "Tsunami Forecast", "Later tsunami arrival", and "live Tsunami monitoring with Tide Tool" (they should be introduced into the "tsunami guidelines" and/or "tsunami monitoring manual".) -> The Expert should further consider the "Tsunami Forecast" from the viewpoint of handling weak tsunamis that won't be handled by MARN but should be watched. -> The Expert should check the Protocol further, and will also check the monitoring shift technician's manual after provided.-> we should wait for the document mentioned in the MARN Action a.	2	1-1 c-1 1-2 d 1-2 f-1 1-2 f-5 1-2 f-6 1-2 f-7
Action to be taken the Expert = to get the status/hints of the issues		
e) the current timeline in regular tsunami drills in MARN -> Wait for the MARN Action h.	2	1-1 c-1 1-2 d 1-2 f-1

Tsunami protocol (CATAC)		
Action to be taken the Expert = to check the current status on		
f) the below items 1)The arrival timing of the information from CATAC 2)The tool that conveys the information from CATAC 3)The plan to carry out the CATAC function -> to wrap up the information received.	1	2
Training materials, Backup system, Guidebook & usage of SNS		
Action to be taken the Expert = to prepare		
g) simple self-study materials that cover the basic issues like hypocenter determination, focal mechanism analysis, seismic travel-timetable -> The Expert should also check any materials shown online in order to handle them. Further, as for establishment of the self-training system, the Expert should contribute to enhance the contents of the monthly bulletins being made by MARN.	2	1-1 c-2 1-2 f-8
Action to be taken the Expert = to consider the issues		
h) the guidebook together with the improved panel (usage of SNS) from the viewpoint of effectiveness in conveying information to the public and in making the public use the information properly -> this issue should be handled in the Action g.	3	1-2 f-2
Action to be taken the Expert = to watch the progress status		
i) the plan on the idea for effective station recovery with establishment of the platform in a map -> The Expert should wrap up the main causes of the long outage like repeater and GPS clock	1	1-2 c
Action to be taken the Expert = to evaluate/check the current status on		
j) For the backup systems, the power supply, the internet, the servers, the building in MARN -> to wrap up the issue through waiting for the result of the MARN Action j.	2	1-2 e
Action to be taken the Expert = to consider the issues on		
k) the ISOLA CMT from the viewpoint of the source process analysis and the initial motion focal mechanism analysis -> Check the manual on these issue together with MARN. Further, to wait for the result from the MARN action g.	1	1-1 b 1-2 a 4-2 4-3 4-4
l) the improved panel from the viewpoint of an essential complementary tool for the “MARN tsunami and seismic guidebook” -> to handle the issue together with the Action g.	3	1-2 f-2
m) the development of the new web page where seismic events are automatically placed in real time from the viewpoint of efficient issuance of tsunami warning	3	1-2 f-2
n) the current plan on the introduction of the automatic filling function into tsunami monitoring task (Established the improvement of the database accordingly)	1	1-2 b
o) the procedures for handling any abnormal seismic activity	3	1-2 f-4
Action to be taken the Expert = to talk the issue		
p) GPS data handling issue	1	equipment
q) Regarding the interview made by Rodolfo & Griselda on 22April21 with the locals living at a coastal area, Rodolfo has provided the Expert with the information on the location and others	3	1-2 f-2
Action to be taken the Expert = to watch the issues		
r) the EEW issue under consideration	None	4-4 Watching
s) the Tsunami Ready from the viewpoint of organizing tsunami handling exercise in the future	None	1-2 f-2 Watching

付録 1 プロジェクト全体の日程概要

Work Schedule (Dispatch of Expert) as of 15Jun21

JMBSC work in El Salvador　JMBSC remote-work

Year	2021										2022												2023			
Month	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Work periods in El Salvador																										
Days	10 (17 virtual-meetings)						45				45						90						90			

付録 2 作業日程実績と当初計画

Work Schedule of the remote-activities with El Salvador Time As of 10Jun21

Prepared by the Expert, JMBSC MORI, for the "Capacity Development of the Analysis for Earthquakes and Tsunamis of El Salvador" Phase 2 during 2021-2023

2021			Virtual meeting numeric orders	Contents of the activities of the Expert (JST is obtained by adding 15 hours to El Salvador Time.)	
Month	Day			Planned	Actual
April	19	Mon	1	Presenting a draft of the Work plan to MARN 15:00-16:00 Explaining the draft and discussing it with the main colleagues of MARN	Presented a draft of the Work plan to MARN 15:00-16:00 (*20Apr21 06:00-07:00JST*) Explained the draft and discussed it with the main colleagues of MARN
	21	Wed	2	Updating the draft	Prepared the next virtual meeting
	22	Thu			Prepared the next virtual meeting
	23	Fri	3	Revising the Work plan, if necessary 15:00-16:00 1. Discussing the revised Work plan with the main colleagues 2. Interview on the issues of "target 1-1)" with the colleagues related to the issues	15:00-16:00 Interviewed on the following issues 1. The Detail of the draft of the Work plan 2. Target 1-1) with the presentation by Luis on the CMT issue 3. Any other business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
	26	Mon	4	Preparation for the meeting on the day 15:00-16:00 Interview on the issues 1. of "target 1-1) & 1-2)" 2. of "target 2" With the colleagues related to the issues	Prepared the meeting on the day 15:00-16:00 Interviewed on the below issues 1. Target 1-1) 2. Target 1-2) 3. Target 2 4. Any other business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
	27	Tue			Prepared the next virtual meeting
	28	Wed	5	Preparation for the meeting on the day 15:00-16:00 Interview on the issues 1. of "target 1-1) & 1-2)" 2. of "target 2" 3. Discussing the issues on 1) the latest implementation of the practical monitoring tasks, 2) the encouragement of the talent and training materials With the colleagues related to the issues	Prepared the meeting on the day 15:00-16:00 Interviewed on the following issues 1. Target 1-1) 2. Target 1-2) 3. Target 2 4. Any other business Made the minutes of the meeting held today; sharing them with JICA and JMBSC. Prepared the next virtual meeting
	30	Fri	6	Preparation for the meeting on the day 15:00-16:00 Interview on the issues 1. of "target 1-1) & 1-2)" and of "target 2", if necessary 2. Discussing the issues further on 1) the latest implementation of the practical monitoring tasks, 2) the encouragement of the talent and training materials 3. Discussing the guideline for the monitoring tasks, if it is available With the colleagues related to the issues	Prepared the meeting on the day 15:00-16:00 Interviewed or discussed the below issues 1. Target 1 and Target 2 2. Tsunami protocol/guideline (cancellation, DGPC, CATAC, drill) 3. Training materials 4. Any Other Business (1) Backup system (2) Guidebook and usage of SNS 16:00-16:40 Reported to the JICA El Salvador through a virtual meeting Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
May	3	Mon	7	Making questionnaire, exams, and a draft on the lecture schedule Preparation for the meeting on the day 15:00-16:00 Explaining the questionnaire, the exams, and the schedule. And, discussing the issue handled in them in order to understand requests from MARN properly	Prepared the meeting on the day 15:00-15:50 1. Wrapped up of the below items 1) Targets 1&2 2) Tsunami protocol (cancellation, DGPC, CATAC, drill) 3) Training materials 4) Backup system 5) Guidebook and usage of SNS 2. Discussed the schedule of the virtual meetings beyond 05May21 3. Any Other Business
	5	Wed		Collecting the answer of the questionnaire and the exams Preparation for the meeting on the day 15:00-16:00 Explaining the analyzed results from the questionnaire, the exams, and the schedule. And, discussing the direction of the project to develop the capacity of MARN, making a short lecture, if necessary	Made the minutes of the meeting held on Monday; shared them with JICA and JMBSC. Prepared the next virtual meeting

May	7	Fri	8	Making a draft of the plan on the technology transfer and the training in the project Preparation for the meeting on the day 15:00-16:00 Discussing the draft with the main colleagues	Prepared the meeting on the day 15:00-16:00 Discussed the below items 1. Schedule of the virtual meetings beyond 07May21 1-1 Relation between targets and activities 1-2 Procedures 1-3 Activity timeline 2. DGPC communication and cancellation to be checked 3. CATAC on the latest performance to be checked 4. Any Other Business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
	10	Mon		Revising and making the plan on the technology transfer and the training in the project Preparation for the meeting on the day 15:00-15:30 Discussing the plan with the main colleagues 15:30-16:00 Making short lecture as the first step to the colleagues related to the subject Making any proposal on the actions MARN should take in the future, if needed	Revised and made the plan on the technology transfer and the training in the project Prepared the next meeting Made any proposal on the actions MARN should take in the future
	12	Wed	9	Preparation for the meeting on the day 15:00-15:30 Discussing the CATAC issues shown in the Target 2 and the DGPC issues shown in the Target 3 with the main colleagues in order to extract challenges, if any 15:30-16:00 Making short lecture to the colleagues related to the subject	Prepared the meeting on the day 15:00-16:00 Handled the below items 1.Checking the current status of the "tsunami monitoring procedures" 2.Evaluation of DGPC 3.Evaluation of CATAC 4.Checking the current status of the "station recovery" 5.Checking the current status of the CMT 6.Checking the current status of the "tsunami warning handling" 7.Checking the current status of "GPS data handling" 8.Any Other Business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
	14	Fri	10	Making any document handling the CATAC and DGPC issues Preparation for the meeting on the day 15:00-15:30 Discussing the CATAC and the DGPC issues with the main colleagues, if necessary Discussing the equipment to be procured in the project like a set of radio communication tool and a server for any seismic monitoring station 15:30-16:00 Making short lecture to the colleagues related to the subject	Prepared for the meeting on the day 15:00-16:00 Handed the below items 1. Evaluation of the "tsunami monitoring procedures" 2. *None* (Questionnaires/examinations of DGPC) 3. None (Questionnaires/examinations of CATAC) 4. Evaluation of the "station recovery" 5. Evaluation of the CMT 6. Evaluation of the "tsunami warning handling" 7. Evaluation of "GPS data handling" 8. Any Other Business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
	17	Mon	11	Updating the document on the CATAC and DGPC issues, if necessary Making any document on the wrap up the equipment procurement issue including the procurement time line Preparation for the meeting on the day 15:00-15:30 Discussing the equipment procurement document prepared with JICA/MARN (Note: the day and the time for the discussion should be confirmed by JICA.) 15:30-16:00 Making short lecture to the colleagues related to the subject	Prepared the meeting on the day 15:00-16:00 Handled the below items. 1.Discussion on the direction of the project to develop the capacity related to the DGPC 2.Checking the current status on "tsunami warning supporting issues" 3.Checking the current status on "the current timeline in regular tsunami drills in MARN" 4.Discussion on the direction of the project to develop the capacity related to the CATAC 5.Checking the current status on "the self-study issue and the self-study textbook issue" 6.Checking the current status on "the back-up system issue" 7.Any Other Business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting

May	19	Wed	12	Handling the equipment procurement issue Preparation for the meeting on the day 15:00-15:30 Discussing the equipment procurement document prepared with JICA/MARN (Note: the day and the time for the discussion should be confirmed by JICA.) 15:30-16:00 Making short lecture to the colleagues related to the subject	Prepared the meeting on the day 15:00-16:00 Discussed the below items 1. *None* (Questionnaires/examinations on the tsunami monitoring procedures on the timeline, the cancellation, and the documents to be used by the shift staff) 2. Making a draft of the plan on the direction of the project to develop the capacity related to the DGPC 3. Evaluating the current status on "tsunami warning supporting issues" 4. Evaluating the current status on "the current timeline in regular tsunami drills in MARN" 5. Making a draft of the plan on the direction of the project to develop the capacity related to the CATAC 6. Evaluating the current status on "the self-study issue and the self-study textbook issue" 7. *None* (Questionnaires/examinations on the current plan on the idea for station recovery issue) 8. Evaluating the current status on "the back-up system issue" 9. *None* (Questionnaires/examinations on the ISOLA CMT from the viewpoint of the source process analysis and the initial motion focal mechanism analysis) 10. *None* (Questionnaires/examinations on the current plan on the introduction of the automatic filling function into tsunami monitoring task (Established the improvement of the database accordingly)) 11.*None* (Questionnaires/examinations on p) GPS data handling issue) 12.Any Other Business

	21	Fri	13	Revising the Work plan prepared in the initial period in this remote-activity Preparation for the meeting on the day 15:00-15:30 Explaining the plan and discussing it with the main colleagues of MARN and JICA (Note: the day and the time for the discussion should be confirmed by JICA.) 15:30-16:00 Making short lecture to the colleagues related to the subject	Revised the Work plan prepared in the initial period in this remote-activity Prepared the meeting on the day 15:00-16:00 Handled the below issues 1.Discussion on the direction of the project to develop the capacity on the tsunami monitoring procedures on the timeline, the cancellation, and the documents to be used by the shift staff 2.Making the plan on the direction of the project to develop the capacity related to the DGPC 3.Making the plan on the direction of the project to develop the capacity related to the CATAC 4.Discussion on the direction of the project to develop the capacity on the idea for station recovery issue 5.Discussion on the direction of the project to develop the capacity on the ISOLA CMT from the viewpoint of the source process analysis and the initial motion focal mechanism analysis 6.Discussion on the direction of the project to develop the capacity on GPS data handling issue 7.Any Other Business Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting
May	24	Mon		Making the idea on the visit to El Salvador through considering the latest pandemic issues including vaccination issue of the Expert, and the possibility of remotely handling the tasks to be carried out in the visit Preparation for the meeting on the day 15:00-16:00 Explaining the idea and discussing it with the main colleagues of MARN and JICA (Note: the day and the time for the discussion should be confirmed by JICA.)	Made the idea on the visit to El Salvador through considering the latest pandemic issues including vaccination issue of the Expert, and the possibility of remotely handling the tasks to be carried out in the visit Prepared the meeting on the day 15:00-16:00 Explained the idea and discussed it with the main colleagues of MARN
	26	Wed	14	Revising the Work plan further, if necessary, and the idea on the next visit Preparation for the meeting on the day 15:00-16:00 Explaining the plan and the idea and discussing them with the main colleagues of MARN	Prepared the meeting on the day 15:00-16:00 Discussed the below items 1.Making the plan on the technology transfer and the training in the project on 1) the tsunami monitoring procedures on the timeline, the cancellation, and the documents to be used by the shift staff, 2) the idea for station recovery issue, 3) ISOLA CMT, 4) GPS data handling issue 2. Discussion on the direction of the project to develop the capacity for 1) the tsunami warning supporting issues like Tsunami Forecast, Later tsunami arrival, and live Tsunami monitoring with Tide Tool, 2) the timeline in regular tsunami drills in MARN ,3) the simple self-study materials that cover the basic issues like hypocenter determination, focal mechanism analysis, seismic travel-timetable, 4) the back-up system issue. 3. Checking the current status on 1) the guidebook together with the improved panel (usage of SNS) from the viewpoint of effectiveness in conveying information to the public and in making them use the information properly, 2) the improved panel from the viewpoint of an essential complementary tool for the "MARN tsunami and seismic guidebook", 3) the development of the new web page where seismic events are automatically placed in real time from the viewpoint of efficient issuance of tsunami warning, 4) the procedures for handling any abnormal seismic activity, 5) the interview made by Rodolfo & Griselda on 22April21 with the locals living at a coastal area, 6) Tsunami Ready from the viewpoint of organizing tsunami handling exercise in the future 4.Equipment procurement (a set of radio for transmission and a server) 5.Any Other Business 5.1DGPC issue / 5.2The remote activity plan on the remained meetings / 5.3The work plan and the next visit Made the minutes of the meeting held today; shared them with JICA and JMBSC. Prepared the next virtual meeting

May	28	Fri	15	Preparation for the meeting on the day 15:00-15:30 Wrap-up lecture to the colleagues related to the subject 15:30-16:00 Discussion on the issue in order to understand the requests form MARN for the future activities of the Expert in the project	13:30-14:30JST Reporting JICA the latest progress of the remote-activities Prepared the meeting on the day 15:00-16:00 (El Salvador Time) 1.Making a draft of the plan on the technology transfer and the training in the project on 1.1the tsunami warning supporting issues like "Tsunami Forecast", "Later tsunami arrival", and "live Tsunami monitoring with Tide Tool" / 1.2the timeline in regular tsunami drills in MARN / 1.3the simple self-study materials that cover the basic issues like hypocenter determination, focal mechanism analysis, seismic travel-timetable / 1.4the back-up system issue / 2.Evaluating the current status on 2.1the guidebook together with the improved panel (usage of SNS) from the viewpoint of effectiveness in conveying information to the public and in making them use the information properly / 2.2the improved panel from the viewpoint of an essential complementary tool for the "MARN tsunami and seismic guidebook" / 2.3the development of the new web page where seismic events are automatically placed in real time from the viewpoint of efficient issuance of tsunami warning / 2.4the procedures for handling any abnormal seismic activity / 2.5the interview made by Rodolfo & Griselda on 22April21 with the locals living at a coastal area / 2.6the Tsunami Ready from the viewpoint of organizing tsunami handling exercise in the future / 3.Equipment procurement 4.Any Other Business 1) The remote activity plan on the remained meetings, 2) The work plan and the next visit Made the minutes of the meeting; shared them with JICA and JMBSC. Prepared the next virtual meeting
	31	Mon	16	Making the report on the remote-activities Preparation for the meeting on the day 15:00-16:00 Explaining the report and discussing it with DG of DGOA and the main colleagues of MARN (Note: the day and the time for the discussion should be confirmed by MARN.)	Made the report on the remote-activities Prepared the meeting on the day 15:00-16:00 Wrapped up the meetings in the remote activities and talked on the work plan and the next visit
June	2	Wed	17	Preparation for the meeting on the day 15:00-15:05 Greetings to MARN 15:10-16:00 Explaining the report and discussing it with JICA (Note: the day and the time for the discussion should be confirmed by JICA.)	Prepared the meeting on the day 15:00-15:10 Preparatory discussion with MARN 15:10-15:40 Explained the report and discussed it with DG of DGOA and the main colleagues of MARN 15:40-15:50 Reviewed the virtual meeting held on the latest Monday
	9	Wed	18		Prepared the meeting on the day 16:00-17:00 (*10May21 07:00-08:00JST*) Explained the report and discussed it with JICA

付録３　目標達成に向けて収集した資料

遠隔活動での優先順位	遠隔活動における目標の優先順位の意味 1：できるだけ達成に近づける 2：同上 3：着手する 4：特に扱うことはしない	MARNが提供してくれた資料 （一部専門家が独自に収集）
1	目標とする成果１	
1	1) フェーズ１での導入内容の現状確認・評価	
1	a) 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	tabla_twitter
1	b)発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	Performance CMT-Tool-12May
2	c) その他	
2	c-1) 津波監視手引書	1. Tsunami Protocol (IAM-MFN-PA-03 PRotocolo de actuación por amenaza de tsunami en El Salvador rev 1 18nov2019) 2. Tsunami Protocol Word version (IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019)
1	2) 見届けることとしていた課題	
1	a) CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	Performance CMT-Tool-12May
1	b) 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	Presentation_LMixco26-04-21 (ppt file; the “development of the new web page where seismic events are automatically placed in real time”)
1	c) 地震観測網復旧の効率的な取扱いのための道具：開発（地震観測網復旧の手順書作成）	estadisticas-funcionamiento-estaciones-V3
1	d) 津波警報解除手順書：作成	1. recopilacion-acciones-sismos-8.1-mexico 2. 8sep17_ChiapasMexico_Marigrams_ITIC
3	f) その他	
3	f-1)現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立	By the Tsunami Protocol (IAM-MFN-PA-03 PRotocolo de actuación por amenaza de tsunami en El Salvador rev 1 18nov2019) and the Tsunami Protocol Word version (IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019)
3	f-2) MARNガイドブック：確立	1. Presentation_LMixco26-04-21 (ppt file; “improvement of the panel that sends information for the social network”) 2. Guia de sismos y tsunamis 2017 half size 3. guia-de-sismos-y-tsunamis-2017 https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/ Guía de sismos y tsunamis 2017 | CIDOC Virtual<https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/>
3	f-4) 異常地震活動対応標準手順：確立	Protocol for the seismic activity (IAM-MFN-PA-08 Actuacion por Amenaza de Sismos en El Salvador 2021)
1	目標とする成果 2	
1	CATACとの情報の共有化の促進	1. CATAC tsunami exercise held on 11Nov20 (Ejercicio Regional CATAC_Pacwave) 2. Technical explanation of the CATAC tsunami drill held in 11Nov20 (Simulacro-CATAC-TSUNAMI-CA-20) 3. Comments from MARN on the CATAC tsunami drill held in 11Nov20 (Comentarios sobre simulacro) 4. LOG OF CATAC_DRILL_11-11-2020 5. Regional Drill, CATAC_Pacwave, by CATAC translated from Spanish 6. Emails on seismic activity sent from CATAC (ex. CATAC-INETER_ M=4.2, 58 Km al suroeste de Pochomil, Nicaragua)
1	目標とする成果 3	
1	DGPCの津波警報利用：適切化	1. local leaders interview report 2. Presentation_LMixco26-04-21 3. webinar_DGPC_report.
3	目標とする成果4	
3	今後の業務改善に向けた提言	
3	1) GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）/ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定	Continuous-gps-station-ElSalvador-2021
3	2) 地震波形を用いた解析による震源断層の滑り量分布の把握	1. Presentation_LMixco23-04-21 (ppt file; ISOLA CMT software) 2. ISOLA CMT manual (ISOLA_bookchapter_English) 3. b_installation
3	3)モーメントレート関数表示機能（震源時間関数の把握）	Ibid.
4	4) その他	
4	地震波初動解析による発震機構把握	Ibid.
4	エルサルバドルの地震マイクロゾーニング地図の更新のためのガイドラインの検討	PPT_IDB_Project
1	機材	
1	機材調達	1. Marn-Procurement-28May2021_LMixco

4	他の国際協力機関の関連活動の状況把握	
4	ユネスコによるTsunami Readyプロジェクト	1. Boladem onte (ppt file; a picture showing the shore where 23 families were reportedly affected by a strong wave on 02May15.) 2. local leaders interview report.(Santiago Bay, Barra_1) 3. TR_FlowChart_Roles 4. PTWS-TR_English-Pilot Program Tsunami Ready PTWS_Application Form 5. PTWS-TR_English Feb 2017 6. PTWS_Tsunami_Ready_Flyer_Eng_20210223 7. TRguidelinetopics_PTWS-XXVIII_April_2019
4	スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW)開発	ewarnica-fase3
4	米州開発銀行（Inter-American Development Bank, IDB)による地震危険度評価プロジェクト	1. doc-proyecto-bid 2. IDB-activity_summary 3. PPT_IDB_Project

Period

第二次国内遠隔業務結果報告書
（エルサルバドル国　地震・津波情報の分析能力強化 Phase 2、2021～2023 年）

令和 3 年 10 月 26 日

JMBSC 森　滋男

1. 作業日程実績

当初のワークプランに従い、一部手直しして作業を実施した。その作業経過は、**付録２**に示した。なお、プロジェクト全体の日程概要を**付録１**に示した。

2. 成果

2.1 ワークプラン[1] に示した作業目標と作業手順

上位目標

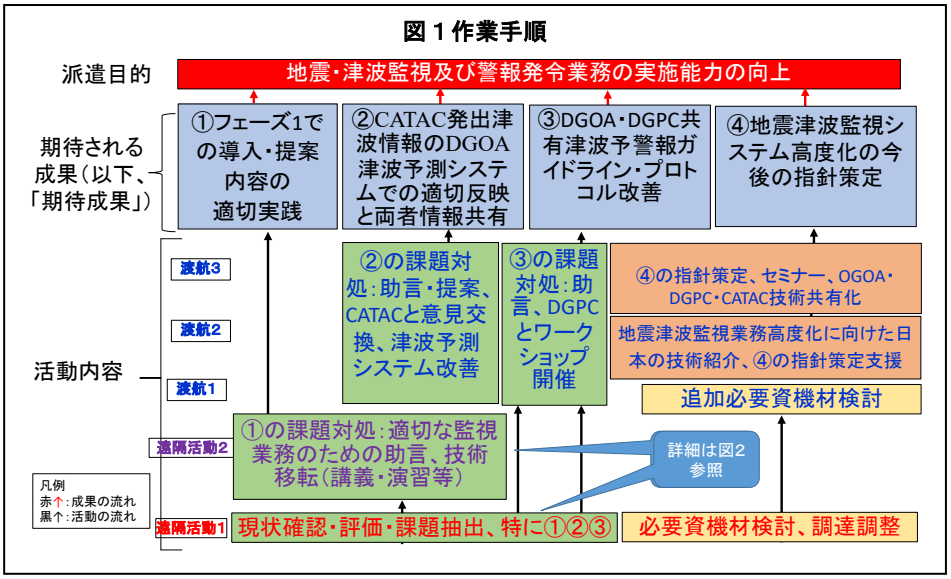
MARN の DGOA をカウンターパート（以下、「C/P」）機関とし、地震・津波監視及び警報発令業務の実施能力の向上

