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Thirtieth Session of the Intergovernmental Co-ordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS)

11-15 September 2023

Agenda Item 4.3

REPORT OF

WG 2 Tsunami Detection, Warning and Dissemination

This document has been prepared by the Working Group, chaired by Bill Fry, New Zealand, with contributions from TT chairs Charles McCreery (USA), Laura Kong (USA), Tim Melbourne (USA), Rennie Viomounga, Mathew Moihoi and Francois Shindele. Recommendations contained herein are the consensus opinion of WG2.

Intersessional activities of WG2 are comprised of the advances of four working groups: Task Team Tsunami Service Providers (TT TSP), Task Team Seismic Data Sharing in the South West Pacific (TT Data Sharing), Task Team Minimum Competency Levels for National Tsunami Warning Centre Operations (TT Minimum Competencies) and Task team Integrated PTWS Sensor Networks for Tsunami Detection and Characterisation (TT Networks).

This report summarises the outcomes and recommendations arising from the TT.

During the intersessional period, WG2 also contributed to the response of the Hunga Tonga/Hunga Ha'apai volcano and tsunami (HTHH). This work resulted in interim guidelines for continued monitoring of tsunamis generated by the volcano and is summarized in this report.

Recommendations arising from each TT and HTHH follow their respective sections and are compiled in a summary table at the end of this report.

Table of Contents

1 Task Team Summaries

1.1 Task Team on Tsunami Service Providers (Chair Charles McCreery)

1.1.1 **EQ Source Zone Proposal** (ICG XXX agenda item 4.5)

The August 12, 2021, Mw 8.1 earthquake in the South Sandwich Islands demonstrated that the the Scotia Arc Subduction Zone is a tsunami threat to PTWS coasts. Tsunami waves from this earthquake reached PTWS coasts within 4-6 hours (e.g., southernmost Chile and bases on the Antarctic Peninsula) and tsunami waves of more than 0.2 m amplitude were recorded in the Pacific as far away as French Polynesia, Hawaii, and Alaska (*Figure 1*).