目標とする成果

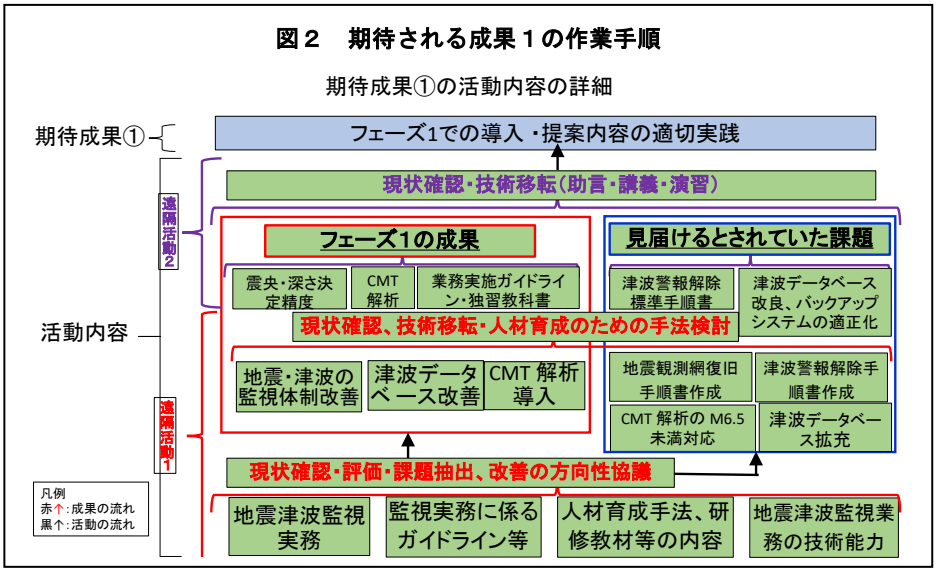
成果１：フェーズ1で導入・提案した内容が適切に実践される。
成果２：CATACから発出される津波情報がDGOAの津波予測システムに適切に反映され、両者間の情報共有が促進される。
成果３：DGOAがDGPCと共有する津波予警報のためのガイドライン・プロトコルが改善される。
成果４：地震・津波監視システムの高度化に資する技術が紹介され、システムの高度化に向けた今後の指針が定まる。

３頁目に作業目標一覧（**表１**）を示し、下の**図１**と**図２**とに作業手順を示した。これらの図に示すように、第二次国内遠隔活動は、作業目標のうち、成果 1 及び機材調達に主として取り組むこととしていた。

図１作業手順



[1] Work Plan of the Short-term Expert Dispatch to MARN in El Salvador as of 23Aug21



2.2 第二次国内遠隔活動における目標の詳細と達成状況

第二次国内遠隔活動で扱うべき「目標（成果）」、その達成状況、及び残された課題を以下に説明する。

１．「扱うべき目標」について、ワークプランでは次のように述べている。

１）成果の達成状況を踏まえつつ、下欄に示す活動を実施する：

> **目標（成果）　１について、**
> １）達成された改善状況を確実にするために、必要な講義や/演習等を実施する。
> ２）自己研鑽の仕組み構築として、地震津波監視担当グループが毎月作成する地震月報の作業を活用。その際、自習教科書や MARN のホームページで公開されている MARN ガイドブックを利用。
> ３）地震月報作成作業の改善に向けて、地震活動を分析するためのいくつかのツールの講義や演習実施。
> **目標（成果）　２及び３について、**
> ４）DGPC と MARN との連携を促進するために、双方が行った最新の活動を相互に理解するためのワークショップ及び津波警報発表訓練を行うこととし、その準備や交渉を進め、実施する。同様にして、CATAC との連携を促進する。

２）これらの活動は、第一次国内遠隔活動の報告書にある活動結果を踏まえて、MARN とともに取り組んでいく。

２．この計画に沿って行った第二次の活動の到達状況を**次頁の表１**に示した。この表は、目標（成果）を「エルサルバドルにおける地震・津波情報の分析能力強化」に関わる５つの要素（**右欄**にある４つの要素（Elements）及び機材調達）で分類し、さらに、日々の監視業務に関連する技術事項で細分類し、個々の成果について相互の関連が明確になるように努めたものである。

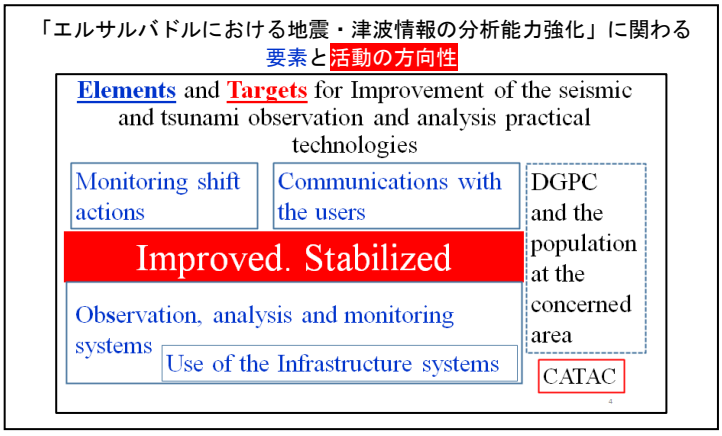


表１ 第二次国内懸隔活動で優先的に取り組んだ目標（成果）

遠隔活動での優先順位	目標とする成果の型	監視			広報		遠隔活動での成果達成状況
	目標とした成果（改善させる機能） 津波警報システムを構成する要素(Elwment)及び各要素の基本機能に応じた分類 （注：遠隔活動における目標の優先順位の意味： 1及び2：達成に近づける、3：着手、4：来年対応）	業務	手引書	情報処理システム	市民防災局	一般国民	（注：「計画」とは「業務の課題と改善の方向性についてのDGOAとの協議」を踏まえた「DGOA担当職員と定める技術移転・研修計画」）
	要素 a:観測、分析、及び監視システム						
	分類1: 地震津波監視						
1	1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	○					計画策定中（第4回会議）
2	1-1-c-1 津波監視手引書		○				計画策定中（第6回会議）
1	1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	○					計画策定中（第14回会議）
3	1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立		○				作業中
3	1-2-f-4 異常地震活動対応標準手順：確立		○				活動結果の整理中
4	4-4-e 震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入			○			活動結果の整理中
	分類2: CMT及びMw監視						
1	1-1-b 発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	○					計画策定中（第5回会議）
1	1-2-a CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	○					計画策定中（第7回会議）
3	4-2 地震波形を用いた解析による震源断層の滑り量分布の把握			○			作業中
3	4-3モーメントレート関数表示機能（震源時間関数の把握）			○			作業中
4	4-4-a 地震波初動解析による発震機構把握			○			作業中
	分類3:津波対応						
1	1-2-d 津波警報解除手順書：作成		○		○		作業中
3	1-2-f-5 津波警報解除後の注意喚起情報：導入検討	○	○		○	○	作業中
3	1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	○	○				作業中
3	1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	○	○	○			活動結果の整理中
	要素b: CATACを含むインフラの利用						
	分類4: 復旧及びバックアップ						
1	1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）		○	○			MARN対応注視中
1	1-2-e バックアップシステムの適正化：対応			○			MARN対応注視中
	分類5: CATACとの協力を含むデータ及び情報収集						
1	2 CATACとの情報の共有化の促進	○	○	○			作業中
3	4-1 GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）/ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定			○			調査中
4	スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW）開発						調査中
	要素c: DGPCを含むMARNからの情報の利用者との意思疎通						
	分類6: DGPCとの協力を含む防災のための津波警報の発信						
3	1-2-f-3 e-mailの公式利用、FAX点検の日課への導入：確立		○	○	○		作業中
1	3 DGPCの津波警報利用：適切化		○		○		作業中
	要素d: 監視担当者の対応（人材育成）						
	分類7: 自主研鑽						
2	1-1-c-2 津波監視現業体制での技術レベル：維持・改善研修体制確立		○	○			作業中
3	1-2-f-2 MARNガイドブック：確立		○		○	○	作業中
3	1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討			○			作業中
	要素e: 機材						
1	機材調達						作業中

2.3 第二次国内遠隔活動におけるその他の目標の達成状況

他の目標の達成状況は**下の表２**に整理した。

表２ その他の目標（成果）

遠隔活動での優先順位	目標とする成果の型	監視			広報		遠隔活動での成果達成状況
	来年対応としていた「目標とした成果（改善させる機能）」	業務	手引書	情報処理システム	市民防災局	一般国民	
4	4-4-b マグニチュード過小評価手法 / 日本の地震・津波監視業務に関し、過去事象の教訓・課題・改善共有			○			来年対処
4	4-4-c 内陸地震活動の震源分布推定の精度向上のためのDD手法			○			
4	4-4-d 複数地震同時発生への自動震源解析の信頼性向上のためのIPF手法			○			
4	4-4-f 津波警報の精緻化のための海岸を分割した警報発表手法			○			
4	4-4-g 津波観測測器がない海岸のボランティアによる監視安全・効率化			○			
4	4-4-h エルサルバドルの地震マイクロゾーニング地図の更新のためのガイドラインの検討			○			調査中
4	米州開発銀行（Inter-American Development Bank, IDB)による地震危険度評価プロジェクト						作業中
	他の国際協力機関の関連活動の状況把握						
4	ユネスコによるTsunami Readyプロジェクト						作業中

3. 成果達成状況の詳細

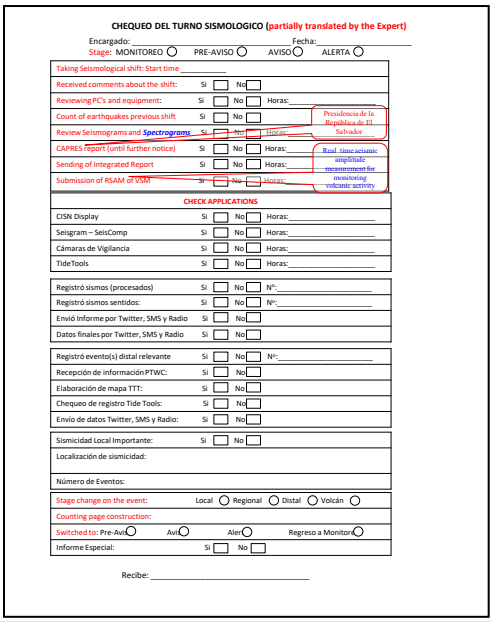
ここでは、要素・分類順に個々の目標（想定している成果）の達成状況を説明する。なお、以下で用いている計画とは、「仕様書」にある「業務の課題と改善の方向性についてのDGOA との協議」を踏まえた「DGOA 担当職員と定める技術移転・研修計画」のこと である。その作成例は、作業段階の目標 1-1-a、1-1-c-1、及び 1-2-b について**付録５**に示した。

3.1 要素 a: 観測、分析、及び監視システム

分類 1: 地震津波監視

達成状況: 右の表の通りであり、目標 **1-2-f-1** を除いて、現状確認を終え、整理又は計画策定段階にある。これらの作業では、**1-1-a** と **1-2-b** については、「how to use the “panel”, Documento_Mensajería_Tsunamis_LMixco2021(1) from 01Sep21」を利用して、**1-2-f-4** については、津波プロトコルと他の３つの文書を利用して、それぞれ進めている。なお、作業に用いている文書は**付録３**と**付録４**とに整理した。これらは MARN が提供してくれたものである。

1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	計画策定中（第4回会議）
1-1-c-1 津波監視手引書	計画策定中（第6回会議）
1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	計画策定中（第14回会議）
1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立	作業中
1-2-f-4 異常地震活動対応標準手順：確立	活動結果の整理中
4-4-e 震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入	活動結果の整理中


CHEQUEO DEL TURNO SISMOLOGICO (partially translated by the Expert)

Encargado: Fecha:

Stage: MONITOREO PRE-AVISO AVISO ALERTA

Taking Seismological shift: Start time

Received comments about the shift: Si No

Reviewing PC's and equipment: Si No Horas:

Count of earthquakes previous shift Si No

Review Seismograms and Spectrograms Si No Horas:

CAPRES report (until further notice) Si No Horas:

Sending of Integrated Report Si No Horas:

Submission of RSAM of VSM Si No Horas:

Presidencia de la República de El Salvador

Real time seismic amplitude measurement for monitoring volcanic activity

CHECK APPLICATIONS

CISN Display Si No Horas:

Seisgram – SeisComp Si No Horas:

Cámaras de Vigilancia Si No Horas:

TideTools Si No Horas:

Registró sismos (procesados) Si No N°:

Registró sismos sentidos: Si No N°:

Envió Informe por Twitter, SMS y Radio Si No

Datos finales por Twitter, SMS y Radio Si No

Registró evento(s) distal relevante Si No N°:

Recepción de información PTWC: Si No

Elaboración de mapa TTT: Si No

Chequeo de registro Tide Tools: Si No

Envío de datos Twitter, SMS y Radio: Si No

Sismicidad Local Importante: Si No

Localización de sismicidad:

Número de Eventos:

Stage change on the event: Local Regional Distal Volcán

Counting page construction:

Switched to: Pre-Avi Avi Aler Regreso a Monitoreo

Informe Especial: Si No

Recibe:

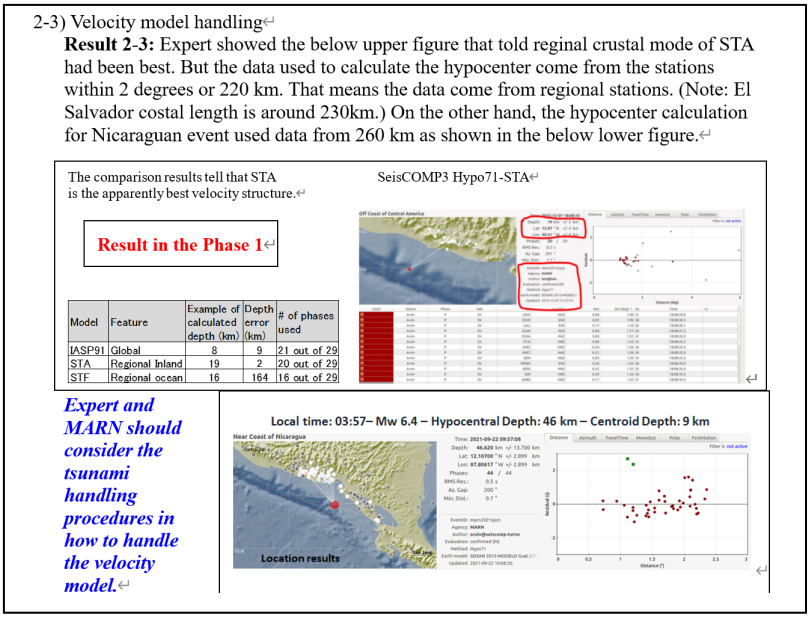
残された課題

1) 目標 **1-2-f-1** が作業中である。その中の一つとして、監視当番者の引き継ぎ時の点検リスト（**右コラム欄**参照）に検討事項がある。即ち、このリストについて、津波や地震を適切に取り扱うことを確かなものにする観点から専門家は精査が必要である。

2) 目標 **1-1-c-1** については計画策定中ではあるが、地震波速度構造モデルの運用に検討事項が残っている。詳細は次の通り：

あ）震源計算に用いる地震波速度構造モデルは、MARN では 3 種類用意している。うち一つは標準的な「全球型の地殻構造モデル」IASP91 である。それ以外の２つは、「地域型の地殻構造モデル」であり、Phase 1 で開発したものである。

い）運用は、自動震源計算では、全球型が使われている。それは津波警報発表で対処する地震は通常、規模が大きい。このため、利用データは国外からのものが多くなり、震源計算の精度向上には全球型が望ましいためである（注：このことは Phase 1 では専門家は意識していなかった）。一方、新たに開発した２つの「地域型」のの評価は**右のコラム欄**に示すように主に国内データで行い、地域型２つのうち STA の利用を推奨する結果を得ていた。


2-3) Velocity model handling

Result 2-3: Expert showed the below upper figure that told reginal crustal mode of STA had been best. But the data used to calculate the hypocenter come from the stations within 2 degrees or 220 km. That means the data come from regional stations. (Note: El Salvador costal length is around 230km.) On the other hand, the hypocenter calculation for Nicaraguan event used data from 260 km as shown in the below lower figure.

The comparison results tell that STA is the apparently best velocity structure.

SeisCOMP3 Hypo71-STA

Result in the Phase 1

Model	Feature	Example of calculated depth (km)	Depth error (km)	# of phases used
IASP91	Global	8	9	21 out of 29
STA	Regional Inland	19	2	20 out of 29
STF	Regional ocean	16	164	16 out of 29

Expert and MARN should consider the tsunami handling procedures in how to handle the velocity model.

Local time: 03:57– Mw 6.4 – Hypocentral Depth: 46 km – Centroid Depth: 9 km

Location results

う）先日の 9 月 22 日にニカラグアとエルサルバドル

の境界沖合を震源とする地震では、当番者は STA を利用し、結果として、自動震源計算の結果よりも震源の深さの精度を落とすことになってしまった。
え）津波警報発表作業では自動震源計算で用いている全球型をそのまま用いることが適当である。それは、津波警報で対象とする地震は規模が大きく、国外でも多くの場所で観測されるためであり、人手による震源計算に際して、国外のデータも利用すべきである。一方、内陸に発生した地震や規模が小さめの地震では、地域型を利用すべきである。
以上の事情を踏まえて、地域型の利用基準を確立のためにさらに本件を検討する。

(注: 本課題は、上述の 9 月 22 日の地震の取り扱いで見いだされたものである。この取り扱い（ツイッターへの発信状況、情報発表タイミング及び内容）は、**右のコラム欄**に示してある。)

Messages posted on the MARN twitter of the public on the Nicaragua event of 22Sep21 03:57 a.m. (OT, local time)

	Type of message	Elapsed time from OT	Contents	Purpose *(to be confirmed)*	Actual description (Translated into English by the Expert and adder the blue letters)
1	Calm	2 min	Felt, occurrence e of earthquake	To calm	Preliminary parameters of the earthquake felt in Salvadoran territory will be released shortly.
2	Preliminary	4 min	Preliminary M and the epicenter location (feature off the event)	To tell how to consider the event (Loca event z1; 6.5 -> tsunami maild threat)	Seismic magnitude 6.5, off the coast of Nicaragua
3	Final	15 min	Final seismic parameter **with the epicenter map**	To tell how to consider the event (z1; 6.3-> no threat)	Seismic magnitude 6.3, off the coast of Nicaragua117 km south of Playa Las Tunas (in El Salvador). Depth. 46km
4	Tsunami	20 min	Judgement on the tsunami threat	To tell if we should consider tsunami	Based on the parameters of the earthquake, there is NO tsunami threat to El Salvador.

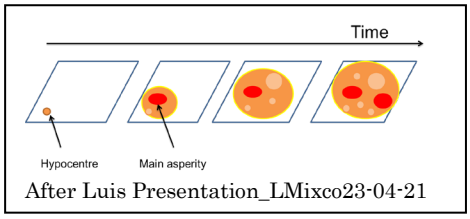
https://twitter.com/MedioAmbienteSV/status/1440619938834645006
https://twitter.com/MedioAmbienteSV

分類 2: CMT 及び Mw 監視

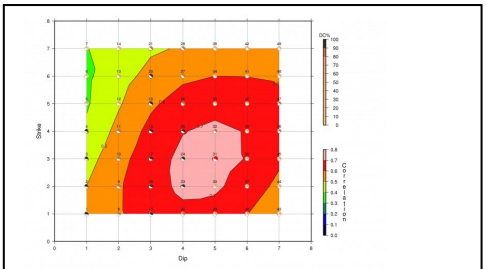
達成状況

右の表の通りであり、来年実施する予定であった 3 つの項目についても、調達機材に含まれている ISOLA の機能を活用するという方向で作業に着手している。下の**コラム欄**には右に目標 **4-2** に関わる図、左に目標 **4-3** に関わる図を示した。

1-1-b 発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；MwはモーメントマグニチュードⅠ）	計画策定中（第5回会議）
1-2-a CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	計画策定中（第7回会議）
4-2 地震波形を用いた解析による震源断層の滑り量分布の把握	作業中
4-3モーメントレート関数表示機能（震源時間関数の把握）	作業中
4-4-a 地震波初動解析による発震機構把握	作業中



After Luis Presentation_LMixco23-04-21



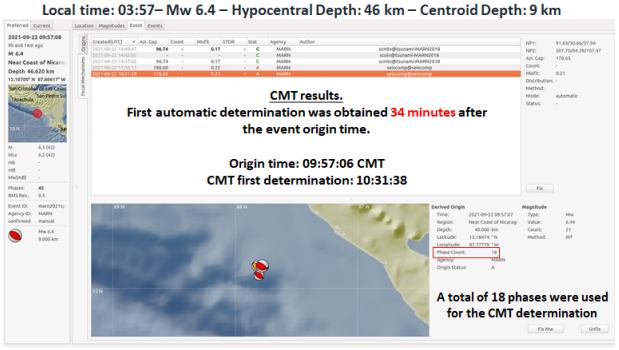
After Luis Presentation_LMixco23-04-21

残された課題

目標 **1-1-b** については、計画策定中であるが、「自動処理に時間を要した」ことの検討が残されている。詳細は次の通り：**右のコラム欄**にあるように前述のニカラグアとの境界沖合の 9 月 22 日の地震について、自動処理で CMT 結果を得るのに 34 分を要した。この理由を検討している。この原因は観測波形と計算波形の整合性の評価基準にあるものと推測している。今後 MARN はこの地震での自動処理過程でのログを分析することにしている。

To get the reason why it took 34 minutes to obtain the CMT results as shown below.

Local time: 03:57– Mw 6.4 – Hypocentral Depth: 46 km – Centroid Depth: 9 km



分類 3:津波対応

達成状況

右の表の通りである。

1-2-d 津波警報解除手順書：作成	作業中
1-2-f-5 津波警報解除後の注意喚起情報：導入検討	作業中
1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	作業中
1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	活動結果の整理中

残された課題

1) 作業中の３つの目標のうちの目標 **1-2-d** については、２つの検討課題がある：DGPC での解除の基準、及び MARN 解除基準にみられる 2 時間経過監視の技術的根拠。詳細は以下の通り：

津波警報解除手順は、**下のコラム欄**に示すように、津波プロトコルで取り扱われている。

津波プロトコルからの抜粋（西語から英語への翻訳は地震専門家（森）による）

Conditions to be met to cancel tsunami threat

- That the final parameters of the earthquake do not meet the threshold of tsunamigenic eventgeneration.
- Do not observe significant changes or increases in sea level (less than 10 cm) in tide gauges near the coast of El Salvador after the estimated time of arrival of the tsunami.
- Do not observe changes or increases in sea level (less than 10 cm) in tide gauges near the seismic source after the estimated time of arrival of the tsunami. (In case of regional or distal sismos) .
- Corroborate the direction of energy propagation from PTWC products.
- Sufficient tsunami decay after a long time (at least two hours according to PTWC after estimated arrival times).
- That the PTWC indicate that the threat has passed to the Salvadoran coasts.
- That local conditions do not continue to produce strong water currents in canals or ports that require the prolongation of the tsunami warning state.
- That the area has not been hit by damaging waves for at least two hours.

On the issuance of the cancellation

Finally, DGPC is informed of the cancellation of the threat and the cancellation is disseminated by the different media and social networks, for this see in annex 3 the formats of cancellation messages, in addition to including in the closing report of the event the cancellation of the threat.

しかし、以下のことについて、検討が必要である：

あ）警報解除の判断について、DGPC は MARN からの情報だけでなく、PTWC からの情報も利用している模様である。DGPC における解除判断の基準は DGPC が利用している手順を記述した文書を DGPC から提供してもらい内容を精査して、対応を検討する。

い）津波プロトコルには「解除にあたり 2 時間経過を注視」という趣旨の記述があり、PTWC がこのことを述べており、MARN はそれに倣っているとのこと。しかし、技術的根拠は不明。

2) 作業中の３つの目標のうちの **1-2-f-5** については、ごく小さな津波に関しての扱いが明確ではないという課題がある。即ち、注意喚起情報は、津波警報解除後については、**下のコラム欄**に示すように津波プロトコルで明示されているが、津波警報を発表するに至らなかった地震によるごく小さな津波に関しての扱いが明確ではない。

津波プロトコルからの抜粋（西語から英語への翻訳は地震専門家（森）による）

Cancellation Messages

1. Earthquake 08/03/2015, 20:48 SV time, Colombia coast, Mag. 7.9, tsunami threat to El Salvador is cancelled. (116 characters)
2. Mag earthquake. 7.9, coast of Colombia, [2015-03-08, 20:48 SV time], tsunami threat is canceled for El Salvador. (115 characters)
3. The threat of tsunami off the coast of El Salvador has passed, however, it is recommended to stay away from the beaches. (118 characters)

In the event that abnormal fluctuations in the sea surface are expected due to the "tsunami" even after cancellation, the following notifications should be added to the cancellation information:
"The sea may show abnormal fluctuations in the sea surface, but we do not expect damage or no damage." (238characters).

3) 作業中の３つの目標のうちの **1-2-f-6** については、次の４つの課題がある：

あ）2017 年 9 月 7 日エルサルバドル時間 22:49 にメキシコ Chiapas 沿岸を震源とする地震が発生した。**右及び右下のコラム欄**に示すように、この地震の際、津波の高さが小さくなってきた以降に大きな津波がエルサルバドルに襲来した。この現象への対処は津波プロトコルにも記述されているとのことなのでその確認。

The internal document in MARN

Compilation of information and actions carried out by earthquake of magnitude 8.1, off the coast of Chiapas, Mexico, on September 7, 2017, at 22:49:21 (El Salvador time)

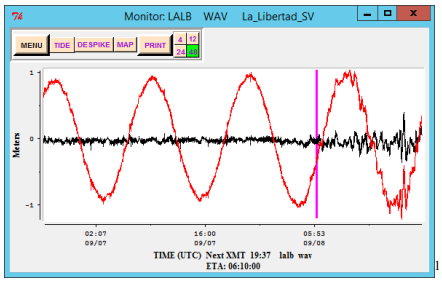
Unfortunately, there is no evidence of the times when the information on tsunami threat is disseminated by the radio of the **civil protection** system.

For the Sept. 7 earthquake, the first message via twitter, that there is a threat of a tsunami threat to the Salvadoran coast, is published at 00:20:39 after the earthquake occurred (Annex 8). For the earthquake on November 24, 2016, it was approximately 9 minutes after the earthquake occurred.

い）上述の現象への理解を DGPC 求めることが必要（目標 **1-2-d** 関連）。

う）上述の現象が起こりうる海域をシミュレーションで特定（MARN の潮位計運用者に依頼）。

え）**右上のコラム欄**にある 2016 年 11 月 24 日の地震の点検。



The excerpt from ITIC document. This shows the tsunami by removing the astronomical tidal change.

要素 b: CATAC を含むインフラの利用
分類 4: 復旧及びバックアップ

達成状況

この分類では、**右**の通りとなっている。

1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）	MARN対応注視中
1-2-e バックアップシステムの適正化：対応	MARN対応注視中

残された課題

引き続き、MARN 内における作業の進捗を注視しつつ、新たな提案を検討することが必要。**右及び次頁**に注視の詳細を示した。

c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network

The Platform project was once stopped but would restart soon. It would take care of the rapid recovery actions with the station network map. The Expert should continuously watch its progre from now.

- On the other hand, the rate of operation of the seismic network lookskept around 86% in rec years as shown in the below list.But it is 67% in 2020, if including the stations that are stopp for a long period. T he main causes of the long outage s come from “GPS clock” down a “repeater” outage.
- The Expert should consider whether we have any measures to fix the outage earlier like keeping spare equipment or 2) establishing the system to give us how to handle the issue lik showing any “priority”.

Tipo de alimentación	2015 (%dias funcionado)	2016 (%dias funcionado)	2017 (%dias funcionado)	2018 (%dias funcionado)	2019 (%dias funcionado)	2020 (%dias funcionado)
Promedio general	65%	74%	83%	82%	76%	67%
total estaciones	46	45	45	47	48	55
Estaciones no consideradas para promedio corregido (marcadas en amarillo) – ver justificación en notas	7	4	3	4	9	13
Promedio corregido	74%	81%	85%	88%	86%	84%

e) Establishment of backup for the tsunami warning system
The backup issue is achieved accordingly as follows:
- The building, where the seismic system and the monitoring shift staff are working, is the same during recent years or is earthquake-proof. So, it is safe against the strong motion/shake by earthquakes. Now it is being "repaired"; the "repairment" is not related to earthquake-proof function, though.
- The backup system is installed in the other building. On the other hand, one of the servers is needed to be duplicated. The server is requested in this Project.
- The internet congestion has not occurred after prioritizing the seismic line. On the other hand, the SNS like twitter for the public to get information issued from MARN has been experiencing a sort of "congestion" or response slowdown due to a surge of access when any remarkable earthquake occurred.
- The server system, where SeisCOMP3 is working, is configured to have the duplication like mirror site.

But the below items should be watched further:
- As for the power supply issue, MARN should check whether any renewal plan of batterie has been made.
- As for handling some slight possibility to evacuate from the building due to fire or something unknow, we should consider any measurement against the possibility.
- As for the case that the entire M ARN should evacuate from the premises, we should discuss how to manage the case. One idea was that we should use any portable tool like a smart phone in order to get information sent from CATAC/PTWC and to issue tsunami warning to DGPC / the public. (Note: The commercial internet line for receiving emails from CATAC and PTWC are duplicated or contracted with two companies. So, one of them could backup another.)

分類 5: CATAC との協力を含むデータ及び情報収集

達成状況

CATAC との 2 回の遠隔会合で得られた情報を整理している段階である。目標 **4-1（GPS）**及び目標**スイス SED の EEW** については、Phase 2 の活動の最後に扱うことにしていた。しかし、CATAC が津波警報にこれらの技術を利用するとしていることから、検討を開始した。なお、以下の情報が今後の整理を進める上で重要：

a) 情報共有の手段は、**右の２つのコラム欄**のように整理できる。

b) CATAC は、津波警報を、「震源によっては 10 分以内に津波が襲来する海岸（**下図**の赤い所）があること」を考慮して発信するとのこと。

2 CATACとの情報の共有化の促進	作業中
4-1 GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）／ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定	調査中
スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW）開発	調査中

Discussed as follows:

a) CATAC thinks that **WMO-GTS circuit/line** is "slow" for handling large amount information. On the other hand, Expert thinks that it has sufficient function to handle text messages, so it can be a backup line to get text messages sent from CATAC

b) CATAC thinks that **the "satellite communication"** has the function to handle large amount of information, and the cost for initial installation and operation are not so expensive (***to be checked.***)

c) CATAC uses (or has the contract with the provider of) **two circuits/lines to issue** the tsunami information to the countries of the Central America.

d) CATAC thinks that **the commercial telephone line** doesn't have the function to handle large amount of information. On the other hand, Expert thinks that it has sufficient function to handle text messages.

e) CATAC thinks that **optical fiver circuit** will be useful. The Expert thinks that the cost to use the circuit should be expensive **if we use leased circuit/line**. (Note: The Expert was not able to catch the exact meaning on this issue, so should request CATAC to explain thisissue **again, if permissible.)**

W.S.: The proposal was to investigate whether we can use the private communication systems of the electrical power companies in Central America which are independent from the normal Internet.

上表の衛星通信に関する日本における状況

In Japan, https://japan.cnet.com/article/35166497/
It seems that the service will start in 2021 or 2022 depending on the place of residence.
A deposit of $ 99 (about 10,400 yen) is required to apply.
When you start using the service, it costs an additional $ 499 (about 52,400 yen) and tax. This is the price of the "Starlink Kit," which consists of a small receiving antenna, installation equipment, and a Wi-Fi router. The service itself costs $ 99 per month. The deposit payment terms state that refunds are possible before the order is placed, and that payment of the deposit does not guarantee the provision of services.

c) CATAC は 1 秒刻みでデジタル化された GPS データを実時間で利用。このため、**右図（Figure 1）**に示すような地震波形も利用できる可能性がある。なお、右図では永久変位も見ることができる。

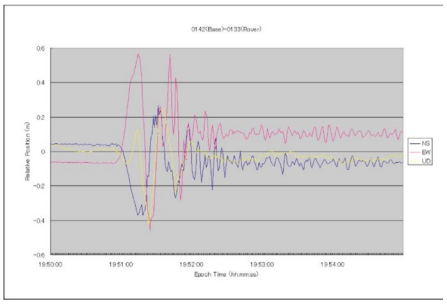


Figure 1. Ground displacement of the 2003 M8.0 Tokachi-Oki earthquake on September 26, 2003 observed by kinematic GPS with **1Hz sampling**. It clearly shows static crustal displacements (offsets between 19:50 and 19:52) as well as long-period seismic waves. (After "Geospatial Information Authority of Japan"

残された課題

以下のことへの対処が必要となっている。

1) CATAC の本格試運転・本格運用開始の把握

今後期待される進捗は次の通り：

a) ICG/PTWS 遠隔会合、今年 12 月初めに開催予定。この会合で CATAC が公式運用を始めることと開始日が提案され、決定される見込み。またこの会合で本格試運転開始も提示される見込み。

b)本格試運転は、上の会合の前に開始される見込み。

c) ICG/PTWS の通常会合、来年 11 月日本で開催予定。

(注：中米作業グループ会合の開催予定の見通しは時期不明。)

2) CATAC と MARN との協力

CATAC からこのことについて提案があり、**右のコラム欄**にあるような話し合いが遠隔打合せの中で持たれた。地震専門家（森）は、この話し合いをメールで再開・継続することを主導することになっている。その際、両者の通常の連絡ルートを利用することとされ、話し合いの方向性は、**右のコラム欄**に整理した課題を解決するものとされている。なお、これら課題は、"Draft minutes of the virtual meeting held on 08Oct21ver4" (Draft minutes of the talk on cooperation between CATAC and MARN Prepared by MARN and the JICA Expert on 13Oct21)に示されたものである。

Cooperation between CATAC and MARN

1.Purpose of the talk

To promote the cooperation between CATAC and MARN

2.Agenda

- Purpose of the cooperation
- Exchange of seismic and tsunami processing results in real time
- Unify processing parameters and definition of common event bulletin in a short time after the earthquake
- Install a permanent voice and video connection
- To establish satellite internet connection both at CATAC and MARN
- To define that MARN could be the backup of CATAC in case of impact of earthquake or other events at CATAC

Agenda 3 Exchange of seismic and tsunami processing results in real time

Challenges for MARN to get them in real time

To clarify the "specification" of "getting them in real time" like as follows:Contents / Timing / Stability / Method (reliability and cost)

Challenges for MARN to provide them in real time

To clarify the "specification" of "send them in real time like as follows:Contents / Timing / Stability / Method (reliability and cost)

Agenda 4 Unify processing parameters and definition of commonevent bulletin in a short time after the earthquakes

Challenges for MARN

It might be necessary for us to use the same velocity structure model and the same algorithm to get seismic parameters and CMT.

Agenda 5 Install a permanent voice and video connection

Challenges for MARN

1 To consider who, how, when, and where to use / 2 To consider how to maintain

Agenda 6 To establish satellite internetconnection both at CATAC and MARN

Challenges for MARN

1 We should considerthe cost to have and keep the "SpaceX Starlink".

2 We should kno

In Japan, https://japan.cnet.com/article/35166497/
It seems that the service will start in 2021 or 2022 depending on the place of residence.
A deposit of $ 99 (about 10,400 yen) is required to apply.
When you start using the service, it costs an additional $ 499 (about 52,400 yen) and tax. This is the price of the "Starlink Kit," which consists of a small receiving antenna, installation equipment, and a Wi-Fi router. The service itself costs $ 99 per month. The deposit payment terms state that ref unds are possible before the order is placed, and that payment of the deposit does not guarantee the provision of services.

3) MARN 所有の GPS data の利用の検討

CATAC が GPS データを津波警報作業で利用するとのことを踏まえ、標記のことについて Phase 2 の当初予定より早めて開始する。**次頁のコラム欄**に MARN 所有の GPS のリストを示した。このうち、利用可能性がある観測点として、1 秒サンプリングとできる#1 と#2 とがあり、これらについてリアルタイムデータ収集可能とする方策を検討する。なお、これらは以前 JICA が無償供与した機材である。

Expert should consider how to get real-time data from the stations #1 and #2.

Parámetros de estaciones GPS El Salvador (2018-2019-2020)

No.	COD-ID	Estation	Antenna Type	Receiver Type	How to get the data	Ref.	Sampling rate	Memory capacity in the receiver	Processing	Surveying type	positioning
1	LNUB	Las Nubes	TPSCR.G5	Topcon NetG3A	**Internet**	JICA	30 sec (1Hz can be used.)	15 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
2	ALAR	Lomas de Alarcón	TPSCR.G5	Topcon NetG3A	**Internet**	JICA	30 sec (1Hz can be used.)	15 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
3	ACAJ	Puerto de Acajutla	TRM41249.00	Trimble NetRS	**Internet**	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
4	SNJE	San José	TRM41249.00	Trimble NetRS	**Internet**	UW	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
5	CNR1	Centro Nacional de Registro	TRM41249.00,	Topcon GB1000	**Internet**	UW	30 sec (1Hz can be used.)	100 Mb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
6	SSSV	San Salvador	SEPCHOKE_B3E6	SEPT POLARX5	**Internet**	JPL	1Hz (resampling to 30 sec)		Real Time and post-processing	Static (kinematic can be used)	DGPS or Absolute
7	AIES	Aeropuerto Internacional El Salvador	TRM41249.00	Trimble NetRS	On site	UW	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
8	LALI	Puerto de La Libertad	TRM41249.00	Topcon GB1000	On site	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
9	SVCI	San Vicente	TPSCR.G5	Trimble NetRS	On site	JICA	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
10	VMIG	Volcán de San Miguel	TRM 57971-00	Trimble Net R9	On site	UW	30 sec (1Hz can be used.)	4 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
11	PATI	Patio de Finca Santa Isabel	TRM41249.00	Trimble R7	On site	MARN	30 sec (1Hz can be used.)	100 Mb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
12	PMON	Piamonte	TRM41249.00,	Topcon GB1000	**Internet**	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute

要素 c: DGPC を含む MARN からの情報の利用者との意思疎通

分類 6: DGPC との協力を含む防災のための津波警報の発信

達成状況

1-2-f-3 e-mailの公式利用、FAX点検の日課への導入：確立	作業中
3 DGPCの津波警報利用：適切化	作業中

DGPC と 2 回の遠隔会合を持ち、次ことが合意された：

a) 津波合同訓練、今年 11 月 5 日（金）実施。部内訓練とし、両機関とも手順の確認を行う。

b) 将来は、より実践的なものとし、1，2 箇所の地方自治体、例えばラ・リベルタなども巻き込んで実施。

c) 訓練結果の評価は、ワークショップを来年 1 月 25 日（火）に共催開催して実施。開催準備の負担軽減のため、開催時間は 2 時間とする。なお、DGPC は 1 月初めと月曜日が多忙であるとのことで、このことを考慮して日程設定した。

残された課題

次の対応が必要となっている：

1)訓練準備の速やかな開始。なお、暫定的に、訓練では**右及び次頁のコラム欄**に示すような情報発信・受信を考えている。

2) 目標 **1-2-f-3** について、DGPC とともに検討を進める。

Herramientas a utilizar en el ejercicio del 05Nov21

Time of issuance	Actual	Type	Elapsed time from OT	Tools for issuance to DGPC			
			Actual	radio ->	fax ->	SMS ->	SNS
3:15	**Start message**		**0 min**	**Actual**	**Actual**		
3:17	1	Calm message	2 min	Actual		virtual	virtual
3:18	2	Preliminary message	3 min	Actual			
3:19			4 min		Actual		
3:27			5 min			virtual	virtual
3:25	***3***	***Tsunami message***	***10 min***	***Actual***			
3:26			***11 min***		***Actual***		
3:27			***12 min***			***virtual***	***virtual***
3:30	***4***	***Updated message***	***15 min***	***Actual***			
3:31			***16 min***		***Actual***		
3:32			***17 min***			***virtual***	***virtual***
3:15 - 3:45	**Cancellation of the Exercise**		**Depend**	**Depend**	**Depend**		
3:43		Tsunami message	28 - 30 min	virtual	virtual	virtual	virtual
3:45	5	Cancellation message	30 min	Actual	Actual	virtual	virtual
3:46	**End message**		**31 min**	**Actual**	**Actual**		

Messages to be issued from MARN to DGPC in the tsunami simulation exercise on 05Nov21

Time of issuance	Actual	Type	Elapsed time from OT		Contents of Information (Controlled or Automatic)	Purpose of issuance	Description in the message (To be elaborated further)
			Virtual	Actual			
3:15	**Start message**			**0 min**	**Start of the exercise (C)**	**To inform the start of the exercise**	**The exercise start.**
3:17	1	Calm message	< 2 min	2 min	Felt, occurrence of earthquake (A)	To calm the pubic	Preliminary parameters of the earthquake felt in Salvadoran territory will be released shortly.
3:18	2	Preliminary message	< 3 min	3 min	Preliminary M and the epicenter location (A, C)	To tell how to consider the event (Local; 7.8 = high tsunami threat)	Seismic magnitude 7.8, off the coast of El Salvador; there is a high ttsunami hreat.
3:19			< 4 min	4 min			
3:27			< 5 min	5 min			
3:25	***3***	***Tsunami message***	***< 10 min***	***10 min***	***Judgement on the tsunami threat (A,C)***	***To tell if we should evacuate immediately***	***There is high tsunami threat to El Salvador. The waves will begin to reach El Salvador by 03:43 on 2021-11-05.***
3:26			***< 11 min***	***11 min***			
3:27			***< 12 min***	***12 min***			
3:30	***4***	***Updated message***	***< 15 min***	***15 min***	***Updated seismic parameter with the epicenter map with CMT/Mw (C)***	***To tell how to consider the event (7.9 = high tsunami threat)***	***Seismic magnitude 7.9, off the coast of El Salvador 110 km south of La Libertad. Depth 15 km. The waves could be greater than 3 meters along the entire Salvadoran coast.***
3:31			***< 16 min***	***16 min***			
3:32			***< 17 min***	***17 min***			
3:15 - 3:45	**Cancellation of the Exercise**			**Depend**	**Cancellation of the exercise due to any contingent issue (C)**	**To stop the exercise**	**The exercise should stop immediately.**
3:43		Tsunami message	< 35 min	28 - 30 min	Observation of tsunami (C)	To tell if we should evacuate further	Tsunami has been observed at La Libertad.
3:45	5	Cancellation message	2 hours	30 min	Judgement on the tsunami advisory cancellation (C)	To tell that we cancel the advisory	Earthquake 11/05/2021, 14:15 SV time, Salvadorian coast, Mag. 7.9, tsunami threat to El Salvador is cancelled. However, it is recommended to stay away from the beaches for several hours.
3:46	**End message**			**31 min**	**End of the exercise (C)**	**To inform the endt of the exercise**	**The exercise has been finished.**

要素 d: 監視担当者の対応（人材育成）

分類 7: 自主研鑽

達成状況

1-1-c-2 津波監視現業体制での技術レベル：維持・改善研修体制確立	作業中
1-2-f-2 MARNガイドブック：確立	作業中
1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討	作業中

右の表の通りであり、全ての目標が作業中である。

残された課題

作業中の３つの目標に向けてさらに作業進めることが必要であり、特に次の対処が必要である：

1) 目標 **1-1-c-2** については、Phase 1 で作成した自主研修教科書が利用されなかったことから、より簡素なものの作成（主な利用者は監視シフト職員を想定）。なお、盛込む項目として、次のものを例として提案した：

a) 走時表作成方法

b) 震源計算方法

c) 発震機構解析方法

d) 津波予想図利用（**右のコラム欄**に示す。M と震源の深さを把握したとき、各海岸に予想される津波の大雑把な高さを推定するのに利用。これについて、MARN からは、潮位計で実況が得られることから、不要かもしれないとのコメント。専門家から、この種の教材はMとその影響との関係についてある種のセンスを磨くのに役立つと思われると説明。）

e) 断層面における応力の高まりと解放のシナリオ（**次頁右下のコラム欄**参照）。

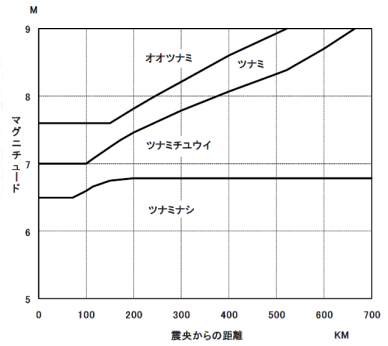
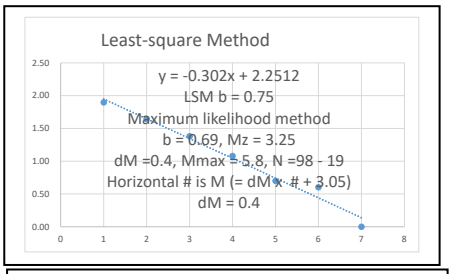
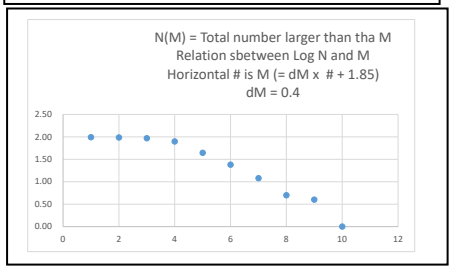


図 7（上） M（マグニチュード）に基づいて津波判定を行う津波予報図．求まった M と震央距離から津波判定を行う．例えば M8.0 の場合，震央から半径 386km 以内の津波予報区がツナミ，半径 236km 以内の津波予報区がオオツナミと計算機処理により判定する．

After Kusano & Yokota 2011

f) b 値（M 別地震発生頻度分布の傾き。グーテンベルク・リヒター式。**下の２つ及び右下のコラム欄**参照。





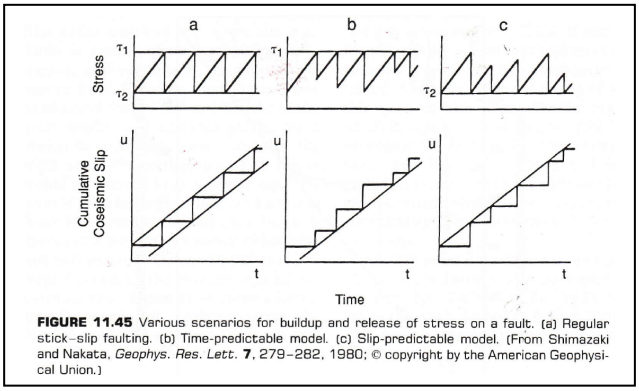
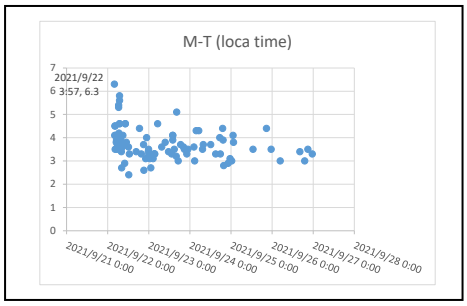


FIGURE 11.45 Various scenarios for buildup and release of stress on a fault. (a) Regular stick–slip faulting. (b) Time-predictable model. (c) Slip-predictable model. (From Shimazaki and Nakata, *Geophys. Res. Lett.* **7**, 279–282, 1980; © copyright by the American Geophysical Union.)

g) M-T 図の利用（**下のコラム欄**参照）



(P.S.)

The b-value reported in the meeting were as follows:

Least-Square Method 0.65 and Maximum Likelihood Method 0.69.

But the former should be changed to 0.75 due to my "data handling error". (So sorry!)

So, the b-value should be roughly 0.7.

(Note 1: the accuracy level of MLM is higher than LSM.)

(Note 2: the b-value calculated from dM larger than 0.25 gives us slightly smaller amount.)

Blue area handles Maximum Likelihood Method.

b = log e / ("average M" − Mz)

log e = 0.43429; Mz is the smallest M to be used to calculate.

The "dM" is the width of handling M.