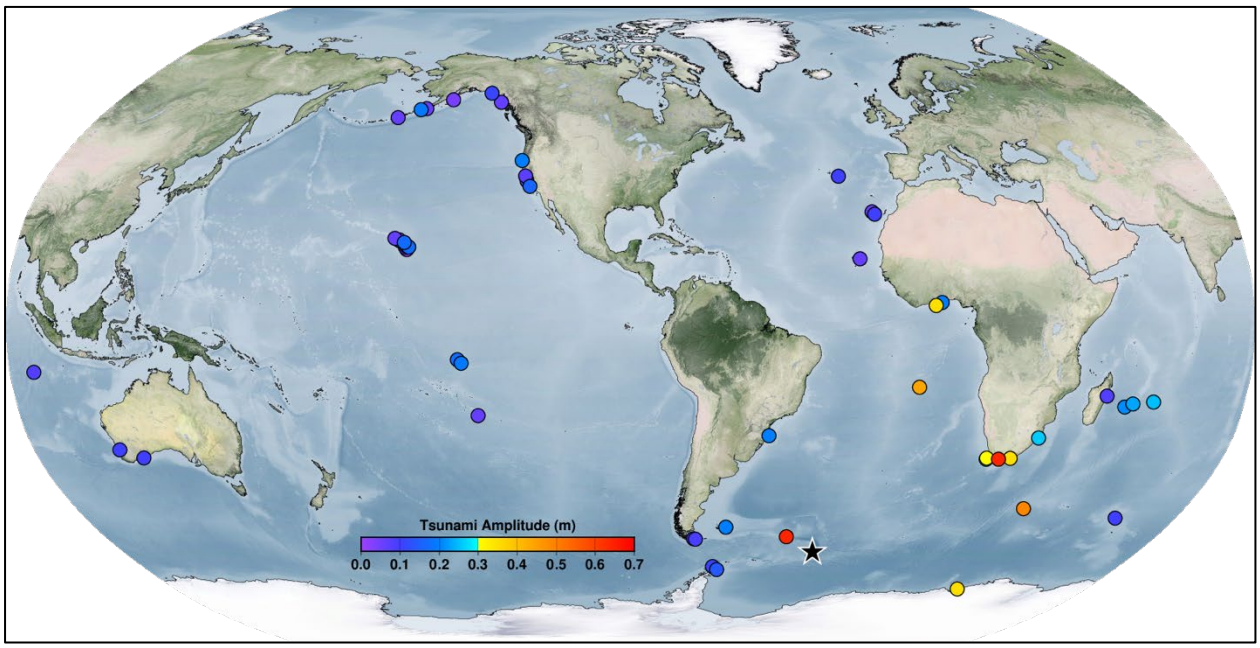

Figure 1. Tsunami amplitudes from the August 12, 2021 magnitude 8.1 earthquake in the South Sandwich Islands (black star) recorded on coastal sea-level gauges in the Atlantic Ocean, Pacific Ocean, Indian Ocean, and Antarctica. Each dot represents a gauge, and the color of the gauge indicates the tsunami amplitude in meters as shown in the color-bar legend.

The Scotia Arc where this earthquake occurred is currently a part of the CARIBE-EWS Earthquake Source Zone (*Figure 2*). Large earthquakes in this seismic zone occur frequently. Since the year 2000, 34 earthquakes of magnitude 6.5 or larger have occurred there -- appropriate for a Tsunami Information Statement for the CARIBE-EWS. Yet earthquakes from this region are less of a tsunami threat to CARIBE-EWS coasts than they are to PTWS coasts, as illustrated by the August 12, 2021, event. The east-west directionality of the main beams of energy as well as the South America land mass effectively limit tsunami energy going towards the Caribbean (*Figure 3*). Aside from being more of a threat to the Pacific, such tsunamis are also more of a threat to IOTWMS coasts than to CARIBE-EWS coasts and they are obviously a threat to southern Atlantic coasts where there currently is no system. Six observations above the 0.3m threat level were recorded on gauges in the southern Atlantic (*Figure 1*).