M widths are "2.05 − 2.45", "2.45 − 2.85", —

dM	0.4	N(M)	Log N	ΔN(M)	Log N	Mz	3.25	Mean M	3.9	0.69	for MLM
2.1	2.4	1	0.00	98	1.99						
2.5	2.9	4	0.60	97	1.99						
2.9	3.3	14	1.15	93	1.97						
3.3	3.8	35	1.54	79	1.90						
3.7	4.2	20	1.30	44	1.64						
4.1	4.4	12	1.08	24	1.38						
4.5	4.8	7	0.85	12	1.08						
4.9	5.2	1	0.00	5	0.70						
5.3	5.8	3	0.48	4	0.60						
5.7	6.0	1	0.00	1	0.00						
6.1	6.4	1	0.00	1	0.00						
						Not icluded due to Main event					
		Total #	99.00								

2) 目標 **1-2-f-8 に**ついては、ワークプランで述べているように、部内用として毎月作成してきている「地震月報」について、この作成作業を自主研修体制構築に利用する検討。専門家は MARN とともにこの検討を開始している。この作成作業において、「その内容の改善を進めるため、これを作成する監視シフト職員が相互に意見を出し合って作成する」という体制の構築を検討する。また、部外にも地震月報を公表していくことも検討。なお、地震月報の具体的な改善策について、専門家は地震月報の最新版を仔細に検討して研修システム構築に向けて検討する。これまで次の案を MARN に提案してきた：

Earthquake bulletin list (Tentative as of 16Sep21)

Type	Feature		Name	Frequency	Timing	Authorization (Guideline)	Purpose (Output)		Target (Outcome)	
							Note: All are includoing tsunami.	Mainly for who?	Disaster prevention	Others
1	Emergent information			Irregularly issuing	Just after occurrence of disastrous earthquakes	Tsunami Protocol Earthquake Protocol (*Daily activity list*) (*guideline to be considered*)	1 To identify the damaged area and the size of disaster as soon as possible	First aid organizations	Contribute to disaster prevention	Support the first aid
2	Emergent information	Additional If necessary		Irregularly issuing	After issuance of emergent information		2 To make DGPC and the public understand the feature of the event	DGPC The public		Contribute to disaster mitigation
3	Technical Information		Informe_Tecnico	Irregularly issuing	The internal protocol says its issuance frequency as follows: **Notice: more than 0; Warnig: 1 / day; Alert: 2 / day; Emergency: more than 2 / day**	**Earthquake Protocol** (*template to be considered*)	3 To properly consider occurrence of any additional large disastrous event	DGPC		Cultivate reliability of MARN in the society
							4 To contribute to the scientific society	Scientist		
4	Newsletter	Monthly newsletter		Monthly issuing	Within 10 days from the end of the month		5 To understand the state of seismic stress distribution	MARN		Have the chance of OJT
							6 To cultivate the knowledge of the DGPC and the public for understanding seismic stress distribution	DGPC The public		
5	Explanation of the basic knowledge on earthquakes	Including the information issued from MARN	MARN Guidebook	Always shown (updating)	Just when any change is made in duty works of MARN or is developed in scientific knowledge		7 To cultivate the knowledge of the DGPC and the public for understanding the meaning of the information issued from MARN	DGPC The public		

a) M-T 図導入検討。M-T 図の利用例：

"202103sekai_jishin_kobetsu_1"及び"202103tohoku_kobetsu_1"にある。**上に示した MT 図**は、"Minutes of the virtual meeting held on 29Sep21 ver2"から抜き出したもので、余震が徐々に安定して減ってきている様子が一目で把握可能である。

b) 過去の顕著な地震を、新たに発生した顕著

な地震の震源を示す図に明示。これにより、発生した地震の性格（繰返し発生など）の理解に有用。利用例は、次の文書にある：202103nihon_jishin。また、この種の図の作成の手段について、MARN が持っているか確認し、持っていない場合、提供する。
なお、緊急に発表してきている情報も含めて、部外に公表してきている情報を**前頁のコラム欄**に整理した。

要素 e: 機材

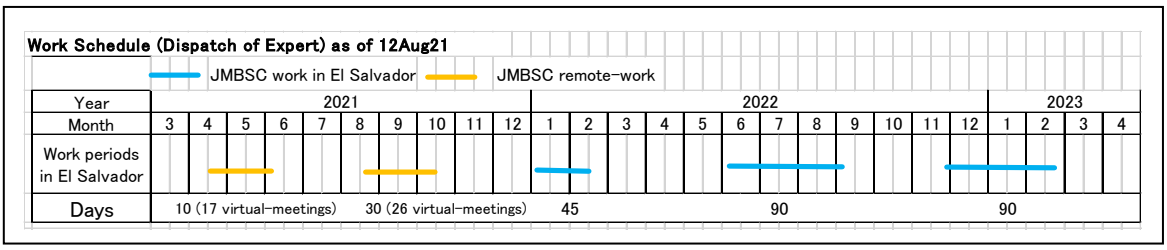
機材調達	作業中

達成状況
右のコラム欄にある機材が調達手続きに進んでいる。

Marn-Procurement as of 15Oct21

EQUIPMENT DESCRIPTION	Quotation provided from	COMMENTS/JUSTIFICATION	QUANTITY	UNIT COST	TOTAL
Digital radios: Brand: Ubiquiti. Model: AirFiber 5XHD Range: Greater than 100Km Frequency 5Ghz 802.11 security protocol	1. The manufacturer's website 2. The price in the country (two to three times what is shown on the internet, asking a quote to a local dealer)	To strengthen the operation rate of the seismic network through the improvement of transmission lines using digital technology.To be used at the three locations: One of the sets of antennas use " 34dBi gain" due to the long distance between the locations that use the radio communications. a) SanJose - Jayaque (Codes: SNJE-JAYA) b) Las Nubes - Lomas de Alarcon (Codes:NUBE-LOAL) c) Centro de Gobierno (repeater point) - Marn. Through this link, information comes from the Pacayal station (Code: PACA.)	6	US$429.00	US$2,574.00
Ubiquite brand dish antenna, model AF-5G23-S45, frequency 5Ghz, 23dBi gain, range greater than 15km, include hardware for installation.			4	US$99.00	US$396.00
Dish antenna Ubiquiti brand, RocketDish 5G34 model, 5Ghz frequency, 34dBi gain, range greater than 15km, include hardware for installation.			2	US$329.00	US$658.00
Workstation: Workstation Model: Precision 7920 Tower Chassis CL. Processor: Intel Xeon Silver 4210R (2.4GHz, 3.2GHz Turbo,10C, 9.6GT/s 2UPI, 13.75MB Cache, HT (100W)) DDR4-2400. Operating System Windows 10 Pro for Workstations (6 Cores Plus) Multi - English, French, Spanish. Memory: 64GB 4x16GB DDR4 2933MHz RDIMM ECC Memory. Graphics Card: NVIDIA® Quadro® P1000, 4GB, 4 mDP (7X20T). Hard Drive: M.2 1TB PCIe NVMe Class 40 Solid State Drive. Keyboard: Dell Black Wired 10 Key Numeric Keypad KB813 Smart Card Keyboard. Mouse: Dell USB Laser 6-Button Mouse. Monitor: Dell 27 Monitor - P2722H.	1. Dell (most economical) https://www.dell.com/en-us/work/shop 2. HP with the specifiction similar to the Dell	1. To run specialized seismological and tsunami monitoring software. 2. More focused on tsunami simulations in real time	1	US$4,167.23	US$4,167.23
Laptops: screen display size 13.3 Inches, max Screen Resolution 1920 x 1080 Pixels Processor 1.6 GHz i5 RAM 8 GB SDRAM Hard Drive 256 GB ssd Wireless Type 802.11ac		To be used in the field in the configuration and maintenance of the seismic network.	2	US$1,000.00	US$2,000.00
ISOLA (MatLab software & specific toolboxes) Perpetual Standard License Individual: it is allowed to install the software on 4 PCs but there can only be one user, who will have unique credentials, with which they can access the software and others tools.	MatLab	To get 1) Display of moment rate function to understand the actual seismic magnitude earlier 2) Slip distribution in a finite fault area, 3) Flexible calculation of GFDB and handling in-depth analysis related to the determination of theCMT Note 1 Its calculations are not in real time. Note 2 OSOP CMT doesn't have the above functions but can work in real time. Note 3 Both can handle initial motion (polarity) analysis for grasping focal mechanisms by entering polarities.	1	US$8,560.00	US$8,560.00
					US$18,355.23

付録 1 プロジェクト全体の日程概要



付録 2 作業経過と当初計画

Meetings in the remote-activities (16Aug21 - 15Oct21) with El Salvador Time as of 25Oct21

Prepared by the Expert, JMBSC MORI, for the "Capacity Development of the Analysis for Earthquakes and Tsunamis of El Salvador" Phase 2 during 2021-2023

2021			Virtual meeting numeric orders	Contents of the activities of the Expert in El Salvador Time (JST is obtained by adding 15 hours to El Salvador Time.)	Virtual meeting numeric orders	Contents of the activities of the Expert in El Salvador Time (JST is obtained by adding 15 hours to El Salvador
Month	Day			Planned		Actual
Aug	18	Wed	1	**To prepare the documents for the meeting on the day** *(Note: All the meeting days should have this action to be taken by the Expert. So this action is not shown below.)* 15:00-16:00 Meeting with the following agenda: 1) the draft of work plan, 2) review of the current status, 3) schedule for explaining the draft to the DG of MARN	1	**To prepare the documents for the meeting on the day** *(Note: All the meeting days should have this action to be taken by the Expert. So this action is not shown below.)* 15:00-16:00 Meeting with the following agenda: 1) the draft of work plan, 2) review of the current status, 3) schedule for explaining the draft to the DG of MARN
Aug	20	Fri	2	15:00-16:00 1) "a) The proper & stable judgement on generation of tsunami, 2) Review of the current status	2	15:00-16:00 1) "a) The proper & stable judgement on generation of tsunami, 2) Review of the current status
Aug	23	Mon	3	15:00-15:30 Explaining the latest draft to DG and getting his comment 15:30-16:00 Review of the actions to be taken	3	15:00-15:30 Explaining the latest draft to DG and getting his comment 15:30-16:00 Review of the actions to be taken
Aug	25	Wed	4	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "b) The CMT analysis in the practical monitoring task to get focal mechanism and Mw ", 3) review of the actions to be taken	4	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "b) The CMT analysis in the practical monitoring task to get focal mechanism and Mw ", 3) review of the actions to be taken
Aug	27	Fri	5	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "c-1) Tsunami Monitoring Manual", 3) "f-3) Introduction of the daily inspection of radio, fax, and email as the authorized transmission methods to DGPC", 4) review of the actions to be taken 16:00-17:00 Explaining the latest draft to "El Salvador JICA" *(provisional schedule)*	5	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "c-1) Tsunami Monitoring Manual", 3) "f-3) Introduction of the daily inspection of radio, fax, and email as the authorized transmission methods to DGPC", 4) review of the actions to be taken 16:00-17:00 Explaining the latest draft to "El Salvador JICA"
Aug	30	Mon	6	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "c-2) The self-training system & materials to keep the tsunami handling skills of the monitoring shift officers at the enough level", 3)"c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network", 4) review of the actions to be taken	6	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "c-2) The self-training system & materials to keep the tsunami handling skills of the monitoring shift officers at the enough level", 3)"c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network", 4) review of the actions to be taken
Sep	1	Wed	7	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "a) Introduction of GFDB based on the local seismic velocity structure to cover the events under M6.5 in CMT", 3) "d) Establishment of tsunami warning cancellation procedures including DGPC", 4) review of the actions to be taken	7	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "a) Introduction of GFDB based on the local seismic velocity structure to cover the events under M6.5 in CMT", 3) "d) Establishment of tsunami warning cancellation procedures including DGPC", 4) review of the actions to be taken
Sep	3	Fri	8	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "f-1) Establishment of the Tsunami Monitoring materials", 3) review of the actions to be taken	8	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "f-1) Establishment of the Tsunami Monitoring materials", 3) review of the actions to be taken
Sep	6	Mon	9	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Preparation for the virtual meeting with CATAC", 3) "b) Introduction of auto-filling-function and elaboration of depth handling in the tsunami database", 4) review of the actions to be taken.	9	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Preparation for the virtual meeting with CATAC", 3) "b) Introduction of auto-filling-function and elaboration of depth handling in the tsunami database", 4) review of the actions to be taken.
Sep	8	Wed	10	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "e) Establishment of backup for the tsunami warning system", 3)"f-4) Establishment of the standard procedures that handle any abnormal seismic activities", 4) review of the actions to be taken	10	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "e) Establishment of backup for the tsunami warning system", 3)"f-4) Establishment of the standard procedures that handle any abnormal seismic activities", 4) review of the actions to be taken
Sep	10	Fri	11	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Implementation the virtual meeting with CATAC" *(to be considered further)*, 3) "f-2) Establishment of the MARN guidebook to make "DGPC and the people" properly use the information sent from MARN", 4) "Promoted DGOA to share any information with CATAC", 5) review of the actions to be taken	11	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Implementation the virtual meeting with CATAC", 3) "f-2) Establishment of the MARN guidebook to make "DGPC and the people" properly use the information sent from MARN", 4) "Promoted DGOA to share any information with CATAC", 5) review of the actions to be taken
Sep	13	Mon	12	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC ", 3) review of the actions to be taken	12	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC ", 3) review of the actions to be taken
Sep	15	Wed	13	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Preparation for the virtual seminar with DGPC", 3) review of the actions to be taken		Independence DayA19:K23
Sep	17	Fri	14	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) review of the actions to be taken	13	15:00-16:00 Meeting with CATAC 1) ODGA/MARN project 2) Issuing procedures of tsunami information with timeline 3) Issuing tools 4) Covering area of events 5) Covering data 6) Status of official initiation of CATAC function 7) Cooperation between CATAC and MARN 8) Any other business
Sep	20	Mon	15	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Implementation of the seminar with DGPC (*to be considered further*)", 3) review of the actions to be taken	14 15	15:00-16:00 Discussing the following agenda: 1) Progress of the target shown in the previous meeting Plan the Target 2-b) Auto-filling-function and elaboration of depth handling 2) Preparation for the virtual meeting with DGPC 3) Review of the actions to be taken Target 1-c-2 Self-training system & materials Target 2-c Recovery procedures with the "Platform" Target 2-d Tsunami warning cancellation Target 2-f-2 MARN guidebook Questionnaire Target 2-e Backup for the tsunami warning system Questionnaire Target 2-f-1 Tsunami Monitoring materials Questionnaire Target 2-f-4 Procedures handling abnormal seismic activities

Sep	22	Wed	16	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2)"f-6) Introduction of estimating the arrival of larger tsunamis after that initial tsunamis are diminishing", 3) equipment procurement, 4) review of the actions to be taken	16	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2)"f-6) Introduction of estimating the arrival of larger tsunamis after that initial tsunamis are diminishing", 3) equipment procurement, 4) review of the actions to be taken
Sep	24	Fri	17	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) review of the actions to be taken	17	15:00-16:00 Talk with DGPC□ 1) DGOA/MARN project 2) Planning of cooperation of tsunami simulation exercises 3) Planning of workshops on the prevention of earthquake and tsunami disaster 4) Sharing the status of MARN and DGPC on the prevention of earthquake and tsunami disaster 5) AOB
Sep	27	Mon	18	Ibid.	18	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) review of the actions to be taken
Sep	29	Wed	19	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Preparation for the exercise of the "emergency information issuance to the DGPC" or to the "public"", 3) review of the actions to be taken	19	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Preparation for the exercise of the "emergency information issuance to the DGPC" or to the "public"", 3) review of the actions to be taken
Oct	1	Fri	20	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) review of the actions to be taken	20	15:00-16:00 Discussing the following agenda: 1) Draft minutes of the meeting held on 29Sep21 2) Progress of the target shown in the previous meeting 2-1) CATAC issue, 2-2) DGPC issue 3) Preparation for the exercise with DGPC 4) Review of the actions to be taken
Oct	4	Mon	21	Ibid.	21	15:00-16:00 Discussing the following agenda: 1) Draft minutes of the meeting held on 29Sep21 2) Progress of the target shown in the previous meeting 2-1) Directivity in the cooperation with CATAC 2-2) Detail of the tsunami simulation exercise with DGPC 2-3) Velocity model handling 2-4) Actions to be needed in order to wrap up the below issues: a) procedures of tsunami and earthquake handling, b) CMT and Mw handling c) Equipment procurement, d) Self training issue, e) MARN guidebook 3) Review of the actions to be taken
Oct	6	Wed	22	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) Following Target 4 issues "1) Use of the real time data of the GPS stations in the system in order to get accurate Mw earlier", "2) Grasping the distribution of amount of slips on the seismic source fault surface", "3) Making displaying moment rate function", "4)-1 Initial motion analysis for grasping focal mechanisms", "4)-8 Consideration on the guideline for updating the seismic microzoning maps", 3) review of the actions to be taken	22	15:00-16:00 Discussing the following agenda: 1) Draft minutes of the meeting held on 04Oct21 2) Progress of the target shown in the previous meeting 2-1) Directivity in the cooperation with CATAC 2-2) Detail of the tsunami simulation exercise with DGPC 2-3) Actions to be needed to wrap up the below issues: a) procedures of tsunami and earthquake handling with velocity model handling b) CMT and Mw handling c) Equipment procurement d) Self training issue e) MARN guidebook 3) Review of the actions to be taken Target 4: "Established the guideline for introduction of the additional technologies that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance" 4-1 GPS / 4-2 Slips on the seismic source fault surface / 4-3 Moment rate function / 4-4-1 Polarity for focal mechanisms / 4-4-8 Seismic microzoning maps 4) Plan on the tsunami exercise 5) Report on the 2nd remote activities
Oct	8	Fri	23	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) "Implementation of the exercise of the "emergency information issuance to the DGPC" or to the "public"" ***(Note: The exact day and the time of the drill should be considered further.***), 3) the draft report	23	15:00-16:00 Talk with CATAC on the cooperation between CATAC and MARN
Oct	11	Mon	24	15:00-16:00 Discussing the following agenda: 1) the progress of the target shown in the previous meeting, 2) the revised draft report	24	15:00-16:00 Discussing the following agenda: 1) Draft minutes of the virtual meeting held on 06Oct21, 2) Draft minutes of the virtual meeting held on 08Oct21, 3) Remained actions to achieve the targets: 3-1) Cooperation with CATAC, 3-2) Tsunami simulation exercise to be held together with DGPC, 3-3) Emergency procedures and the daily check list for the shift officers, 3-4) Equipment procurement, 3-5) Others 4) Draft report on the 2nd remote activities 5) AOB (the time to explain the report to the DG of MARN)
Oct	13	Wed	25	15:00-16:00 Discussing the following agenda: 1) the report, 2) the time to explain the report to the DG of MARN	25	15:00-16:00 Talk with DGPC on the plan of the tsunami simulation exercise to be held on 05Nov21
Oct	15	Fri	26	15:00-15:30 Explaining the report to the DG of MARN (***Note: The exact day and the time should be discussed further.***) 15:30-16:00 Reviewing and checking the remained issue and the next visit activity plan 16:00-17:00 Explaining the report and discussing it with JICA (***Note: The exact day and the time should be discussed further.***)	26	15:00-16:00 Discussing the following agenda: 1) Draft report on the 2nd remote activities, 2) Reviewing and checking the remained issue and the next visit activity plan 16:30-17:30 Explaining the report and discussing it with JICA (Note: The date of explaining the report to the DG of MARN was 20th of October.)

付録 3 第二次国内遠隔活動で収集した文書類

目標	MARNが提供してくれた資料
要素 a:観測、分析、及び監視システム	
分類1: 地震津波監視	
1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	1.Tsunami_Drills_issue (20Aug21) 2. Documento_Mensajería_Tsunamis_LMixco2021(1) (30Aug21) 3. TsunamiProtocol (20Sep2) 4. Answer to the Question 2_ made by Prof Mori (29Sep21) 5. CheckList 2.0 (06Oct21)
1-1-c-1 津波監視手引書	
1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	
1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立	
1-2-f-4 異常地震活動対応標準手順：確立	1. Earthquakes Protocol (13Sep21) 2. Replicas_seiscomp_nicaragua_evento_Mw64 (29Sep21) 3. Magnitud del sismo del 10 de octubre 1986 (11Oct21)
4-4-e 震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入	1. 2021-08-25-pregunstas-mori (23Aug21)
分類2: CMT及びMw監視	
1-1-b 発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	1. Performance CMT-Tool_ISOLA-12May_event (23Aug21) 2. Performance CMT-Tool-22Sept_Nicaragua_event_stations_used (22Sep21)
1-2-a CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	
4-2 地震波形を用いた解析による震源断層の滑り量分布の把握	
4-3モーメントレート関数表示機能（震源時間関数の把握）	
4-4-a 地震波初動解析による発震機構把握	
分類3:津波対応	
1-2-d 津波警報解除手順書：作成	None
1-2-f-5 津波警報解除後の注意喚起情報：導入検討	None
1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	None
1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	None
要素b: CATACを含むインフラの利用	
分類4: 復旧及びバックアップ	
1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）	None
1-2-e バックアップシステムの適正化：対応	PPT_Mexico_PTWC_CATAC_DELL_HP (13Sep21)
分類5: CATACとの協力を含むデータ及び情報収集	
2 CATACとの情報の共有化の促進	None
4-1 GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）/ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定	1. GPS type and feature as of 28Sep21filled by Douglas (29Sep21)
スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW）開発	None
要素c: DGPCを含むMARNからの情報の利用者との意思疎通	
分類6: DGPCとの協力を含む防災のための津波警報の発信	
1-2-f-3 e-mailの公式利用、FAX点検の日課への導入：確立	None
3 DGPCの津波警報利用：適切化	1. Drill Proposal (06Oct21)
要素d: 監視担当者の対応（人材育成）	
分類7: 自主研鑽	
1-1-c-2 津波監視現業体制での技術レベル：維持・改善研修体制確立	1. Punteo_reunión_7sep2021_LMixco_observaciones-ingles (08Sep21) Punteo_reunión_7sep2021_LMixco_observaciones-ingles (reviewed by MORI) (08Sep21)
1-2-f-2 MARNガイドブック：確立	
1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討	1. Boletin Mensual de Actividad Sísmica - Enero2021 (30Aug21) 2. Boletin Mensual de Actividad Sísmica - julio 2020 (30Aug21) 3. Boletin Mensual de Actividad Sísmica - Marzo 2021 (30Aug21)
要素e: 機材	
機材調達	1. Cotizacion_Workstation_Tower7920_DELL (25Aug2) 2. MARN_Quote 12492635_Licencia Perpetua Individual de MATLAB (30Aug21() 3. PPT_Mexico_PTWC_CATAC_DELL_HP (13Sep21) 4. Cotizacion_Workstation_HP Z8 G4 (13Sep21) 5. Cotizacion_Workstation_Tower7920_DELL2 (13Sep21) 6. Marn-Procurement as of 06Sep21ver4 (revised 13Sep21) (13Sep21)

付録 4 第一次国内遠隔活動で収集した文書類

Priority in 1st activity	Target With priority 1&2: to be achieved as close as possible in the 1st acitivity With priority 3: to be handled in the 1st activity With priority 4: N/A in the 1st activity	Documents provided by MARN (partially collected by the Expert)
1	Target 1	Target 1
1	1) Verified the latest status of the technologies, the materials, or the s	
1	a) **The proper & stable judgement** on **generation of tsunami** (**Timing,** within 10 min. **Accuracy,** kept at the enough level)	tabla_twitter
1	b) **The CMT analysis in the practical monitoring task** to get focal mechanism and Mw	Performance CMT-Tool-12May
2	c) Other technologies, materials or systems	
2	c-1) **Tsunami Monitoring Manual**	1. Tsunami Protocol (IAM-MFN-PA-03 PRotocolo de actuación por amenaza de tsunami en El Salvador rev 1 18nov2019) 2. Tsunami Protocol Word version (IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019)
1	2) Verified the actions on some issues that were left in Phase 1 to be t	
1	a) Introduction of **GFDB** based on the local seismic velocity structure to **cover the events under M6.5 in CMT**	Performance CMT-Tool-12May
1	b) Introduction of **auto-filling-function** and **elaboration of depth handling** in **the tsunami database**	Presentation_LMixco26-04-21 (ppt file; the "development of the new web page where seismic events are automatically placed in real time")
1	c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network	estadisticas-funcionamiento-estaciones-V3
1	d) Establishment of tsunami warning **cancellation procedures** (Target 1-1 c-1) including DGPC	1. recopilacion-acciones-sismos-8.1-mexico 2. 8sep17_ChiapasMexico_Marigrams_ITIC
3	f) Other actions	
3	f-1) Establishment of the **Tsunami Monitoring materials** (Targets 1-1 c-1 & 1-2 d)	By the Tsunami Protocol (IAM-MFN-PA-03 PRotocolo de actuación por amenaza de tsunami en El Salvador rev 1 18nov2019) and the Tsunami Protocol Word version (IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019)
3	f-2) Establishment of the **MARN guidebook** to make DGPC and the people properly use the information sent from MARN	1. Presentation_LMixco26-04-21 (ppt file; "improvement of the panel that sends information for the social network") 2. Guia de sismos y tsunamis 2017 half size 3. guia-de-sismos-y-tsunamis-2017 https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/ Guía de sismos y tsunamis 2017 | CIDOC Virtual<https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/>
3	f-4) Establishment of **the standard procedures** that handle any **abnormal seismic activities**	Protocol for the seismic activity (IAM-MFN-PA-08 Actuacion por Amenaza de Sismos en El Salvador 2021)
1	Target 2	
1	Promoted DGOA to share any information with **CATAC**	1. CATAC tsunami exercise held on 11Nov20 (Ejercicio Regional CATAC_Pacwave) 2. Technical explanation of the CATAC tsunami drill held in 11Nov20 (Simulacro-CATAC-TSUNAMI-CA-20) 3. Comments from MARN on the CATAC tsunami drill held in 11Nov20 (Comentarios sobre simulacro) 4. LOG OF CATAC_DRILL_11-11-2020 5. Regional Drill, CATAC_Pacwave, by CATAC translated from Spanish 6. Emails on seismic activity sent from CATAC (ex. CATAC-INETER_ M=4.2, 58 Km al suroeste de Pochomil, Nicaragua)
1	Target 3	
1	Reinforced **protocols and procedures on tsunami threat** - in use by MARN and **DGPC** (Targets 1-1 c-1, 2 d, and 2 f-1)	1. local leaders interview report 2. Presentation_LMixco26-04-21 3. webinar_DGPC_report.
3	Target 4	
3	Established **the guideline for introduction of the additional technologies** that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance	
3	1) Use of the real time data of the **GPS** stations in the system in order to get **accurate Mw earlier through observing W-phase** with the data	Continuous-gps-station-ElSalvador-2021
3	2) Grasping the **distribution of amount of slips on the seismic source fault surface** by analyzing the seismic waves	1. Presentation_LMixco23-04-21 (ppt file; ISOLA CMT software) 2. ISOLA CMT manual (ISOLA_bookchapter_English) 3. b_installation
3	3) **Making displaying moment rate function** (or source time function) to understand the actual seismic magnitude earlier	Ibid.
4	4) Any other technologies	
4	Initial motion analysis for grasping **focal mechanisms**	Ibid.
4	Consideration on the guideline for updating **the seismic microzoning maps** of El Salvador	PPT_IDB_Project
1	Equipment	
1	Equipment procurement	1. Marn-Procurement-28May2021_LMixco

付録 5「業務の課題と改善の方向性についての DGOA との協議」を踏まえた「DGOA 担当職員と定める技術移転・研修計画」の例

例 1　目標 1-1-a (作業中)

Tentative

Draft of the Plan on the technology transfer & the training about "Proper and stable judgement on generation of tsunami" (Target 1-1-a)

Prepared by the Expert on 25Aug21

1. Detail of the target
Target 1-1-a: Verified the latest status of the "proper & stable judgement on generation of tsunami" established in Phase 1
Criterion: Its issuance timing should be within 10 min with sufficient accuracy level

2. Actions needed to achieve it

Legend for the pointed column
Ocher-color items: to need consideration of the Expert
Green-color items: to need actions conducted by MARN
Blue-color items: to need Meetings or actions conducted by both
No-color items: to be wrapped up

Actions	Target
Action to be taken MARN = to provide the Expert with any documents/data	
a) Tsunami procedures used by the shift staff	1-1 a 1-2 f-3
b) Data for checking the latest status of "the timing" & "the accuracy"	1-1-a
f) the current enhanced tsunami database showing the partition of depth, region, and magnitude.	1-1 a
Action to be taken MARN = to implement the analysis/review/check on	
m) MARN will introduce the automatic judgement, whether the event should be handled or not, function into the monitoring system in order to resolve the issue on the maximum 30 minutes lapse for the preliminary message issuance.	1-1 a

3. Status at the start day of the 2nd remote activity
"MARN Actions a, f, and m" are being considered by MARN. On the other hand, "MARN Action b" has been done; and Expert has analysed the data. The results are as follows:
They are verified as shown below but with some challenges:
1) Issuance timing of the final messages related to tsunami warning
- It has been shortened by several minutes or improved further as expected, probably because the remained actions[1] had been conducted accordingly.
- Namely, the time elapsed was between 9.5 & 21.2 min in 2017 and has been between is 8.0 & 17.4 min from 2019 to 2021. See the below list, which expresses with minutes and seconds, and the below Figure 3 that shows the progress of improvement in El Salvador through comparing with that in Japan during recent 60 years.
2) Challenges on the final messages

[1] The improvement comes mainly from the introduction of the automatic filling function.