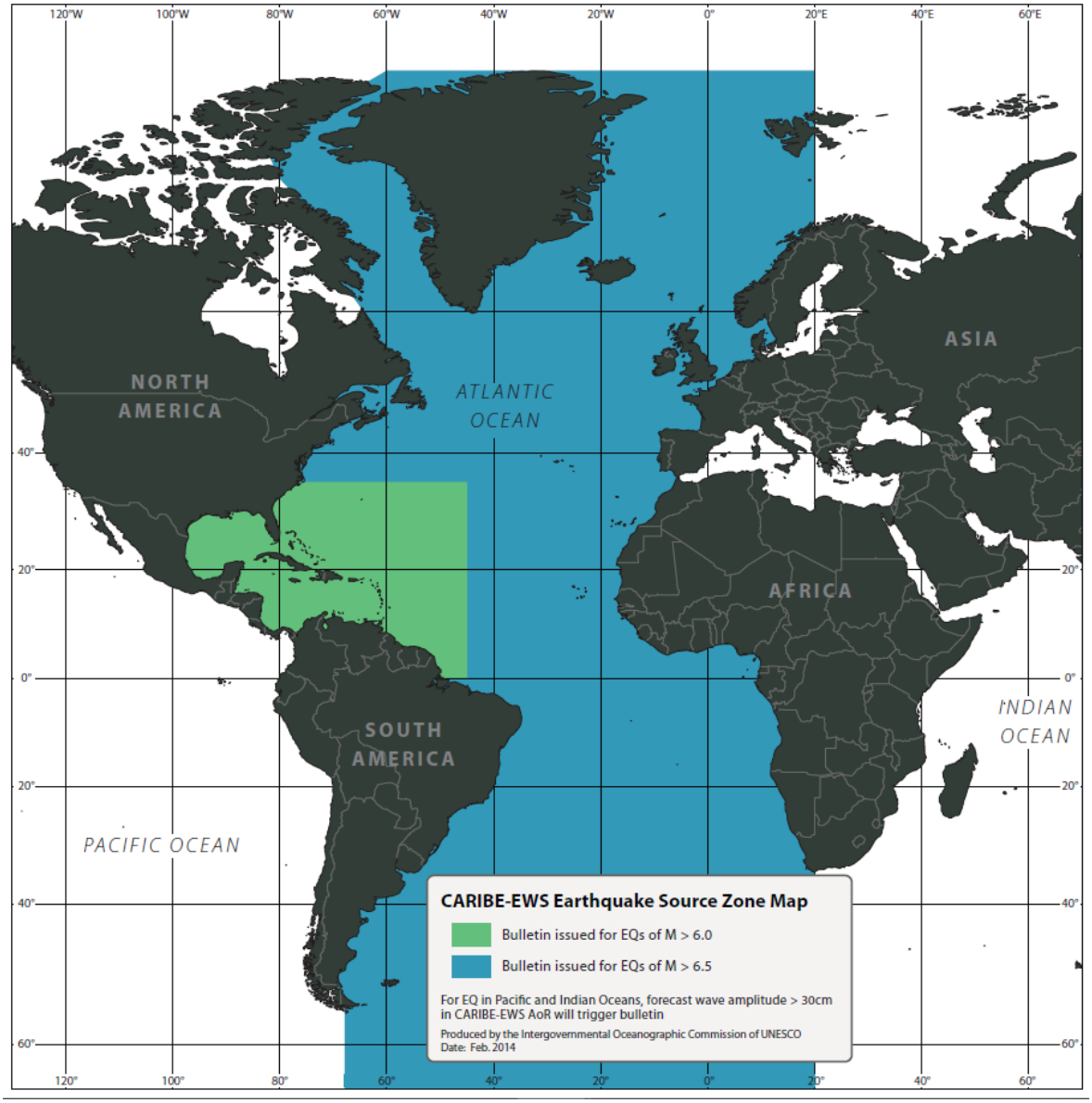

Figure 2. The current CARIBE-EWS Earthquake Source Zone.

Current rules allow the Tsunami Service Providers of one system to issue products for earthquakes outside of their own system's Earthquake Source Zone, either if they forecast or record tsunami amplitudes of 0.3m or more within their own coastal service area, or if the earthquake might reasonably create concern about a tsunami threat in their area even when there is not a threat. But those events should be an exception. For Scotia Arc events, the most concern is routinely within the PTWS coastal service area. Yet those events are not part of the PTWS Earthquake Source Zone (*Figure 4*).