- Those emergency messages like the "final messages" must be steadily issued because they are sometimes surely related to save lives. The stable issuance also cultivates reliability to the MARN performance in the public.
- Therefore. the maximum issuance timing should be shortened as much as possible. The Expert should take care of the maximum, 27.0 min in the period of 2019 - 2021, further, even though the size of the event was M4.4 that was not related to tsunami warning.

Time elapsed M>=4.0		Phase 1 2014	2015	2016	2017	2019	2020	2021	Phase 2 Evaluation
Preliminary	Average	5:30			5:49	4:32	5:34	5:08	Kept
	Maximum	07:39 M4.2			09:00 M8.0		10:14 M4.2		Kept
Final	Average	20:13 +/- 7:29 (12:44 - 27:42)			15:20 +/- 05:52 (09:28 - 21:12)	10:45 +/- 01:47 (08:58 - 12:32)	13:57 +/- 03:26 (10:31 - 17:23)	12:44 +/- 02:47 (09:57 - 15:31)	Improved
	Maximum	40:14 M4.2			35:43 M5.3		27:59 M4.4		Improved

3) Issuance timing of the preliminary messages
- It has been kept at the standard level.
- Namely, the time elapsed is around 5.8 min in 2017, and has been around 4.5~5.1 min from 2019 to 2021. But they are in the similar status, 5.5 min, of 2015. See the above list, which expresses with minutes and seconds.
- The maximum is 30 minutes. The event was small magnitude, so the monitoring staff should have judged whether the event should be handled or not, because MARN has the norm that only felt events should be handled. The issue could be resolved by introducing the automatic judgement function into the monitoring system. MARN will do so. -> MARN Action m

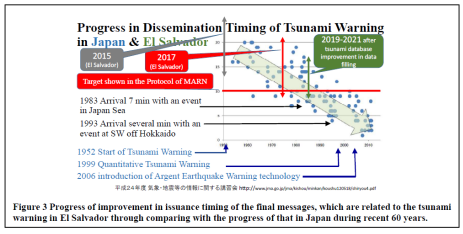
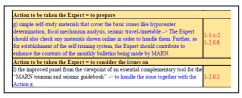


Figure 3 Progress of improvement in issuance timing of the final messages, which are related to the tsunami warning in El Salvador through comparing with the progress of that in Japan during recent 60 years.

4) Challenges on the preliminary messages[i]
- The messages must also be steadily issued because they are surely related to the final messages.
- The average could be shortened with any support from EEW function or other technologies in the future.
- Further, we should consider how to shorten the timing of issuance of preliminary messages. -> MARN is handling the panel shown in the right column and the next page column[ii]. It is being developed to improve the monitoring

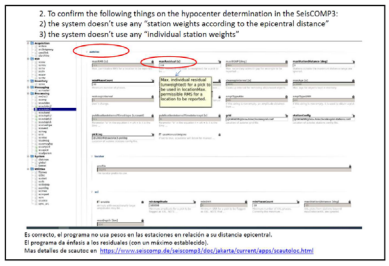


actions by increasing reliability and shortening the "elapsed time". As one of its development procedures, MARN has conducted the monitoring drill (See the ppt file "Tsunami_Drills_issue" provided from MARN on 21Aug21 at 06:57JST) using this new technology. The development will be completed by the end of this year. Further MARN has made the manual how to use it. (Note: Expert comment: we have many panels there without clarified instructions when each panel should be handled. So, conducting drills and practices are surely essential to use it properly.)

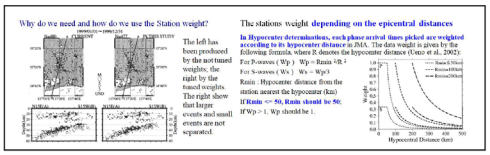
5) Accuracy of the information in the final message
- It has been kept at the best level.
- Namely, the root mean square (RMS) of residuals (Res) between observation times and calculation times of the information in the final messages is around 0.44 sec in 2017 and is around 0.53 sec from 2019 to 2021. See the below list. They are kept in the improved level, because those around 2014 – 2015 show around 1.00 sec.

RMS_Res (sec) M>=4.0		Phase 1 2014	2015	2016	2017	2019	2020	2021	Phase 2 Evaluation
Preliminary	Average					0.73	0.72	0.75	
	Maximum					1.95 M4.0			
Final	Average	1.09 - 1.66	0.91 - 0.97	0.38 - 0.61	0.39 - 0.49	0.53	0.57	0.46	Kept
	Maximum	2.6 M4.2			1.7 M6.1	1.23 M4.2			Kept

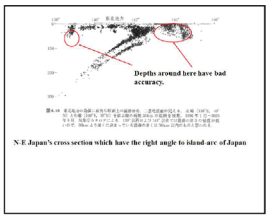
6) Challenges on the accuracy
The hypocenter determination in the SeisCOMP3 doesn't use "station weights according to the epicentral distance" and "individual station weights". But it uses RMS to evaluate the data to be used.
(Note: MARN has provided the right figure showing where we can understand the issues. The figure shows *"Max. individual residual (unweighted) for a pick to be used in locationMax. permissible RMS for a location to be reported." And "That is correct, the program does not use weights at the stations in relation to their epicentral distance. The program emphasizes residuals (with an established*



maximum). More details of scautoc in
https://www.seiscomp.de/seiscomp3/doc/jakarta/current/apps/scautoloc.html")
Therefore, Expert should check if there is any separation in locations of large events and moderate/small ones that are obtained from automatic calculation.



In addition, we should know that the below issue, but it's not easy to handle it well.



4. Further actions
4-1 To consider the challenges mentioned above and to propose how to do from now. Particularly, as for the panel, to clarify the relation between the current "tsunami handling procedures" and the panel handling procedures.
4-2 To get the documents or the implementation and to consider if additional actions of Expert are needed.
4-3 To consider if any additional technology transfer is needed
4-4 To consider if any additional training is needed
4-5 To fix this document

Period

[i] This note is for the page 2: MARN mentioned on 06Jul21 as follows: In the case of earthquakes greater than 7.0 off our coasts, the coasts of Guatemala and Nicaragua, it has been decided to include the first estimate of arrival times in a sectoring manner in the country; that is, an estimate for the west, center and east coast; which is extracted from the pre-calculated arrival times in the new Tsunami database. (Note: For a better understanding, it will be much easier to explain it to the Expert with doing an exercise, which MARN could do later in future meetings that we will have, about how the panel (or the auto-filling function) works.)

[ii] This note is for the page 2: The panel figure has the following explanation about it, "This document shows all the new functions that should exist in the update of the seismology panel for automatic sending of messages about the occurrence of earthquakes; where on this occasion, it is intended to include the part of tsunamis and its derivative products, as well as information on the level of impact on the threatened population.
Before the maps took 2 and a half minutes, and now only 23 seconds, this will help give the technician time to do other things during the seismic event
One of the features of this new panel is that we will guarantee a reduction in the creation time of messages and maps, since we use other scripts and computer libraries that speed up the process."

例 2　目標 1-2-b 及び目標 1-1-c-1（作業中）

Target 1-2-b Plan for MARN as of 20Oct21

Under preparation

Draft of the Plan on the technology transfer & the training about "Auto-filling-function and elaboration of depth handling" (Target 1-2-b)

Prepared by the Expert on 20Oct21

1. Exact Target
   Target 1-2-b: Verified the latest status of the "Auto-filling-function and elaboration of depth handling" established in Phase 1
2. Purpose (to be filled)
3. Actions needed are finished as shown in the right-bottom figure.

Target 1
2) Verified the actions on some issues that were left in Phase 1 to be taken later on
b) Introduction of **auto-filling-function** and **elaboration of depth handling** in the **tsunami** database — To be wraped up (Action n)

4. Documents provided a) Tsunami_Drills_issue, b) Documento_Mensajeria_Tsunamis_LMixco2021(1)
5. Status at the start day of the 2nd remote activity
   b) Introduction of auto-filling-function and elaboration of depth handling in the tsunami database They have been achieved

Legend for the pointed column
Ocher-color items: **to need consideration of the Expert**
Green-color items: **to need action conducted by MARN**
Blue-color items: **to need Meetings or actions conducted by both**
No-color item: to be wrapped up

Target
Action to be taken the Expert = to consider the issues on
n) the current plan on the introduction of the automatic filling function into tsunami monitoring task (Established the improvement of the database accordingly) — 1-2 b

Improvement of the database in the Tsunami scenarios
MARN currently has 561 scenarios modeled:
1) M: from 7.0 to 8.0 in 0.1 steps (11 scenarios?)
2) Depth: three depth values for each of the 27 selected seismic sources (3x27=81 scenarios)
3) Wave height: forecasted at 71 points along the coast
4) Results: tabulated at the municipality level to simplify the results (Note: a municipality can have several forecast points - where the highest value is taken)
5) Wave height values: associated in ranges, <0.3 m, 0.3 - 1.0 m, 1.0 - 3.0 m, and > 3.0 m
6) Earthquake with tsunamigenic characteristics: there is a module of the information dissemination platform that compares the data obtained from Seiscomp3 and the one drawn from the database scenario that most closely resembles the earthquake that has occurred.

(Note: the above was translated into English by the Expert with Google translation software from the email in Spanish sent from MARN.)

2. Current status of new seismic events in real time webpage

- The objective of this new page is to have a query-type page that can be accessed from a computer or mobile device, and show the occurrence of earthquakes automatically that our seismic data acquisition software (SeiscomP3) provides us in a few seconds after an event.
- This tool would greatly help to remove the pressure from the seismology technician to issue seismic information quickly, and in turn align with the nature of the seismic phenomenon, since it can be within a seismic crisis type series or swarm, or well the occurrence of multiple aftershocks after a main earthquake; which represents in terms of time a fatigue or tired situation for the seismology technician to be sending information successively in a short time.

as shown in the below explanations[i].
The Expert would verify the status of the auto-filling-function **by watching actual performance** and the status of elaboration of depth handling in the tsunami database by any document explaining the database.[ii]

5. Further actions
To fix this document　　**Period**

[i] In the Excel document prepared by Griselda, the characteristics of the tsunamigenic zones are tabulated; and indeed, there are 561 scenarios.
[ii] The auto-filling function is already working (at the script level) and MARN has been testing it with scenarios with all the technicians. At the script level it means that the technician executes the individual codes and not within a panel. MARN is still working on developing the panels, which will further facilitate the generation of messages to address tsunami threats.

1 / 1

Target 1-1-c-1　Plan for MARN as of 30Aug21

Under preparation

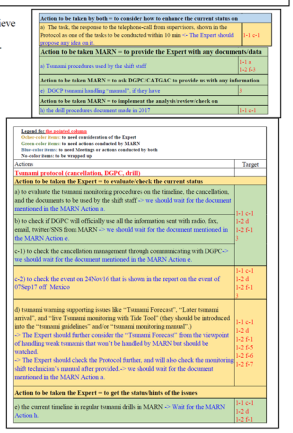
Draft of the Plan on the technology transfer & the training about "Tsunami Monitoring Manual" (Target 1-1-c-1)

Prepared by the Expert on 30Aug21

1. Exact Target
   Target 1-1-c-1: Verified the latest status of the "Tsunami Monitoring Manual" established in Phase 1
2. Purpose
   The manual has the purpose shown in the right column and can also be called guideline.

Purpose: **to establish the detail procedures with timeline during 30 minutes after occurrence of a large earthquake** under the condition of having the authorized protocol for handling tsunami and seismic activity, and **to inform DGPC and the people, as early in advance as possible**, about the occurrence of tsunamis that may cause disasters around the marine coastal zone.

3. Actions needed to achieve it
   See the right and right-bottom figures.



1 / 2

4. Status at the start day of the 2nd remote activity
The actions to be finished are on-going.
- The guideline, which is shown in the right below figure and is made in the Phase 1, is not used in MARN now. Instead, MARN is using another material.
- The Expert should thus get the MARN's material to be provided by MARN. Then the below issues should be checked:
  1) The manual / guideline should describe the items such as "How to select Magnitude & Hypocenter" and "How to get Mw from CMT analysis".
  2) It should consider the "ANNEX 2 TABLES OF ACTIONS AND RESPONSIBILITIES" in the Protocol.
  3) It should describe the first 10 min actions in the same way for all scenarios of local events.
  4) It should handle the action, "Atender telefonos para brindar informacion preliminar" in the Protocol properly.

- As for the tsunami warning drill, where the manual / guideline should be referred to, its current status is as follows:
  1) It is implemented roughly once for two months. But last year it was done only once at the CATAC drill.
  2) The "drill procedures document" made in 2017 exists, but is not referred to, when MARN implements a drill. MARN will review the document.
  3) The timeline of the drills is not so different from the one in the drill lead by CATAC last year.

5. Further actions
5-1 To fix this document

Period

以上

第三次国内遠隔業務結果報告書
（エルサルバドル国　地震・津波情報の分析能力強化 Phase 2、2021～2023 年）

令和 4 年 3 月 14 日

JMBSC 森　滋男

1. 作業日程実績

当初のワークプランに従い、一部手直しして作業を実施した。その作業経過は、**付録２**に示した。なお、プロジェクト全体の日程概要を**付録１**に示した。

2. 成果

2.1 ワークプラン[1] に示した作業目標と作業手順

下欄に目標を示し、下の**図１**と**図２**とに作業手順を示した。これらの図に示すように、第三次国内遠隔活動は、作業目標のうち、成果２及び３並びに機材調達に主として取り組むこととしていた。

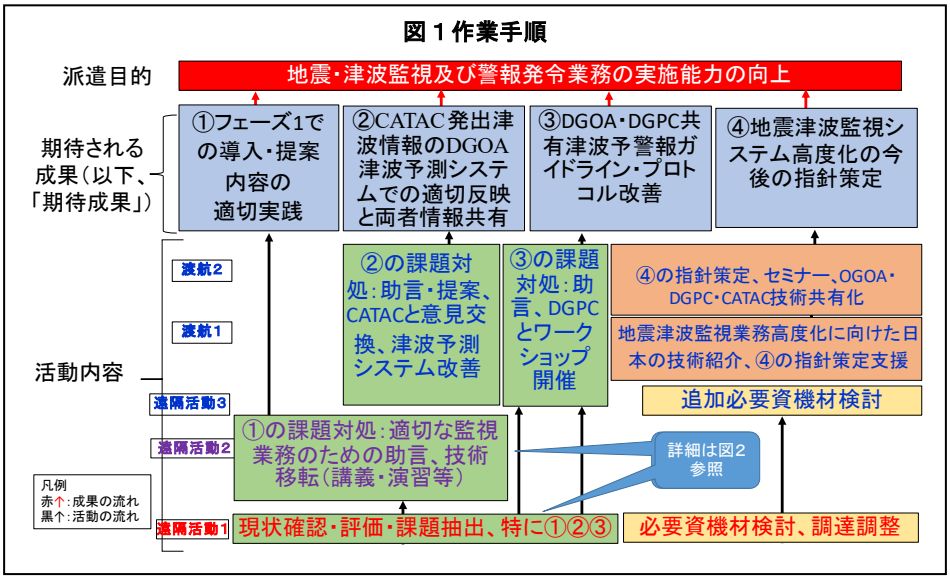
上位目標

MARN の DGOA をカウンターパート（以下、「C/P」）機関とし、地震・津波監視及び警報発令業務の実施能力の向上

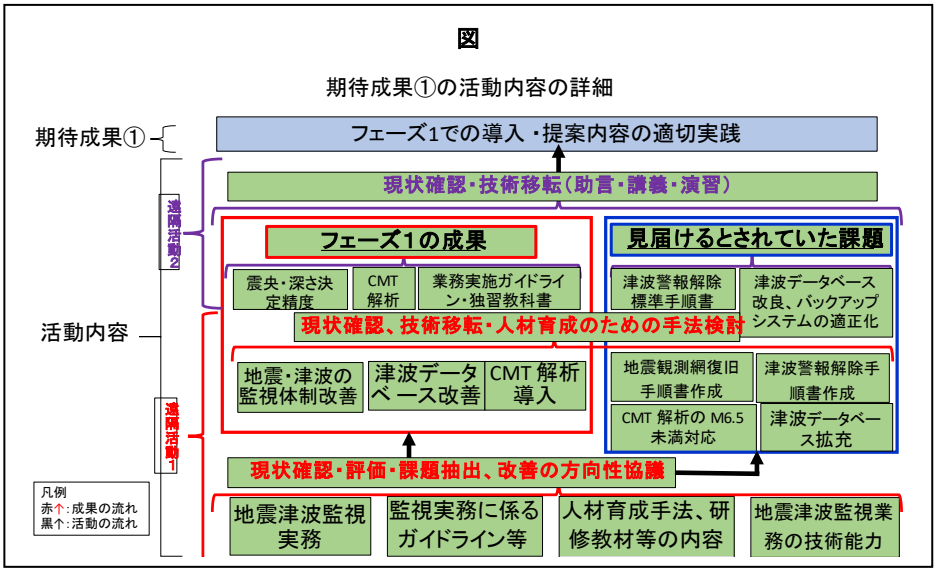
目標とする成果２

成果１：フェーズ1で導入・提案した内容が適切に実践される。
成果２：CATACから発出される津波情報がDGOAの津波予測システムに適切に反映され、両者間の情報共有が促進される。
成果３：DGOAがDGPCと共有する津波予警報のためのガイドライン・プロトコルが改善される。
成果４：地震・津波監視システムの高度化に資する技術が紹介され、システムの高度化に向けた今後の指針が定まる。

図１作業手順



[1] Work Plan of the Short-term Expert Dispatch to MARN in El Salvador as of 12Jan22



2.2 第三次国内遠隔活動における目標の詳細と達成状況

第三次国内遠隔活動で扱うべき「目標（成果）」について、ワークプランでは次の欄に示したように述べている。

目標（成果） 1 について、

1）第２次現地業務で実施したフェーズ１に係る地震・津波監視業務改善のための助言、及び職員に対しての研修を継続する。また、適宜、職員へのアンケート、理解度試験等を実施し、DGOA 担当職員とともに研修内容・教材等の見直しを図る。

2）自己研鑽の仕組み構築として、地震津波監視担当グループが毎月作成する地震月報の作業を活用。その際、自習教科書や MARN のホームページで公開されている MARN ガイドブックを利用。

3）地震月報作成作業の改善に向けて、地震活動を分析するためのいくつかのツールの講義や演習実施。

目標（成果） 2 について、

4）DGOA と合意した内容をもとに、CATAC から発出される津波情報を津波予測システムに適切に反映し、両者間の情報共有を促進する（第 1・2 次現地業務へ継続）。想定される活動は次の通り:

ア）CATAC から発出される津波情報が DGOA の津波予測システムに適切に反映されるための助言・提案を行う。

イ）DGOA と CATAC 間のシステムのバックアップ機能を構築するための助言・提案を行う。

ウ）DGOA と CATAC 間の情報共有促進に資する助言を行い、DGOA 担当職員とともに、適宜、CATAC と意見交換を行う。

エ）CATAC とともに、津波警報内容の理解促進と連携強化を目的とした共同津波警報訓練、及び合同ワークショップを立案し、実施する。

目標（成果）3 について、

5）DGOA と合意した内容をもとに、DGPC と共有する津波予警報ガイドライン・プロトコルを改善する（第 1・2 次現地業務へ継続）。想定される活動は次の通り:

ア）DGOA が DGPC と共有する現状の津波予警報ガイドライン・プロトコルを整理し、課題に対して助言を行う。

イ）津波予警報ガイドライン・プロトコルに、CATAC から発出される津波情報を適切に反映する。

ウ）DGOA と DGPC 間の情報共有促進に資する助言を行い、DGOA 担当職員とともに、適宜、DGPC と意見交換を行う。

エ）DGPC とともに、津波警報内容の理解促進と連携強化を目的とした共同津波警報訓練、及び合同ワークショップを立案し、実施する。

機材調達

追加で必要となる資機材の有無を確認し、必要な場合は、JICA エルサルバドル事務所に相談・提案する。

これらについて、これまでの達成状況を踏まえつつ、遠隔活動を実施し、第三次の活動の到達状況を**下の表１**に示した。この表は、目標（成果）を「エルサルバドルにおける地震・津波情報の分析能力強化」に関わる５つの要素（**右欄**にある４つの要素（Elements）及び機材調達）で分類し、さらに、日々の監視業務に関連する技術事項で細分類し、個々の成果につい

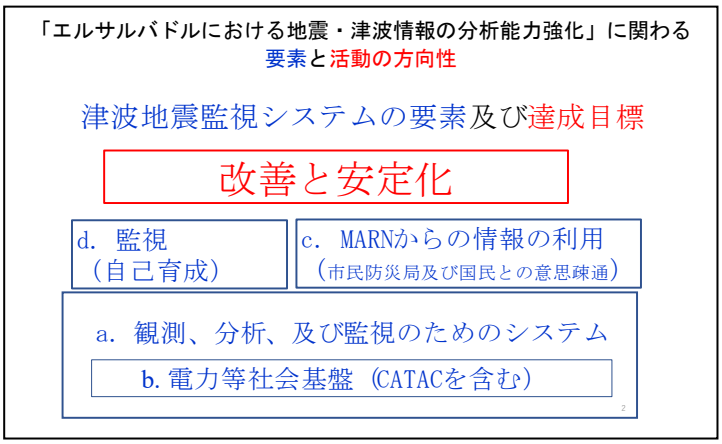


表１ 第三次国内懸隔活動で取り組んだ目標（達成状況） **次頁へ続く**

目標とする成果の型	監視			広報		遠隔活動での成果達成状況（注：「計画」とは「業務の課題と改善の方向性についてのDGOAとの協議」を踏まえた「DGOA担当職員と定める技術移転・研修計画」）
目標とした成果（改善させる機能） 津波警報システムを構成する要素(Elwment)及び各要素の基本機能に応じた分類	業務	手引書	情報処理システム	市民防災局	一般国民	
要素 a:観測、分析、及び監視システム						
分類1: 地震津波監視						計画策定（第312回会議から）
1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	○					計画策定（第204回会議から）
1-1-c-1 津波監視手引書		○				計画策定（第206回会議から）
1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	○					計画策定（第214回会議から）
1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立		○				作業中
1-2-f-4 異常地震活動対応標準手順：確立		○				活動結果の整理中
4-4-e 震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入			○			活動結果の整理中
分類2: CMT及びMw監視						計画策定（第326回会議から）
1-1-b 発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	○					計画策定中（第205回会議）
1-2-a CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	○					計画策定中（第207回会議）
4-2 地震波形を用いた解析による震源断層の滑り量分布の把握			○			機材調達注視中
4-3モーメントレート関数表示機能（震源時間関数の把握）			○			機材調達注視中
4-4-a 地震波初動解析による発震機構把握			○			機材調達注視中
分類3:津波対応						計画策定（第317回会議から）
1-2-d 津波警報解除手順書：作成		○		○		作業中
1-2-f-5 津波警報解除後の注意喚起情報：導入検討	○	○		○	○	作業中
1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	○	○				作業中
1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	○	○	○			活動結果の整理中
要素b: CATACを含む電力等社会基盤						
分類4: 復旧及びバックアップ						MARN対応等注視中
1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）		○	○			機材調達注視中
1-2-e バックアップシステムの適正化：対応			○			MARN対応注視中
分類5: CATACとの協力を含むデータ及び情報収集						計画策定（第326回会議から）
2 CATACとの情報の共有化の促進	○	○	○			作業中
4-1 GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）/ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定			○			調査中
スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW）開発（**EWBS**）						注視中
要素c: MARNからの情報の利用（市民防災局、国民）						
分類6: DGPCとの協力を含む防災のための津波警報の発信						計画策定（第317回会議から）
1-2-f-3 e-mailの公式利用、FAX点検の日課への導入：確立		○	○	○		計画策定（第206回会議から）
3 DGPCの津波警報利用：適切化		○		○		作業中

て相互の関連が明確になるように努めたものである。

表１ （続き）第三次国内懸隔活動で取り組んだ目標（達成状況）

要素d: 監視（人材育成）						
分類7: 自主研鑽						計画策定（第319回会議から）
1-1-c-2 津波監視現業体制での技術レベル：維持・改善研修体制確立		○	○			作業中
1-2-f-2 MARNガイドブック：確立		○		○	○	作業中
1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討			○			作業中
要素e: 機材						
機材調達						作業中

2.3 第三次国内遠隔活動におけるその他の目標の達成状況

他の目標の達成状況は**下の表２**に整理した。進捗はなかった。

表２ その他の目標（達成状況）

目標とする成果の型	監視			広報		
来年度対応としていた「目標とした成果（改善させる機能）」	業務	手引書	情報処理システム	市民防災局	一般国民	遠隔活動での成果達成状況
4-4-b マグニチュード過小評価手法 / 日本の地震・津波監視業務に関し、過去事象の教訓・課題・改善共有			○			今後対処
4-4-c 内陸地震活動の震源分布推定の精度向上のためのDD手法			○			
4-4-d 複数地震同時発生への自動震源解析の信頼性向上のためのIPF手法			○			
4-4-f 津波警報の精緻化のための海岸を分割した警報発表手法			○			
4-4-g 津波観測測器がない海岸のボランティアによる監視安全・効率化			○			
4-4-h エルサルバドルの地震マイクロゾーニング地図の更新のためのガイドラインの検討			○			調査中
米州開発銀行（Inter-American Development Bank, IDB)による地震危険度評価プロジェクト						作業中
他の国際協力機関の関連活動の状況把握						
ユネスコによるTsunami Readyプロジェクト						作業中

3. 成果達成状況の詳細

ここでは、要素・分類順に個々の目標（想定している成果）の達成状況を説明する。なお、以下で用いている計画とは、「仕様書」にある「業務の課題と改善の方向性についてのDGOA との協議」を踏まえた「DGOA 担当職員と定める技術移転・研修計画」のこと である。その作成例は、**付録６**に示した。

3.1 要素 a: 観測、分析、及び監視のためのシステム

分類 1: 地震津波監視

分類1: 地震津波監視	計画策定（第312回会議から）
1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	計画策定（第204回会議から）
1-1-c-1 津波監視手引書	計画策定（第206回会議から）
1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	計画策定（第214回会議から）
1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立	作業中
1-2-f-4 異常地震活動対応標準手順：確立	活動結果の整理中
4-4-e 震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入	活動結果の整理中

達成状況: とりまとめ資料 Category 1に示した通り。

残された課題： とりまとめ資料 Category 1 及び Guideline（津波監視手引書）に示した通り。

分類 2: CMT 及び Mw 監視

分類2: CMT及びMw監視	計画策定（第326回会議から）
1-1-b 発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	計画策定中（第205回会議）
1-2-a CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	計画策定中（第207回会議）
4-2 地震波形を用いた解析による震源断層の滑り量分布の把握	機材調達注視中
4-3モーメントレート関数表示機能（震源時間関数の把握）	機材調達注視中
4-4-a 地震波初動解析による発震機構把握	機材調達注視中

達成状況

右の表の通りであり、来年実施する予定であった 3 つの項目についても、調達機材に含まれている ISOLA の機能を活用するという方向で作業に着手している。3 月中の調達リストに示した ISOLA の機能を**下の欄**に示した：

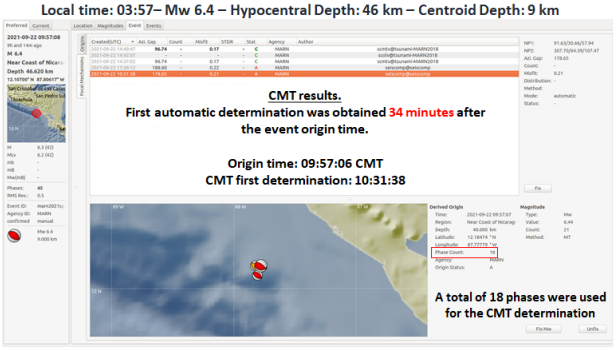
次の機能を有する：
1) 地震の規模をより早期に正確に把握するためのモーメントレート関数の表示
2) 有限断層領域でのスリップ分布取得
3) GFDBの柔軟な計算と、CMTの決定に関する詳細な分析
4) 極性入力で発震機構解析
注：リアルタイム計算ではない。

残された課題

目標 **1-1-b** については、「計画」策定中であるが、「自動処理に時間を要した」ことの検討がある。即ち、**右の欄**にあるようにニカラグアとの境界沖合の 9 月 22 日の地震について、自動処理で CMT 結果を得るのに 34 分を要した。この理由の検討の結果、この原因は観測波形と計算波形の整合性の評価基準にあることが推測され、次の対応をとることとした：MARN は、深さの検索範囲を減らすことで最適な CMT 結果を得るためにプロセスを短縮。このため、自動 CMT 解析を実施する領域として広域領域(Z3)を除外。Z3 の CMT と Mw は、外国の機関によって公開されたものを利用。

To get the reason why it took 34 minutes to obtain the CMT results as shown below.

Local time: 03:57– Mw 6.4 – Hypocentral Depth: 46 km – Centroid Depth: 9 km



分類 3:津波対応

分類3:津波対応	計画策定（第317回会議から）
1-2-d 津波警報解除手順書：作成	作業中
1-2-f-5 津波警報解除後の注意喚起情報：導入検討	作業中
1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	作業中
1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	活動結果の整理中

達成状況: とりまとめ資料 Category 3 に示した通り。

残された課題：とりまとめ資料 Category 3 に示した通り。

要素 b: CATAC を含むインフラの利用
分類 4: 復旧及びバックアップ

分類4: 復旧及びバックアップ	MARN対応等注視中
1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）	機材調達注視中
1-2-e バックアップシステムの適正化：対応	MARN対応注視中

達成状況
目標 1-2-c は、下の欄に示す新しいアプリケーションの調達で対応することとしている。一方、目標 1-2-e は、CATAC と電池の整備に関わっており、注視中。

c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network
The Platform project was once stopped but would restart soon. It would take care of the rapid recovery actions with the station network map. The Expert should continuously watch its progre from now.

- On the other hand, the rate of operation of the seismic network lookskept around 86% in rec years as shown in the below list.But it is 67% in 2020, if including the stations that are stopp for a long period. T he main causes of the long outage s come from "GPS clock" down a "repeater" outage.
- The Expert should consider whether we have any measures to fix the outage earlier like keeping spare equipment or 2) establishing the system to give us how to handle the issue lik showing any "priority".

Tipo de alimentación	2015 (%dias funcionado)	2016 (%dias funcionado)	2017 (%dias funcionado)	2018 (%dias funcionado)	2019 (%dias funcionado)	2020 (%dias funcionado)
Promedio general	65%	74%	83%	82%	76%	67%
total estaciones	46	45	45	47	48	55
Estaciones no consideradas para promedio corregido (marcadas en amarillo) – ver justificación en notas	7	4	3	4	9	13
Promedio corregido	74%	81%	85%	88%	86%	84%

Seismic station network Platform specified with the functional specifications
(Application for the development of software or graphic applications/dashboards)
To geterate computer applications with Seismic station network map on a screen (Platform) aimed at:
1) supporting monitoring officers to identify the status performance of the network at a glance,
2) urging them to take the rapid recovery actions with the station network map,
3) telling them how to do through showing the feature of the stations and the propirty of them.
Specifications: Draft of Specifications om making Platform applicatoins for Seismic Network Monitoring 16Feb22

In order to introduce the recovery procedures with the Platform to effectively maintain seismic observation network (Sub-target 1-2-c).
Namely, the Platform should be monitored by the officers in the monitoring shift, who should try to keep the performance level according to the criterion that the operational rate should be higher than 86% (*to be reviewed*) through
1) dispatching offcers to the station to fix the outage earlier with spare equipment (to be prepared beforehad)
2) handling the issue based on the "priority".
It would take 9 months for manufacturing.

分類 5: CATAC との協力を含むデータ及び情報収集

分類5: CATACとの協力を含むデータ及び情報収集	計画策定（第326回会議から）
2 CATACとの情報の共有化の促進	作業中
4-1 GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）/ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定	調査中
スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW)開発 (**EWBS**)	注視中

達成状況：

次の２つの文書、“**Draft minutes of the virtual meeting with CATAC held on 04Mar22ver2**” 及び and “**Memo for the talk via email as of 09Mar22ver2**”、が作成された。これらには、CATAC から提案された以下の項目があり、これらを CATAC と検討してきている。

項目 1 「地震・津波処理結果」をリアルタイムで交換すること

項目 2 地震発生後短時間で当該地震の震源とマグニチュードとを両機関で統一すること [2]

項目 3 音声や画像を直接やりとりする SNS サービスを利用すること

項目 4 CATAC と MARN の間に衛星インターネット接続を確立すること

項目 5 MARN が、CATAC のバックアップを可能性にすること

残された課題

上述の 2 文書に課題を整理してある。上記の項目 5 については、右の２つの表に示すように、MARN は CATAC になる条件をクリアすることを考慮する必要がある。

GPS の使用については、引き続き次のページリストの#1&#2 からリアルタイムデータを取得する方法を検討する必要がある。

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 changes	> 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 mins	**<30 mins**

	If MARN would take the function of the backup for CATAC, MARN might consider the below issues.
	Fulfillment of capacity requirements for ICG TSP
1	Access to real time data sources and capability to produce standardized seismic/sea level
	parameters
2	Appropriate historical database of earthquakes and tsunamis
3	Maintain or have access to benchmark, pre-calculated numerical model scenarios
4	Revise advisories in light of additional seismic and sea level data
5	Provide timely and effective tsunami advisories to respective NTWCs/TWFPs in CA
6	Provide products in globally standard formats Simplified Regional Formats in Spanish **(in English as well)**
7	**Disseminate tsunami forecast information** freely and timely to NTWCs/TWFPs **on**
	the GTS and Internet and all other possible means of communication
8	Adequate trained and experienced staff, utilities, and resources to operate
	functionally 24 hours per day, seven days per week (24/7)
9	Adequate infrastructure and back up facilities to continue operating during power
	cuts and national emergencies such as all critical equipment on 30min UPS,
	generator or alternative power backup (with 1 day of backup capability), all critical
	equipment operating in duplicate and all critical communications circuits with backup
10	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

[2] About unifying the parameter, MARN has mentioned that about 20 years ago, Nicaragua and El Salvador issued different magnitude independently that made confused the people. So, it might be better for us to consider the issue positively.

Expert should consider how to get real-time data from the stations #1 and #2.

Parámetros de estaciones GPS El Salvador (2018-2019-2020)

No.	COD-ID	Estation	Antenna Type	Receiver Type	How to get the data	Ref.	Sampling rate	Memory capacity in the receiver	Processing	Surveying type	positioning
1	LNUB	Las Nubes	TPSCR.G5	Topcon NetG3A	**Internet**	JICA	30 sec (1Hz can be used.)	15 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
2	ALAR	Lomas de Alarcón	TPSCR.G5	Topcon NetG3A	**Internet**	JICA	30 sec (1Hz can be used.)	15 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
3	ACAJ	Puerto de Acajutla	TRM41249.00	Trimble NetRS	**Internet**	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
4	SNJE	San José	TRM41249.00	Trimble NetRS	**Internet**	UW	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
5	CNR1	Centro Nacional de Registro	TRM41249.00,	Topcon GB1000	**Internet**	UW	30 sec (1Hz can be used.)	100 Mb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
6	SSSV	San Salvador	SEPCHOKE_B3E6	SEPT POLARX5	**Internet**	JPL	1Hz (resampling to 30 sec)		Real Time and post-processing	Static (kinematic can be used)	DGPS or Absolute
7	AIES	Aeropuerto Internacional El Salvador	TRM41249.00	Trimble NetRS	On site	UW	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
8	LALI	Puerto de La Libertad	TRM41249.00	Topcon GB1000	On site	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
9	SVCI	San Vicente	TPSCR.G5	Trimble NetRS	On site	JICA	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
10	VMIG	Volcán de San Miguel	TRM 57971-00	Trimble Net R9	On site	UW	30 sec (1Hz can be used.)	4 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
11	PATI	Patio de Finca Santa Isabel	TRM41249.00	Trimble R7	On site	MARN	30 sec (1Hz can be used.)	100 Mb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute
12	PMON	Piamonte	TRM41249.00,	Topcon GB1000	**Internet**	UW-UPM	30 sec (1Hz can be used.)	1 Gb	Post-Processing	Static (kinematic can be used)	DGPS or Absolute

注:CATAC は、現地時間 2020-03-10 08:00 頃に政府間海洋委員会(IOC)、ユネスコ、ICG/CARIBBEAN-EWS の支援のもとカリブ海を対象とした津波警報発表訓練「Caribe Wave 2022 exercise」を実施した。CATAC が発出し情報について、今後、CATAC 津波警報発表手順や時間経過を把握するため、分析が必要。

要素 c: DGPC を含む MARN からの情報の利用者との意思疎通

分類 6: DGPC との協力を含む防災のための津波警報の発信

分類6: DGPCとの協力を含む防災のための津波警報の発信	計画策定（第317回会議から）
1-2-f-3 e-mailの公式利用、FAX点検の日課への導入：確立	計画策定（第206回会議から）
3 DGPCの津波警報利用：適切化	作業中

達成状況：以下の活動をしてきた:

1) 05Nov21、DGPC と津波訓練を実施。その結果は、文書「**Result of tsunami exercise of DGPC and MARN on 05Nov21 as of 18Feb22**」に整理。次頁にはこの訓練のために準備した手順の２つのリストを参考として示した。

2) 22Jan22、MARN と DGPC はワークショップを共催。結果は「**Minutes of the workshop held on 25Jan22ver2**」に整理。

3) 22Feb22、地震以外を原因とする津波への対処方法を議論し、この種の津波の脅威への対応手順を強化するため、DGPC との遠隔会合を開催。結果は「**Draft minutes of the virtual meeting with DGPC held on 22Feb22ver2**」に整理。

4) 2022 年 3 月第 3 週目、監視作業における連絡手段の検査日課リストの利用テストを実施する予定。その手順は、「**Memo for conducting a trial use of the inspection list for DGPC as of 07Mar22**」および「**Inspection checklist on communication tools between DGPC and MARN as of 07Mar22**」に記載した。

注 1:地域の人々の津波警報への対応を監視する方法は、ワークショップでは議論されなかった。

注 2:訓練で用いた推定震度は、M7.9 を仮定したものではなく、M6.4 を仮定したものであった。訓練では、マグニチュードと震度の関係に対する常識感覚を養うため、訓練の想定に合わせた震度分布用いるのが望ましいと思われる。

Messages to be issued from MARN to DGPC in the tsunami simulation exercise on 05Nov21

Time of issuance	Actual	Type	Elapsed time from OT		Contents of Information (Controlled or Automatic)	Purpose of issuance	Description in the message (To be elaborated further)
			Virtual	Actual			
3:15		**Start message**		**0 min**	**Start of the exercise (C)**	**To inform the start of the exercise**	**The exercise start.**
3:17	1	Calm message	< 2 min	2 min	Felt, occurrence of earthquake (A)	To calm the pubic	Preliminary parameters of the earthquake felt in Salvadoran territory will be released shortly.
3:18	2	Preliminary message	< 3 min	3 min	Preliminary M and the epicenter location (A, C)	To tell how to consider the event (Local; 7.8 ~ high tsunami threat)	Seismic magnitude 7.8, off the coast of El Salvador; there is a high tsunami threat.
3:19			< 4 min	4 min			
3:27			< 5 min	5 min			
3:25	*3*	*Tsunami message*	*< 10 min*	*10 min*	*Judgement on the tsunami threat (A,C)*	*To tell if we should evacuate immediately*	*There is high tsunami threat to El Salvador. The waves will begin to reach El Salvador by 03:43 on 2021-11-05.*
3:26			*< 11 min*	*11 min*			
3:27			*< 12 min*	*12 min*			
3:30	*4*	*Updated message*	*< 15 min*	*15 min*	*Updated seismic parameter with the epicenter map with CMT/Mw (C)*	*To tell how to consider the event (7.9 ~ high tsunami threat)*	*Seismic magnitude 7.9, off the coast of El Salvador 110 km south of La Libertad. Depth 15 km. The waves could be greater than 3 meters along the entire Salvadoran coast.*
3:31			*< 16 min*	*16 min*			
3:32			*< 17 min*	*17 min*			
3:15 - 3:45		**Cancellation of the Exercise**		**Depend**	**Cancellation of the exercise due to any contingent issue (C)**	**To stop the exercise**	**The exercise should stop immediately.**
3:43		Tsunami message	< 35 min	28 - 30 min	Observation of tsunami (C)	To tell if we should evacuate further	Tsunami has been observed at La Libertad.
3:45	5	Cancellation message	2 hours	30 min	Judgement on the tsunami advisory cancellation (C)	To tell that we cancel the advisory	Earthquake 11/05/2021, 14:15 SV time, Salvadorian coast, Mag. 7.9, tsunami threat to El Salvador is cancelled. However, it is recommended to stay away from the beaches for several hours.
3:46		**End message**		**31 min**	**End of the exercise (C)**	**To inform the endt of the exercise**	**The exercise has been finished.**

残された課題：上記のドキュメントは、以下の4つの欄に示す課題が示されている。

Herramientas a utilizar en el ejercicio del 05Nov21

Time of issuance	Actual	Type	Elapsed time from OT	Tools for issuance to DGPC			
			Actual	radio ->	fax ->	SMS ->	SNS
3:15		**Start message**	**0 min**	**Actual**	**Actual**		
3:17	1	Calm message	2 min	Actual		virtual	virtual
3:18	2	Preliminary message	3 min	Actual			
3:19			4 min		Actual		
3:27			5 min			virtual	virtual
3:25	*3*	*Tsunami message*	*10 min*	*Actual*			
3:26			*11 min*		*Actual*		
3:27			*12 min*			*virtual*	*virtual*
3:30	*4*	*Updated message*	*15 min*	*Actual*			
3:31			*16 min*		*Actual*		
3:32			*17 min*			*virtual*	*virtual*
3:15 - 3:45		**Cancellation of the Exercise**	**Depend**	**Depend**	**Depend**		
3:43		Tsunami message	28 - 30 min	virtual	virtual	virtual	virtual
3:45	5	Cancellation message	30 min	Actual	Actual	virtual	virtual
3:46		**End message**	**31 min**	**Actual**	**Actual**		

MARN internal challenges

5) As for the Assessment of the drill,
Observation 4 "information sending panel" should resolved by preparing opportunity when shift officers could take its training. The preparation would be considered by MARN. Further, it would be resolved by introducing the applications that are under consideration in procurement
Observation 6 "checking the values of TIDETOOLs and also a strong training in the interpretation of measurement differences in wave heights" should resolved by preparing opportunity when shift officers could take its training. The preparation would be considered by MARN. Further, it would be resolved by new Workstation that is under procurement.
Idea against **Observation 7** "handling CMT properly" should resolved by preparing self-training materials that would be used by shift officers. Expert should try to develop the materials.
Idea against **Observation 8 &9** "As for drills, we could establish an annual goal of doing this type of exercise, and also a feedback process from the technicians" and "the identification of opportunities for improvement in each of the steps was evidenced. In addition, it was also possible to ensure the correct functioning of the "information delivery panel" tool." would need various scenarios. Expert should try to develop the series of Scenarios.

EWBS issue

6) Result 2-2: MARN has explained the "test of EWBS" under the EEW project and has provided the document with the below explanation in the column.

> In the following link, I have placed a report generated in the earthquake early warning project, on pages 21 to 24 you can find information on theEWBSs that Japan delivered to El Salvador within the framework of the JICA-SIGET project, as well as preliminary results of the tests that have been carried out to measure the delay times from the moment the earthquake occurs until it is transmitted by digital television.
> Now in El Salvador only digital television is broadcast for the Metropolitan Area of San Salvador.
> https://drive.google.com/file/d/1d2nbUUv5UPACyrUgdz9wSEqSuU0_LhYz/view?usp=sharing

Expert has updated the EWBS document made by himself. -> Expert thinks that EWBS could be used not only for EEW but also for Tsunami warning to the public. So, itmight be better for us to talk the idea of its usage for tsunami warning to DGPC.

Excerpts from Workshop minutes

. Results 2) Tentative conclusions
a) We approve the “results” of last year's joint tsunami simulation exercise
b) We conduct at least once a year joint tsunami simulation exercise.
c) As for the next exercise, we will bring it closer to reality with the participation of one or two municipalities such as La Libertad.
d) Every year after the exercise, workshops are held to confirm the results of exercise and to understand the improvement points of tsunami response operations.
e) We should continue to consider the current **challenges related to "collaboration between DGPC and MARN"**; and **we should get solutions before the next tsunami simulation exercise**.

Challenges related to "collaboration between DGPC and MARN" (Discussion items)
a) Communication tools
- Confirmation on the communication methods between MARN and DGPC and their roles
- Introduction of “daily inspection” into the procedures of the “monitoring shift duties” of the official communication tools between MARN and DGPC
- Enhancement of the proper usage of the communication tool like WhatsApp and Telegram between MARN and DGPC
b) Common tsunami cancellation procedures
- Establishment of the criteria on how to cancel tsunami warning
c) Proper usage of advisories from MARN
- Establishment of the descriptions in the messages related to actions to be taken by the people living or staying at the coastal areas. Ex “PREPARATION”, “EVACUATION”, “TAKE ACTIONS”
- Establishment of the way how to use the estimated tsunami heights of the coastal municipalities through sharing the internal procedures in MARN and DGPC)

Manuel Díaz08Feb22 04:26 AM JST from Manuel to Luis Montenegro DPC Translated by MORI
On this occasion we want to ask you the following questions:
1) Review and give us your approval to the report of the workshop, mainly, the part of "2) Tentative conclusions" of the "result". We enclose the memory of the workshop of January 25, the document that is attached is in Spanish and English.
2) Provide MARN with your evaluation of the tsunami drill on November 5, 2021, if they have it.
3) Provide MARN with the ppt files that were planned to be used in the DGPC presentations at the Workshop, if available.
4) Confirm that the DGPC is not receiving any information from CATAC in Nicaragua.
5) Consider the following elements as additional challenges related to the "collaboration between DGPC and MARN":
a) how to handle non-earthquake tsunamis like the Tonga event of 15 January 2022,
b) use EWBS for tsunami warning,
c) carry out a test of the WhatsApp and Telegram applications as an official communication tool in February.
6) Have a short discussion in February on how to handle tsunami generated not by earthquakes.