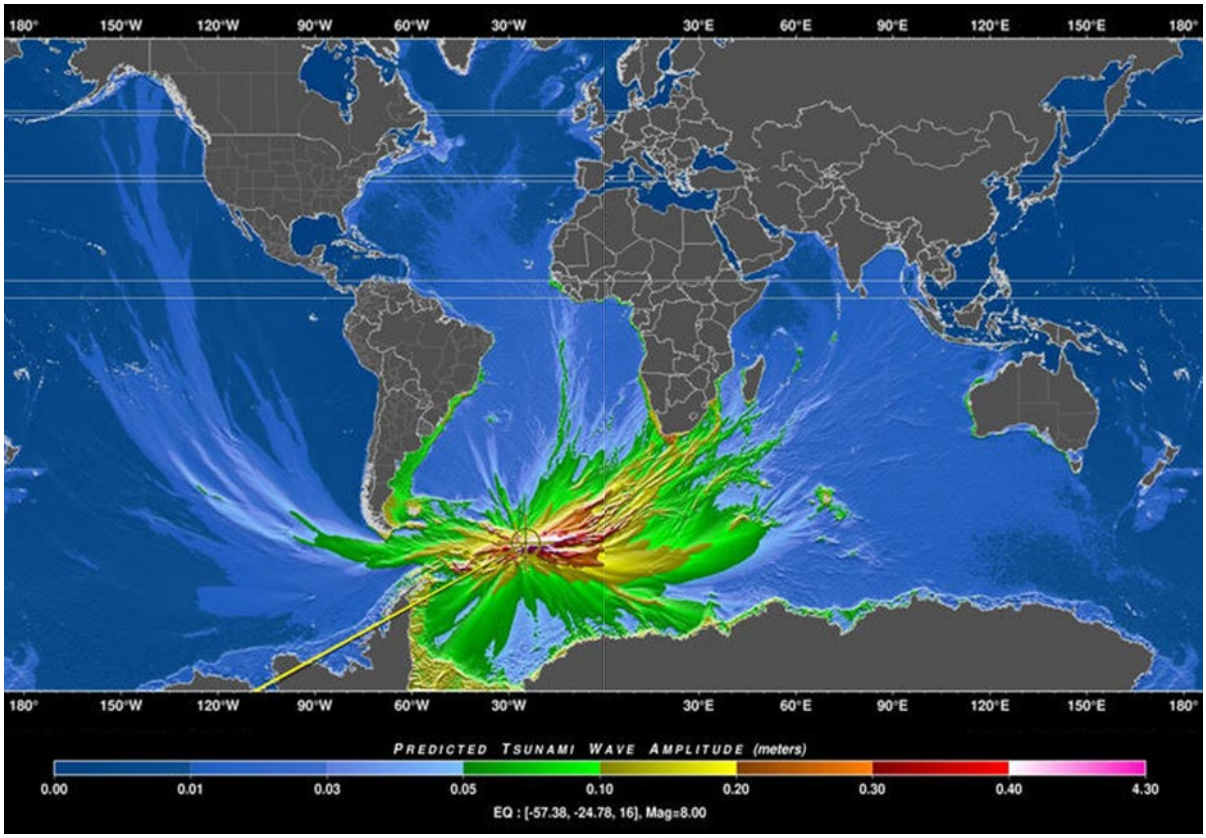

Figure 3 Numerical simulation of the tsunami produced by the August 12, 2021 magnitude 8.1 earthquake in the South Sandwich Islands. The maximum deep-ocean amplitudes of the tsunami are indicated by the color scale at the bottom. The complex directional pattern of tsunami energy is due to the shape and amount of seafloor deformation as well as refraction by bathymetry.

Discussion at the PTWS 29th session and the PTWS Steering Committee in March 2023

In response to the August 12, 2021, Mw 8.1 earthquake, the PTWC proposed to expand the Earthquake Source Zone of the PTWS to the Scotia Arc. And the ICG/PTWS decided the following recommendation through discussion.

Recommendation ICG/PTWS-XXIX.3

Tsunami Detection, Warning and Dissemination

Recommends that the PTWS Earthquake Source Zone be expanded to include the Scotia Arc seismic region to routinely provide Member States of the PTWS with information about the frequent large earthquakes from this region and any subsequent tsunami threat;

The above recommendation was submitted to the TOWS-WG 15the session in February 2022 and was submitted to the IOC 55th Executive Council through discussion at the TOWS-WG 15the session. However, the recommendation was removed from the IOC Decisions and expansion of the PTWS Earthquake Source Zone has not yet realized. The PTWS Steering Committee was held in March 2023 and the PTWS Steering Committee decided the following recommendation.

Recommendation in the PTWS Steering Committee in March 2023

The Group recommended that the issue of expanding the PTWS earthquake source zone to cover the seismicity associated with the Scotia Subduction Zone be discussed at ICG/PTWS-XXX in Tonga. If the ICG agrees with the expansion, then it will instruct the IOC to change the PTWS earthquake source zone map in the TS 130 (2016 version) and this decision will be reported back to the TT-TWO and the TOWS-WG.

Response of Delegation from Chile included in Appendix 5.

Proposal

- WG2 supports the recommendation at the PTWS Steering Committee in March 2023. WG2 proposes to expand the PTWS Earthquake Source Zone to include an area extending from 63° to 52° South latitude and from 72° to 18° West longitude. This area contains the Scotia Arc and its adjacent seismic zones (*Figures 4 and 5*). If the ICG/PTWS endorses this change it will be implemented by the Pacific Tsunami Warning Center as soon as possible and subsequent earthquakes in this region with a magnitude of 6.5 or greater will trigger the issuance of PTWC tsunami information or tsunami threat products, as appropriate, to the PTWS.
- WG2 further proposes to request the IOC to change the PTWS Earthquake Source Zone map in the TS 130 (2016 version).