要素 d: 監視担当者の対応（人材育成）
分類 7: 自主研鑽

要素d: 監視（人材育成）	
分類7: 自主研鑽	計画策定（第319回会議から）
1-1-c-2 津波監視現業体制での技術レベル：維持・改善研修体制確立	作業中
1-2-f-2 MARNガイドブック：確立	作業中
1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討	作業中

達成状況：全ての小目標が作業中であり、「**Category 7**」の文書に整理した。
残された課題：同様に「**Category 7**」の文書に整理した。

要素 e: 機材

Total cost: US $ Dollar18,355.23

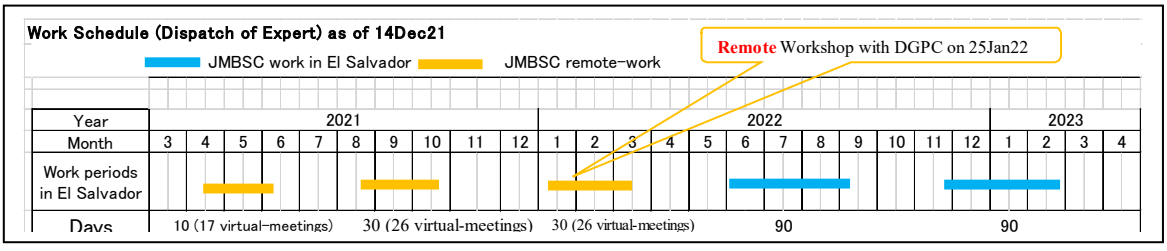
MARN-Procurement as of 09Mar22 EQUIPMENT DESCRIPTION	Quotation provided from	COMMENTS/JUSTIFICATION	QUANTITY	UNIT COST
Done & Delivered Digital radios: Brand: Ubiquiti. / Model: AirFiber 5XHD / Range: Greater than 100Km Frequency 5Ghz / 802.11 security protocol	1. The manufacturer's website 2. The price in the country (two to three times what is shown on the internet; asking a quote to a local dealer)	To strengthen the operation rate of the seismic network through the improvement of transmission lines using digital technology. To be used at the three locations: One of the sets of antennas, which is the below "link c", use " 34dBi gain" due to the long distance between the locations that use the radio communications. a) SanJose - Jayaque (Codes: SNJE-JAYA, latter has a repeater.) b) Las Nubes - Lomas de Alarcon (Codes:NUBE-LOAL, latter has a repeater.) c) Centro de Gobierno (repeater point) - Marn. Through this link, information comes from the Pacayal station (Code: PACA.)	6	US$429.00
Done & Delivered Ubiquite brand dish antenna, model AF-5G23-S45, frequency 5Ghz, 23dBi gain, range greater than 15km, include hardware for installation.			4	US$99.00
Done & Delivered Dish antenna Ubiquiti brand, RocketDish 5G34 model, 5Ghz frequency, 34dBi gain, range greater than 15km, include hardware for installation.			2	US$329.00
Done & to bedelivered in April Workstation: Workstation Model: Precision 7920 Tower Chassis CL. Processor: Intel Xeon Silver 4210R (2.4GHz, 3.2GHz Turbo,10C, 9.6GT/s 2UPI, 13.75MB Cache, HT (100W)) DDR4-2400. Operating System Windows 10 Pro for Workstations (6 Cores Plus) Multi - English, French, Spanish. Memory: 64GB 4x16GB DDR4 2933MHz RDIMM ECC Memory. Graphics Card: NVIDIA® Quadro® P1000, 4GB, 4 mDP (7X20T). Hard / Drive: M.2 1TB PCIe NVMe Class 40 Solid State Drive. Keyboard: Dell Black Wired 10 Key Numeric Keypad KB813 Smart Card Keyboard. Mouse: Dell USB Laser 6-Button Mouse. Monitor: Dell 27 Monitor - P2722H.	1. Dell (most economical) https://www.dell.com/en-us/work/shop 2. HP with the specification similar to the Dell	1. To run specialized seismological and tsunami monitoring software. 2. More focused on tsunami simulations in real time	1	US$4,167.23
Done & to bedelivered in March Laptops: screen display size 13.3 Inches, max Screen Resolution 1920 x 1080 Pixels Processor 1.6 GHz i5 / RAM 8 GB SDRAM / Hard Drive 256 GB ssd Wireless Type 802.11ac		To be used in the field in the configuration and maintenance of the seismic network.	2	US$1,000.00
Done & to bedelivered in March ISOLA (MatLab software & specific toolboxes) Perpetual Standard License Individual: it is allowed to install the software on 4 PCs but there can only be one user, who will have unique credentials, with which they can access the software and others tools.	MatLab	To get 1) Display of moment rate function to understand the actual seismic magnitude earlier 2) Slip distribution in a finite fault area, 3) Flexible calculation of GFDB and handling in-depth analysis related to the determination of theCMT Note 1 Its calculations are not in real time. Note 2 OSOP CMT doesn't have the above functions but can work in real time. Note 3 Both can handle initial motion (polarity) analysis for grasping focal mechanisms by entering polarities.	1	US$8,560.00
Graphic Applications specified with the functional specifications To generate computer applications and functional graphical user interfaces (GUI) aimed at optimizing and automating the sending of seismic and tsunami messages derived from the Seismology Area of MARN Specification: Draft of Specifications on making graphic applications 15Feb22	Developper	In order to shorten and stabilize the necessary time of the actions by the officers in the monitoring shift to issue urgent information like tsunami warning to DGPC and the public through official tools like WhatsApp & Telegram, which should be backups for the radio, and FAX, specific emails, SNS like Twitter, Facebook and the MARN website, to get the specified graphical user interfaces (GUI) with the following functions: 1) sending instant messaging, incorporating all the scripts made in MARN in relation to the production of seismic and tsunami information products, 2) within the GUI, 2-1) automatic messaging to GROUPS of telephones, from the Seismology telephone with "a Telegram application programming interface (API) and a WhatsApp API" 2-2) sending bulletins and seismic information through FAX and specific emails with the module 2-3) automatic messaging to social networks in the official MARN Twitter and Facebook accounts with a Twitter API and a Facebook API respectively 3) publishing/uploading the information of the bulletins derived from the application to the website of the Environmental Observatory/MARN. It would take 9 months for manufacturing.	1	US$4,000.00
Seismic station network Platform specified with the functional specifications (Application for the development of software or graphic applications/dashboards) To geterate computer applications with Seismic station network map on a screen (Platform) aimed at: 1) supporting monitoring officers to identify the status performance of the network at a glance, 2) urging them to take the rapid recovery actions with the station network map, 3) telling them how to do through showing the feature of the stations and the propirty of them. Specifications: Draft of Specifications om making Platform applicatoins for Seismic Network	Developper	In order to introduce the recovery procedures with the Platform to effectively maintain seismic observation network (Sub-target 1-2-c). Namely, the Platform should be monitored by the officers in the monitoring shift, who should try to keep the performance level according to the criterion that the operational rate should be higher than 86% (*to be reviewed*) through 1) dispatching offcers to the station to fix the outage earlier with spare equipment (to be prepared beforehad) 2) handling the issue based on the "priority".	1	US$8,000.00

達成状況：データ通信用無線機は 3 月の第 1 週に配送された。/コンピュータ関連は 3 月の第 3 週に配送見込み。/ MatLab 項目については、3 月第 3 週にライセンス取得予定。/ 残った事項は、アプリケーションに関連するもの。

注: 右に示す地震に対して、MARN は、最終メッセージ発出に 23 分を要した。23 分かかった理由は、タイプミスがあり、図情報作成に時間を要したため。このことについて、今後 MARN は、図作成の前にテキストメッセージを発出することとした。一方、図作成におけるタイプミスをなくすため、自動でタイプすることとし、それに上記のアプリケーションの一つが利用できるとのこと。

O.T. 01:12 El Salvador Time
Calm message: 01:14 (2min)
Preliminary message: 01:17 (5min) M6.9, location (Z2 No amenaza)
Final message: 01:35 (23min) M6.7, location, depth 56km
(**CATAC preliminary** 01:17 M6.4, location, depth10km)

付録 1 プロジェクト全体の日程概要



付録 2 作業経過と当初計画

Meetings in the remote-activities (06Jan22 - 10Mar22) with El Salvador Time as of 04Jan22

Prepared by the Expert, JMBSC MORI, for the "Capacity Development of the Analysis for Earthquakes and Tsunamis of El Salvador" Phase 2 during 2021-2023

2021			Virtual meeting numeric orders	Contents of the activities of the Expert in El Salvador Time (JST is obtained by adding 15 hours to El Salvador Time.)
Month	Day			Plan
Jan	6	Thu		**The start date of the remote activities of the Expert** 1. To present a draft of the work plan to MARN by Email. 2. To prepare the documents for the meeting on the day that are related to 1) outcomes, 2) technology transfer or training, 3) the memo for the coming meeting, and 4) the draft minutes of the meeting held on the day. (Note: All the meeting days should have this action to be taken by the Expert. So this action is not shown below.) 3. To wrap up the conditions that MARN should consider to properly cooperate with CATAC through referring to the documents introduced in the latest ICG/PTWS meeting 4. To continue studying the feasibility of the GPS to use it as a tool for tsunami warning through asking the maker of the GPS that is the target of this study. 5. To procure the equipment. 6. To make an appointment to have a meeting with DG of MARN to explain the work plan on the 3rd remote activities. 7. To make the draft procedures on the remote workshop with DGPC.
Jan	7	Fri	1	To revise the draft of the work plan. 15:00-16:00 To discuss 1) the draft of work plan, 2) review of the status of the outcomes (Note: All the meeting should have this item, so this won't be shown below), 3) schedule for explaining the draft to the DG of MARN
Jan	10	Mon	2	15:00-16:00 To discuss 1) CATAC issue, 2) Workshop issue, and 3) others.
Jan	12	Wed	3	15:00-15:30 To explain the latest draft to DG and getting his comment ***(Note: The exact date and the time should be discussed further.)*** 15:30-16:00 To discuss CATAC issue, and others.
Jan	14	Fri	4	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, and others. 16:00-17:00 To explain the latest draft to JICA ***(Note: The exact date and the time should be discussed further.)***
Jan	17	Mon	5	15:00-16:00 1) Equipment procurement issue, 2) Workshop issue, 3) CATAC issue, and others **(Note: CATAC will initiate the full specification management.)**
Jan	19	Wed	6	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, and others.
Jan	21	Fri	7	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, and others.
Jan	24	Mon	8	15:00-16:00 To discuss Workshop issue.
Jan	25	Tue	9	**08:30-11:30 To implement the Workshop with DGPC on the tsunami exercise held on 05Nov21.** ***(Note: The exact date and the time should be discussed further.)*** ***Alternate plan: 02:30-05:00***
Jan	28	Fri	10	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, 3) Category 1.
Jan	31	Mon	11	15:00-16:00 To discuss Categroy 1 and others

Meetings in the remote-activities (06Jan22 - 10Mar22) with El Salvador Time as of 07Mar22

Prepared by the Expert, JMBSC MORI, for the "Capacity Development of the Analysis for Earthquakes and Tsunamis of El Salvador" Phase 2 during 2021-2023

2021			Virtual meeting numeric orders	Contents of the activities of the Expert in El Salvador Time (JST is obtained by adding 15 hours to El Salvador Time.)
Month	Day			Actual
Jan	6	Thu		**The start date of the remote activities of the Expert** 1. To present a draft of the work plan to MARN by Email. 2. To prepare the documents for the meeting on the day that are related to 1) outcomes, 2) technology transfer or training, 3) the memo for the coming meeting, and 4) the draft minutes of the meeting held on the day. (Note: All the meeting days should have this action to be taken by the Expert. So this action is not shown below.) 3. To wrap up the conditions that MARN should consider to properly cooperate with CATAC through referring to the documents introduced in the latest ICG/PTWS meeting 4. To continue studying the feasibility of the GPS to use it as a tool for tsunami warning through asking the maker of the GPS that is the target of this study. 5. To procure the equipment. 6. To make an appointment to have a meeting with DG of MARN to explain the work plan on the 3rd remote activities. 7. To make the draft procedures on the remote workshop with DGPC.
Jan	7	Fri	1	To revise the draft of the work plan. 15:00-15:45 To discuss 1) the draft of work plan, 2) review of the status of the outcomes (Note: All the meeting should have this item, so this won't be shown below), 3) schedule for explaining the draft to the DG of MARN
Jan	9	Sun		To revise the draft To take the actions according to the timeline of the remote activities
Jan	10	Mon	2	15:00-15:50 To discuss 1) CATAC issue, 2) Workshop issue, and 3) others.
Jan	12	Wed	3	15:00-15:30 To explain the latest draft of Work plan to DG and getting his comment 15:30-16:00 To discuss CATAC issue, and others.
Jan	14	Fri	4	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, and others. **17:30-18:30 To explain the Work plant to JICA**
Jan	17	Mon	5	15:00-16:00 1) Equipment procurement issue, 2) Workshop issue, 3) CATAC issue, and others **(Note: CATAC will initiate the full specification management.)**
Jan	19	Wed	6	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, and others.
Jan	21	Fri	7	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, and others.
Jan	24	Mon	8	15:00-16:00 To discuss Workshop issue.
Jan	25	Tue	9	**08:30-11:00 Workshop with DGPC on the tsunami exercise held on 05Nov21** **17:00-18:30 (08:00-09:30 JST on 26Jan22) To check the Workshop with Interpreter**
Jan	28	Fri		**MARN official holiday** **16:00-17:30 JST With JICA HQ**
Jan	31	Mon	10-11	15:00-16:00 To discuss 1) Workshop issue, 2) CATAC issue, 3) Category 1 and others

Feb	2	Wed	12	15:00-16:00 To discuss Category 3 and others
Feb	4	Fri	13	15:00-16:00 To discuss Category 3 and others
Feb	7	Mon	14	15:00-16:00 To discuss Category 3 and others
Feb	9	Wed	15	15:00-16:00 To discuss Category 3 and others
Feb	11	Fri		*Japanese official holiday (The Commemoration of the Founding of the Nation)*
Feb	14	Mon	16	15:00-16:00 To discuss Category 3 and others
Feb	16	Wed	17	15:00-16:00 To discuss Category 6 and others
Feb	18	Fri	18	15:00-16:00 To discuss Category 6 and others
Feb	21	Mon	19	15:00-16:00 To discuss Category 7 and others
Feb	23	Wed	20	15:00-16:00 To discuss Category 7 and others
Feb	25	Fri	21	15:00-16:00 To discuss Category 7 and others
Feb	28	Mon	22	15:00-16:00 To discuss Category 7 and others
Mar	2	Wed	23	15:00-16:00 To discuss Category 7 and others
Mar	4	Fri	24	15:00-16:00 To discuss 1) Category 7, 2) Remained actions to achieve the targets, 3) The time to explain the report to the DG of MARN
Mar	7	Mon	25	15:00-16:00 To discuss 1) the report, 2) the time to explain the report to the DG of MARN
Mar	9	Wed	26	15:00-15:30 To explain the report to the DG of MARN (***Note: The exact date and the time should be discussed further.***) 15:30-16:00 To review and check the remained issue and the next visit activity plan. 16:00-17:00 To explain the report and to discuss it with JICA (***Note: The exact date and the time should be discussed further.***)
Mar	10	Thu		To wrap up the 3rd remote activities. **The end date of the remote activities of the Expert**

Feb	2	Wed	12	15:00-16:00 To discuss Category 3 and others
Feb	4	Fri	13	15:00-16:00 To discuss Category 3 and others
Feb	7	Mon	14	15:00-16:00 To discuss Category 3 and others
Feb	9	Wed	15	15:00-16:00 To discuss Category 3 and others
Feb	11	Fri		*Japanese official holiday (The Commemoration of the Founding of the Nation)*
Feb	14	Mon	16	15:00-16:00 To discuss Category 3 and others
Feb	16	Wed	17	15:00-16:00 To discuss Category 6 and others
Feb	18	Fri	18	15:00-16:00 To discuss Category 6 and others
Feb	21	Mon	19	15:00-16:00 To discuss Category 7 and others
Feb	22	Tue	20	15:00-16:00 To have a short meeting with DGPC and to discuss Category 7 and others
Feb	25	Fri	21	15:00-16:00 To discuss Category 7 and others
Feb	28	Mon	22-23	15:00-16:00 To discuss Category 7 and others
Mar	2	Wed		***(MARN has a work meeting that could not be change.)***
Mar	4	Fri	24	15:00-15:50 To have a discussion on the non-earthquake tsunami including the volcanic activity in a lake area 15:50-16:00 To discuss 1) Category 7, 2) Remained actions to achieve the targets, 3) The time to explain the report to the DG of MARN
Mar	7	Mon	25	15:00-16:00 To discuss 1) the report, 2) the time to explain the report to the DG of MARN
Mar	9	Wed	26	15:00-16:00 To review and check the remained issue and the next visit activity plan.
Mar	10	Thu		To wrap up the 3rd remote activities. **The end date of the remote activities of the Expert**
Mar	14	Mon	27	15:00-15:30 To explain the report to the DG of MARN (***Note: The exact date and the time should be discussed further.***) 15:30-16:00 To review and check the remained issue and the next visit activity plan. 16:00-17:00 To explain the report and to discuss it with JICA (***Note: The exact date and the time should be discussed further.***)

付録 3 第三次国内遠隔活動で収集した文書

Target (To make the plan on technology transfer & training in the project)	Documents provided by MARN during the 3rd aremote activities
Element a:"Observation, analysis and monitoring systems"	
Category 1: seismic and tsunami monitoring	
1-1-a The proper & stable judgement on generation of tsunami	1. Timeline_English_Version (305) Tonga issue 2. Timeline (305) Tonga issue 3. Tsunamis En El Salvador-Generación_ Medición y Mitigación-(1) (307)
1-2-b Introduction of auto-filling-function and elaboration of depth handling in the tsunami database	
1-1-c-1 Tsunami Monitoring Manual	
1-2-f-1 Establishment of the Tsunami Monitoring materials	
1-2-f-4 Establishment of the standard procedures that handle any abnormal seismic activities	
4-4-e Station weighting/correction for enhancement to hypocenter determination	
Category 2: CMT and Mw monitoring	
1-1-b The CMT analysis in the practical monitoring task to get focal mechanism and Mw	
1-2-a Introduction of GFDB based on the local seismic velocity structure to cover the events under M6.5 in CMT	
4-2 Grasping the distribution of amount of slips on the seismic source fault surface by analyzing the seismic waves	
4-3 Making displaying source time function to understand the actual seismic magnitude earlier	
4-4-a Initial motion analysis for grasping focal mechanisms	
Category 3: tsunami handling	
1-2-d Establishment of tsunami warning cancellation procedures	
1-2-f-6 Introduction of estimating the arrival of larger tsunamis afterdiminishing of initial tsunamis	
1-2-f-7 Promotion of using the Tide Tool in the tsunami monitoring procedures to seize live tsunami arrivals	
1-2-f-5 Introduction of the "Tsunami Forecast" that alerts the people about the small remaining tsunami	
Element b: "Use of the Infrastructure systems including CATAC"	
Category 4: recovery and backup	
1-2-c Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network	
1-2-e Establishment of backup for the tsunami warning system	
Category 5: data and information acquisition including cooperation with CATAC	
2 Promoted DGOA to share any information with CATAC	
4-1 Use of the real time data of the GPS stations in the system in order to get accurate Mw earlier through observing W-phase with the data	
EEW by Swiss **(EWBS)**	2021-12-21-resultados-proyecto-eew-VF
Element c: "Communications with users including DGPC"	
Category 6: issuance tsunami advisory for disaster prevention including cooperation with DGPC	
1-2-f-3 Introduction of the daily inspection of radio, fax, and email as the authorized transmission methods to DGPC	**For Workshop** (MARN) 1)"Result of tsunami exercise of DGPC and MARN on 05Nov21 as of 26Jan22" 2)Tsunamis En El Salvador-Generación_ Medición y Mitigación-(1) 3)Protocola para actuación ante Tsunamis 4)Assessment_Drill_051121 5)Evaluation of the tsunami drill carried out on Friday, November 5, 2021. 6)Perspective of the DOA-MARN 7)Evaluación del simulacro de tsunamis realizado el viernes 5 de noviembre de 2021. 8)Perspectiva del DOA-MARN 9) Discussion items for Workshop that reviews and plans the tsunami simulation exercises 10)GMT20220125-144012_Recording_1920x1080.mp4 11)Grabación_Simulacro_Tsumani_5.11.21.mp4 (DGPC) 12)Versión Final 12NOV21 13)Procedimiento Operativo ante Tsunami-SOP´s Nacional-DGPC Formato autorizado 14)Plan Nacional Tsunami
3 Reinforced protocols and procedures on tsunami threat - in use by MARN and DGPC	
Element d: "Monitoring Shift actions"	
Category 7: self-training	
1-1-c-2 The self-training system & materials to keep the tsunami handling skills in the monitoring shift officers	
1-2-f-8 Consideration on the "self-training system"	
1-2-f-2 Establishment of the MARN guidebook to make DGPC and the people properly use the information sent from MARN	
Element e: Equipment	
Equipment procurement	1. Solicitud de un programador_Proyecto_Prof_Mori (304) 2. Request for specialist in software development (304) 3. Outline of the Specification on making graphic applications as of 17Jan22_ModifiedLMixco_18Jan22 (306) 4. English_version_Plattform_Software_Developer_Plattform_Seismic_Network_Monitoring_10-02-2022 (316)
Target 4 Established the guideline for introduction of the additional technologies that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance	
4-4) Any other technologies	
4-4-b Tools for evaluating the **underestimate of Magnitude**	
4-4-c DD method on enhancement of **hypocenter determination** for inland seismic activities	
4-4-d IPF method for enhancement of automatic hypocenter analysis against **multi-occurrence of earthquakes**	
4-4-f Segmentation of coasts in tsunami warning to make it elaborate	
4-4-g Development of a**ny safe & effective system in the tsunami observation by humans** at coasts without tide gauges	
4-4-h Consideration on the guideline for updating **the seismic microzoning maps** of El Salvador	
Seismic Risk by IDB project	
Watching the other related cooperation activities that are being handled by other international	
Tsunami ready project by UNESCO	

付録 4 第二次国内遠隔活動で収集した文書類

目標	MARNが提供してくれた資料
要素 a:観測、分析、及び監視システム	
分類1: 地震津波監視	
1-1-a 地震発生検知～津波警報発表の時間：20分以上を3年間で5～10分短縮 / 津波・地震監視システム：安定稼働の仕組確立（地震・津波の監視体制改善、津波データベース改善）	1.Tsunami_Drills_issue (20Aug21) 2. Documento_Mensajería_Tsunamis_LMixco2021(1) (30Aug21) 3. TsunamiProtocol (20Sep2) 4. Answer to the Question 2_ made by Prof Mori (29Sep21) 5. CheckList 2.0 (06Oct21)
1-1-c-1 津波監視手引書	
1-2-b 津波データーベース運用改善：地震パラメーター自動入力機能開発及び津波データーベース改良	
1-2-f-1 現業当番者手引書、公式津波プロトコル、及びガイドライン：共有化・確立	
1-2-f-4 異常地震活動対応標準手順：確立	1. Earthquakes Protocol (13Sep21) 2. Replicas_seiscomp_nicaragua_evento_Mw64 (29Sep21) 3. Magnitud del sismo del 10 de octubre 1986 (11Oct21)
4-4-e 震源決定精度向上のための観測点への重みづけの微調整 / ステーションコレクションの導入	1. 2021-08-25-pregunstas-mori (23Aug21)
分類2: CMT及びMw監視	
1-1-b 発震機構とMwの利用：地震発生後15～30分で監視業務で利用可能化（CMT 解析の導入；Mwはモーメントマグニチュード）	1. Performance CMT-Tool_ISOLA-12May_event (23Aug21) 2. Performance CMT-Tool-22Sept_Nicaragua_event_stations_used (22Sep21)
1-2-a CMT解析機能：M6.5未満の地震をカバーするよう地域の地震波速度特性を取込だグリーン関数データベース（GFDB）調達	
4-2 地震波形を用いた解析による震源断層の滑り量分布の把握	
4-3モーメントレート関数表示機能（震源時間関数の把握）	
4-4-a 地震波初動解析による発震機構把握	
分類3:津波対応	
1-2-d 津波警報解除手順書：作成	None
1-2-f-5 津波警報解除後の注意喚起情報：導入検討	None
1-2-f-6 津波の高さが小さくなってきた以降に襲来する大きな津波の予想：検討	None
1-2-f-7 津波実況監視手段Tide Tool の利用：現業者での利用推進	None
要素b: CATACを含むインフラの利用	
分類4: 復旧及びバックアップ	
1-2-c 地震観測網復旧の効率的な取扱いのための道具：Platform開発（地震観測網復旧の手順書作成）	None
1-2-e バックアップシステムの適正化：対応	PPT_Mexico_PTWC_CATAC_DELL_HP (13Sep21)
分類5: CATACとの協力を含むデータ及び情報収集	
2 CATACとの情報の共有化の促進	None
4-1 GPS観測網の地震監視現業での活用（GPS 観測システムから得られるリアルタイムデータの活用）/ 津波地震や浅発地震を対象にしたWphaseによるMw及び発震機構推定	1. GPS type and feature as of 28Sep21filled by Douglas (29Sep21)
スイス（Swiss Seismological Service, SED）によるEarthquake Early Warning（EEW）開発	None
要素c: DGPCを含むMARNからの情報の利用者との意思疎通	
分類6: DGPCとの協力を含む防災のための津波警報の発信	
1-2-f-3 e-mailの公式利用、FAX点検の日課への導入：確立	None
3 DGPCの津波警報利用：適切化	1. Drill Proposal (06Oct21)
要素d: 監視担当者の対応（人材育成）	
分類7: 自主研鑽	
1-1-c-2 津波監視現業体制での技術レベル：維持・改善研修体制確立	1. Punteo_reunión_7sep2021_LMixco_observaciones-ingles (08Sep21) Punteo_reunión_7sep2021_LMixco_observaciones-ingles (reviewed by MORI) (08Sep21)
1-2-f-2 MARNガイドブック：確立	
1-2-f-8 津波監視現業技術レベル維持・改善のための研修体制：部外者参加も含めた検討	1. Boletin Mensual de Actividad Sísmica - Enero2021 (30Aug21) 2. Boletin Mensual de Actividad Sísmica - julio 2020 (30Aug21) 3. Boletin Mensual de Actividad Sísmica - Marzo 2021 (30Aug21)
要素e: 機材	
機材調達	1. Cotizacion_Workstation_Tower7920_DELL (25Aug2) 2. MARN_Quote 12492635_Licencia Perpetua Individual de MATLAB (30Aug21() 3. PPT_Mexico_PTWC_CATAC_DELL_HP (13Sep21) 4. Cotizacion_Workstation_HP Z8 G4 (13Sep21) 5. Cotizacion_Workstation_Tower7920_DELL2 (13Sep21) 6. Marn-Procurement as of 06Sep21ver4 (revised 13Sep21) (13Sep21)

付録 5 第一次国内遠隔活動で収集した文書類

Priority in 1st activity	Target With priority 1&2: to be achieved as close as possible in the 1st acitivity With priority 3: to be handled in the 1st activity With priority 4: N/A in the 1st activity	Documents provided by MARN (partially collected by the Expert)
1	Target 1	Target 1
1	1) Verified the latest status of the technologies, the materials, or the s	
1	a) **The proper & stable judgement** on **generation of tsunami** (**Timing,** within 10 min. **Accuracy,** kept at the enough level)	tabla_twitter
1	b) **The CMT analysis in the practical monitoring task** to get focal mechanism and Mw	Performance CMT-Tool-12May
2	c) Other technologies, materials or systems	
2	c-1) **Tsunami Monitoring Manual**	1. Tsunami Protocol (IAM-MFN-PA-03 PRotocolo de actuación por amenaza de tsunami en El Salvador rev 1 18nov2019) 2. Tsunami Protocol Word version (IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019)
1	2) Verified the actions on some issues that were left in Phase 1 to be t	
1	a) Introduction of **GFDB** based on the local seismic velocity structure to **cover the events under M6.5 in CMT**	Performance CMT-Tool-12May
1	b) Introduction of **auto-filling-function** and **elaboration of depth handling** in **the tsunami database**	Presentation_LMixco26-04-21 (ppt file; the "development of the new web page where seismic events are automatically placed in real time")
1	c) Introduction of the recovery procedures with the "Platform" to effectively maintain seismic observation network	estadisticas-funcionamiento-estaciones-V3
1	d) Establishment of tsunami warning **cancellation procedures** (Target 1-1 c-1) including DGPC	1. recopilacion-acciones-sismos-8.1-mexico 2. 8sep17_ChiapasMexico_Marigrams_ITIC
3	f) Other actions	
3	f-1) Establishment of the **Tsunami Monitoring materials** (Targets 1-1 c-1 & 1-2 d)	By the Tsunami Protocol (IAM-MFN-PA-03 PRotocolo de actuación por amenaza de tsunami en El Salvador rev 1 18nov2019) and the Tsunami Protocol Word version (IAM-MFN-PA-03_Protocolo_de_Actuación_por_amenaza_de_Tsun_ami_en_El_Salvadorfinal 18NOV2019)
3	f-2) Establishment of the **MARN guidebook** to make DGPC and the people properly use the information sent from MARN	1. Presentation_LMixco26-04-21 (ppt file; "improvement of the panel that sends information for the social network") 2. Guia de sismos y tsunamis 2017 half size 3. guia-de-sismos-y-tsunamis-2017 https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/ Guía de sismos y tsunamis 2017 | CIDOC Virtual<https://cidoc.marn.gob.sv/documentos/guia-de-sismos-y-tsunamis-2017-2/>
3	f-4) Establishment of **the standard procedures** that handle any **abnormal seismic activities**	Protocol for the seismic activity (IAM-MFN-PA-08 Actuacion por Amenaza de Sismos en El Salvador 2021)
1	Target 2	
1	Promoted DGOA to share any information with **CATAC**	1. CATAC tsunami exercise held on 11Nov20 (Ejercicio Regional CATAC_Pacwave) 2. Technical explanation of the CATAC tsunami drill held in 11Nov20 (Simulacro-CATAC-TSUNAMI-CA-20) 3. Comments from MARN on the CATAC tsunami drill held in 11Nov20 (Comentarios sobre simulacro) 4. LOG OF CATAC_DRILL_11-11-2020 5. Regional Drill, CATAC_Pacwave, by CATAC translated from Spanish 6. Emails on seismic activity sent from CATAC (ex. CATAC-INETER_ M=4.2, 58 Km al suroeste de Pochomil, Nicaragua)
1	Target 3	
1	Reinforced **protocols and procedures on tsunami threat** - in use by MARN and **DGPC** (Targets 1-1 c-1, 2 d, and 2 f-1)	1. local leaders interview report 2. Presentation_LMixco26-04-21 3. webinar_DGPC_report.

3	Target 4	
3	Established **the guideline for introduction of the additional technologies** that would enhance the seismic and tsunami monitoring system through making diagnosis of the latest system performance	
3	1) Use of the real time data of the **GPS** stations in the system in order to get **accurate Mw earlier through observing W-phase** with the data	Continuous-gps-station-ElSalvador-2021
3	2) Grasping the **distribution of amount of slips on the seismic source fault surface** by analyzing the seismic waves	1. Presentation_LMixco23-04-21 (ppt file; ISOLA CMT software) 2. ISOLA CMT manual (ISOLA_bookchapter_English) 3. b_installation
3	3) **Making displaying moment rate function** (or source time function) to understand the actual seismic magnitude earlier	Ibid.
4	4) Any other technologies	
4	Initial motion analysis for grasping **focal mechanisms**	Ibid.
4	Consideration on the guideline for updating **the seismic microzoning maps** of El Salvador	PPT_IDB_Project
1	Equipment	
1	Equipment procurement	1. Marn-Procurement-28May2021_LMixco

付録 6「業務の課題と改善の方向性についての DGOA との協議」を踏まえた「DGOA 担当職員と定める技術移転・研修計画」の例

例 1　目標 1-1-a (作業中)

Tentative

Draft of the Plan on the technology transfer & the training about "Proper and stable judgement on generation of tsunami" (Target 1-1-a)

Prepared by the Expert on 25Aug21

1. Detail of the target
Target 1-1-a: Verified the latest status of the "proper & stable judgement on generation of tsunami" established in Phase 1
Criterion: Its issuance timing should be within 10 min with sufficient accuracy level

2. Actions needed to achieve it

Legend for the pointed column
Ocher-color items: to need consideration of the Expert
Green-color items: to need actions conducted by MARN
Blue-color items: to need Meetings or actions conducted by both
No-color items: to be wrapped up

Actions	Target
Action to be taken MARN = to provide the Expert with any documents/data	
a) Tsunami procedures used by the shift staff	1-1 a 1-2 f-3
b) Data for checking the latest status of "the timing" & "the accuracy"	1-1-a
f) the current enhanced tsunami database showing the partition of depth, region, and magnitude.	1-1 a
Action to be taken MARN = to implement the analysis/review/check on	
m) MARN will introduce the automatic judgement, whether the event should be handled or not, function into the monitoring system in order to resolve the issue on the maximum 30 minutes lapse for the preliminary message issuance.	1-1 a

3. Status at the start day of the 2nd remote activity
"MARN Actions a, f, and m" are being considered by MARN. On the other hand, "MARN Action b" has been done; and Expert has analysed the data. The results are as follows:
They are verified as shown below but with some challenges:
1) Issuance timing of the final messages related to tsunami warning
- It has been shortened by several minutes or improved further as expected, probably because the remained actions[1] had been conducted accordingly.
- Namely, the time elapsed was between 9.5 & 21.2 min in 2017 and has been between is 8.0 & 17.4 min from 2019 to 2021. See the below list, which expresses with minutes and seconds, and the below Figure 3 that shows the progress of improvement in El Salvador through comparing with that in Japan during recent 60 years.
2) Challenges on the final messages

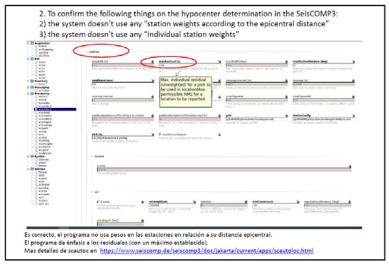
[1] The improvement comes mainly from the introduction of the automatic filling function.

actions by increasing reliability and shortening the "elapsed time". As one of its development procedures, MARN has conducted the monitoring drill (See the ppt file "Tsunami_Drills_issue" provided from MARN on 21Aug21 at 06:57JST) using this new technology. The development will be completed by the end of this year. Further MARN has made the manual how to use it. (Note: Expert comment: we have many panels there without clarified instructions when each panel should be handled. So, conducting drills and practices are surely essential to use it properly.)

5) Accuracy of the information in the final message
- It has been kept at the best level.
- Namely, the root mean square (RMS) of residuals (Res) between observation times and calculation times of the information in the final messages is around 0.44 sec in 2017 and is around 0.53 sec from 2019 to 2021. See the below list. They are kept in the improved level, because those around 2014 – 2015 show around 1.00 sec.

RMS_Res (sec) M>=4.0		Phase 1							Phase 2
		2014	2015	2016	2017	2019	2020	2021	Evaluation
Preliminary	Average					0.73	0.72	0.75	
	Maximum					1.95 M4.0			
Final	Average	1.09 - 1.66	0.91 - 0.97	0.58 - 0.61	0.39 - 0.49	0.53	0.57	0.46	Kept
	Maximum	2.6 M4.2			1.7 M6.1	1.23 M4.2			Kept

6) Challenges on the accuracy
The hypocenter determination in the SeisCOMP3 doesn't use "station weights according to the epicentral distance" and "individual station weights". But it uses RMS to evaluate the data to be used.
(Note: MARN has provided the right figure showing where we can understand the issues. The figure shows *"Max. individual residual (unweighted) for a pick to be used in locationMax. permissible RMS for a location to be reported." And "That is correct, the program does not use weights at the stations in relation to their epicentral distance. The program emphasizes residuals (with an established*



- Those emergency messages like the "final messages" must be steadily issued because they are sometimes surely related to save lives. The stable issuance also cultivates reliability to the MARN performance in the public.
- Therefore. the maximum issuance timing should be shortened as much as possible. The Expert should take care of the maximum, 27.0 min in the period of 2019 - 2021, further, even though the size of the event was M4.4 that was not related to tsunami warning.

Time elapsed M>=4.0		Phase 1							Phase 2
		2014	2015	2016	2017	2019	2020	2021	Evaluation
Preliminary	Average	5:30			5:49	4:32	5:34	5:08	Kept
	Maximum	07:39 M4.2			09:00 M8.0	10:14 M4.2			Kept
Final	Average	20:13 +/- 7:29 (12:44 - 27:42)			15:20 +/- 05:52 (09:28 - 21:12)	10:45 +/- 01:47 (08:58 - 12:32)	13:57 +/- 03:26 (10:31 - 17:23)	12:44 +/- 02:47 (09:57 - 15:31)	Improved
	Maximum	40:14 M4.2			35:43 M5.3	27:59 M4.4			Improved

3) Issuance timing of the preliminary messages
- It has been kept at the standard level.
- Namely, the time elapsed is around 5.8 min in 2017, and has been around 4.5~5.1 min from 2019 to 2021. But they are in the similar status, 5.5 min, of 2015. See the above list, which expresses with minutes and seconds.
- The maximum is 30 minutes. The event was small magnitude, so the monitoring staff should have judged whether the event should be handled or not, because MARN has the norm that only felt events should be handled. The issue could be resolved by introducing the automatic judgement function into the monitoring system. MARN will do so. -> MARN Action m

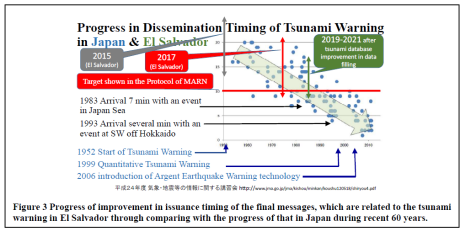
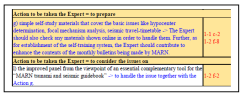
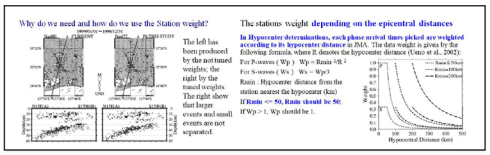


Figure 3 Progress of improvement in issuance timing of the final messages, which are related to the tsunami warning in El Salvador through comparing with the progress of that in Japan during recent 60 years.

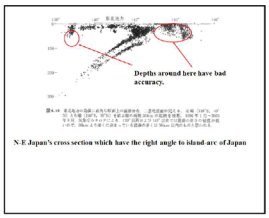
4) Challenges on the preliminary messages[i]
- The messages must also be steadily issued because they are surely related to the final messages.
- The average could be shortened with any support from EEW function or other technologies in the future.
- Further, we should consider how to shorten the timing of issuance of preliminary messages. -> MARN is handling the panel shown in the right column and the next page column[ii]. It is being developed to improve the monitoring



maximum). More details of scautoc in
https://www.seiscomp.de/seiscomp3/doc/jakarta/current/apps/scautoloc.html")
Therefore, Expert should check if there is any separation in locations of large events and moderate/small ones that are obtained from automatic calculation.



In addition, we should know that the below issue, but it's not easy to handle it well.



4. Further actions
4-1 To consider the challenges mentioned above and to propose how to do from now. Particularly, as for the panel, to clarify the relation between the current "tsunami handling procedures" and the panel handling procedures.
4-2 To get the documents or the implementation and to consider if additional actions of Expert are needed.
4-3 To consider if any additional technology transfer is needed
4-4 To consider if any additional training is needed
4-5 To fix this document

Period

[i] This note is for the page 2: MARN mentioned on 06Jul21 as follows: In the case of earthquakes greater than 7.0 off our coasts, the coasts of Guatemala and Nicaragua, it has been decided to include the first estimate of arrival times in a sectoring manner in the country; that is, an estimate for the west, center and east coast; which is extracted from the pre-calculated arrival times in the new Tsunami database. (Note: For a better understanding, it will be much easier to explain it to the Expert with doing an exercise, which MARN could do later in future meetings that we will have, about how the panel (or the auto-filling function) works.)

[ii] This note is for the page 2: The panel figure has the following explanation about it, "This document shows all the new functions that should exist in the update of the seismology panel for automatic sending of messages about the occurrence of earthquakes; where on this occasion, it is intended to include the part of tsunamis and its derivative products, as well as information on the level of impact on the threatened population.
Before the maps took 2 and a half minutes, and now only 23 seconds, this will help give the technician time to do other things during the seismic event
One of the features of this new panel is that we will guarantee a reduction in the creation time of messages and maps, since we use other scripts and computer libraries that speed up the process."

例 2　目標 1-2-b 及び目標 1-1-c-1（作業中）

Target 1-2-b Plan for MARN as of 20Oct21

Under preparation

Draft of the Plan on the technology transfer & the training about "Auto-filling-function and elaboration of depth handling" (Target 1-2-b)

Prepared by the Expert on 20Oct21

1. Exact Target
   Target 1-2-b: Verified the latest status of the "Auto-filling-function and elaboration of depth handling" established in Phase 1
2. Purpose (to be filled)
3. Actions needed are finished as shown in the right-bottom figure.
4. Documents provided a) Tsunami_Drills_issue, b) Documento_Mensajeria_Tsunamis_LMixco2021(1)
5. Status at the start day of the 2nd remote activity
   b) Introduction of auto-filling-function and elaboration of depth handling in the tsunami database They have been achieved

Target 1
2) Verified the actions on some issues that were left in Phase 1 to be taken later on
b) Introduction of **auto-filling-function** and **elaboration of depth handling** in the **tsunami database** — To be wraped up (Action n)

Legend for the pointed column
Ochre-color items: to need consideration of the Expert
Green-color items: to need action conducted by MARN
Blue-color items: to need Meetings or actions conducted by both
No-color item: to be wrapped up

Target
Action to be taken the Expert = to consider the issues on
a) the current plan on the introduction of the automatic filling function into tsunami monitoring task (Established the improvement of the database accordingly) — 1-2 b

Improvement of the database in the Tsunami scenarios

MARN currently has 561 scenarios modeled:

1) M: from 7.0 to 8.0 in 0.1 steps (11 scenarios?)
2) Depth: three depth values for each of the 27 selected seismic sources (3x27=81 scenarios)
3) Wave height: forecasted at 71 points along the coast
4) Results: tabulated at the municipality level to simplify the results (Note: a municipality can have several forecast points - where the highest value is taken)
5) Wave height values: associated in ranges, <0.3 m, 0.3 - 1.0 m, 1.0 - 3.0 m, and > 3.0 m
6) Earthquake with tsunamigenic characteristics: there is a module of the information dissemination platform that compares the data obtained from Seiscomp3 and the one drawn from the database scenario that most closely resembles the earthquake that has occurred.

(Note: the above was translated into English by the Expert with Google translation software from the email in Spanish sent from MARN.)

2. Current status of new seismic events in real time webpage

- The objective of this new page is to have a query-type page that can be accessed from a computer or mobile device, and show the occurrence of earthquakes automatically that our seismic data acquisition software (Seiscomp3) provides us in a few seconds after an event.
- This tool would greatly help to remove the pressure from the seismology technician to issue seismic information quickly, and in turn align with the nature of the seismic phenomenon, since it can be within a seismic crisis type series or swarm, or well the occurrence of multiple aftershocks after a main earthquake; which represents in terms of time a fatigue or tired situation for the seismology technician to be sending information successively in a short time.

as shown in the below explanations[i].
The Expert would verify the status of the auto-filling-function **by watching actual performance** and the status of elaboration of depth handling in the tsunami database by any document explaining the database.[ii]

5. Further actions
To fix this document　　**Period**

[i] In the Excel document prepared by Griselda, the characteristics of the tsunamigenic zones are tabulated; and indeed, there are 561 scenarios.
[ii] The auto-filling function is already working (at the script level) and MARN has been testing it with scenarios with all the technicians. At the script level it means that the technician executes the individual codes and not within a panel. MARN is still working on developing the panels, which will further facilitate the generation of messages to address tsunami threats.

1 / 1

Under preparation

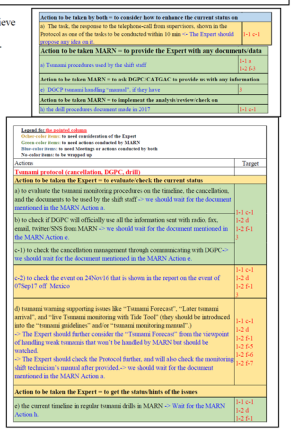
Draft of the Plan on the technology transfer & the training about "Tsunami Monitoring Manual" (Target 1-1-c-1)

Prepared by the Expert on 30Aug21

1. Exact Target
   Target 1-1-c-1: Verified the latest status of the "Tsunami Monitoring Manual" established in Phase 1
2. Purpose
   The manual has the purpose shown in the right column and can also be called guideline.

Purpose: **to establish the detail procedures with timeline during 30 minutes after occurrence of a large earthquake** under the condition of having the authorized protocol for handling tsunami and seismic activity, and **to inform DGPC and the people, as early in advance as possible**, about the occurrence of tsunamis that may cause disasters around the marine coastal zone.

3. Actions needed to achieve it
   See the right and right-bottom figures.



1 / 2

4. Status at the start day of the 2nd remote activity
   The actions to be finished are on-going.
   - The guideline, which is shown in the right below figure and is made in the Phase 1, is not used in MARN now. Instead, MARN is using another material.
   - The Expert should thus get the MARN's material to be provided by MARN. Then the below issues should be checked:
     1) The manual / guideline should describe the items such as "How to select Magnitude & Hypocenter" and "How to get Mw from CMT analysis".
     2) It should consider the "ANNEX 2 TABLES OF ACTIONS AND RESPONSIBILITIES" in the Protocol.
     3) It should describe the first 10 min actions in the same way for all scenarios of local events.
     4) It should handle the action, "Atender telefonos para brindar informacion preliminar" in the Protocol properly.
   - As for the tsunami warning drill, where the manual / guideline should be referred to, its current status is as follows:
     1) It is implemented roughly once for two months. But last year it was done only once at the CATAC drill.
     2) The "drill procedures document" made in 2017 exists, but is not referred to, when MARN implements a drill. MARN will review the document.
     3) The timeline of the drills is not so different from the one in the drill lead by CATAC last year.

5. Further actions
5-1 To fix this document
Period

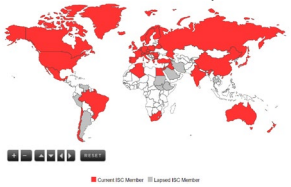
付録 7 ISC

http://www.isc.ac.uk/ **About the International Seismological Centre**

ISC was set up in 1964 with the assistance of UNESCO as a successor to the International Seismological Summary to follow up the pioneering work of Prof. John Milne and Sir Harold Jeffreys in collecting, archiving and processing seismic station and network bulletins and preparing and distributing the definitive summary of world seismicity.

Under the umbrella of the IASPEI, ISC always played a role in setting up international standards such as the International Seismic bulletin Format, the IASPEI Standard Seismic Phase List and the IASPEI Manual of the Seismological Observatory Practice. **The ISC was always serving the scientific research**.

The current mission of the ISC is to maintain: 1) ISC Bulletin – the longest continuous definitive summary of World seismicity; 2) International Seismographic Station Registry (jointly with NEIC/USGS); 3) IASPEI Reference Event List (Ground Truth, jointly with IASPEI).



MARN は、ISC に定期的にデータを提供している。

付録 8 津波データベースと津波チャート

MARN の津波データベースは数値シミュレーションから作られた。今後、実データ例えば 2012 年と 2014 年のイベントで観測されたデータがあればそれによって、データベースの適否を確認することとした。

Note 1: On 26 August in 2012, at 10:37PM, with an earthquake event of M7.3, tsunami was generated; “6.3m was its maximum height (*not the standard tsunami height)*”, and inundation was 40km wide, and reached 300m inland in some areas. Its epicenter was near San Juan del Gozo, 110 km away from its epicenter.

Note2: On 14 October in 2014, at 9:51PM, with an earthquake event of M7.3, its epicenter was near La Union where tsunami with 0.02m was observed.)

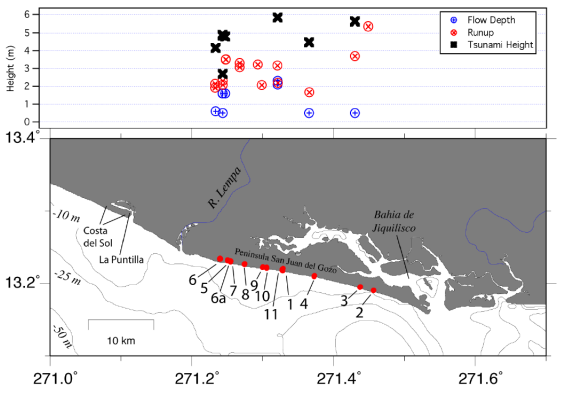


Figure 5.1 Summary of data collected during the field survey.

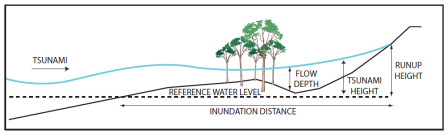


Figure 3.3 Definition sketch for tsunami height measurements and terminology.

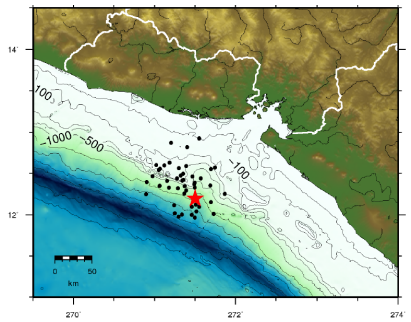


Figure 2.1 The Bathymetry offshore of El Salvador and Northern Nicaragua and the location of the USGS defined earthquake epicenter (red star). Black dots correspond to epicenters of aftershocks through 11 September, 2012. Contours labeled in meters.

付録 9 津波フラッグ

Points to note when operating tsunami flags

As a result of continuing to communicate tsunami flags in operation, such as waving tsunami flags, evacuation of the implementers should not be delayed. Depending on where the earthquake occurred, a tsunami may hit the coast without time. For this reason, only in cases where the safety of the person who carried out the transmission is ensured, the flags should be used. And it is important that the implementer of this transmission fully recognizes this and fully informs users of the beach.

Note 1: Tsunami Flag Specifications

1) It has been proposed that **the size** should be at least 100 cm on the short side, but there is no provision. This will be judged based on the size of the coast.

2) **Red** is not a detailed color specification.

3) The **checkered pattern** is similar to the "U flag", which is one of international maritime signal flags.

Note 2: The international maritime signal flag is a universal flag used to communicate between ships on the sea. The usage is determined by the International Code of Signals (INTERCO), and the signal by the international maritime signal flags is called Flag Signaling.

Note 3: The U flag is an international signal flag that means "your ship path is at risk” and is used overseas as a flag to signal emergency evacuation from the sea. On the other hand, the U flag can be a different meaning when combined with other international signal flags. For example, if you use a combination of "U flag" and "W flag", it means "pray for safety navigation".

Note 4: Price of the flag A company in Japan shows 8000yen (70 US Dollars; ￥7300 & $ 63 without tax). Its size is 100cm×150cm. Its material is plain weave of polyester 100%.

以上