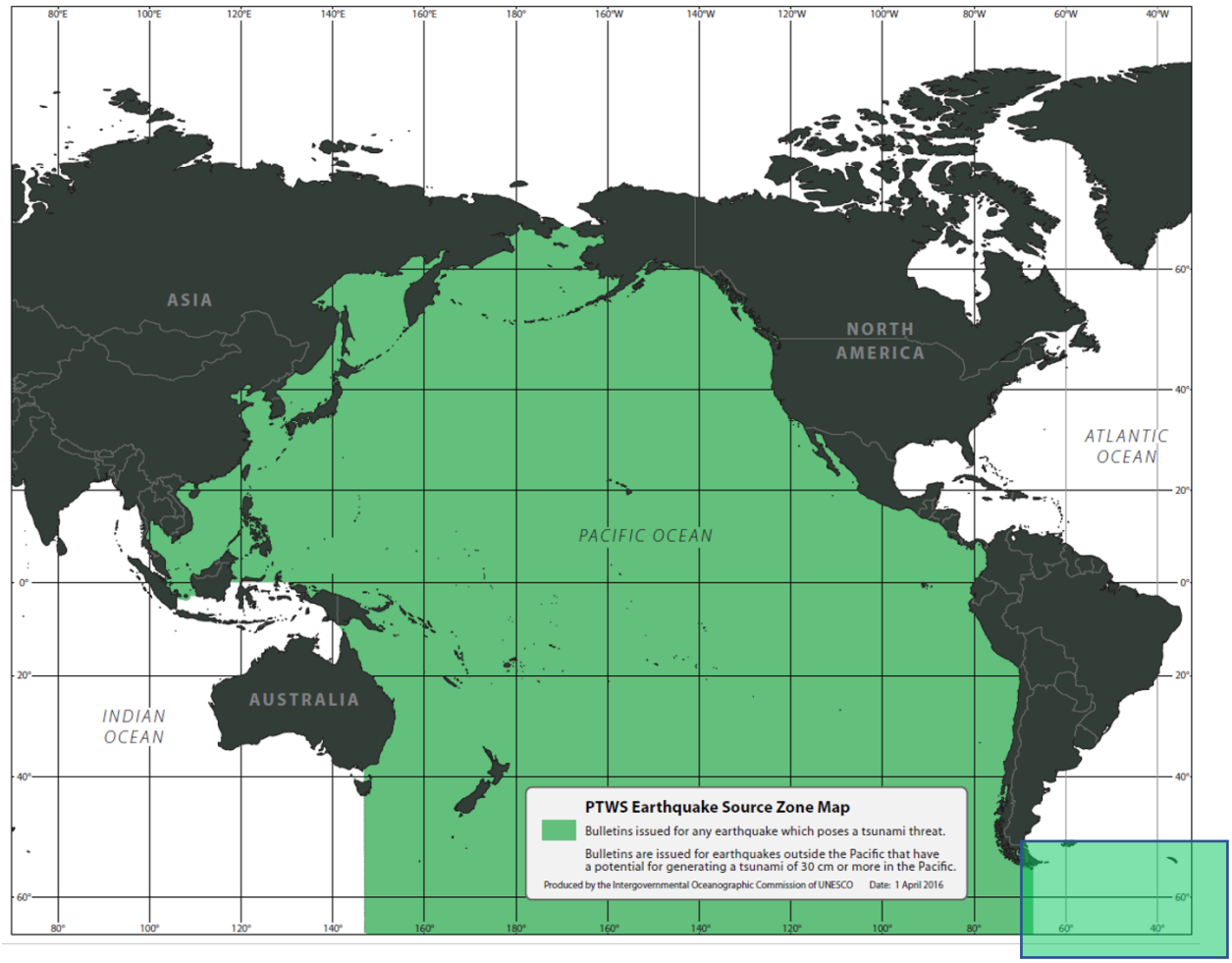

Figure 4. The current PTWS Earthquake Source Zone is indicated in green. The transparent green box at the lower right indicates the approximate proposed addition to the PTWS ESZ that would include the seismic zone associated with the Scotia Arc and South Sandwich Islands.

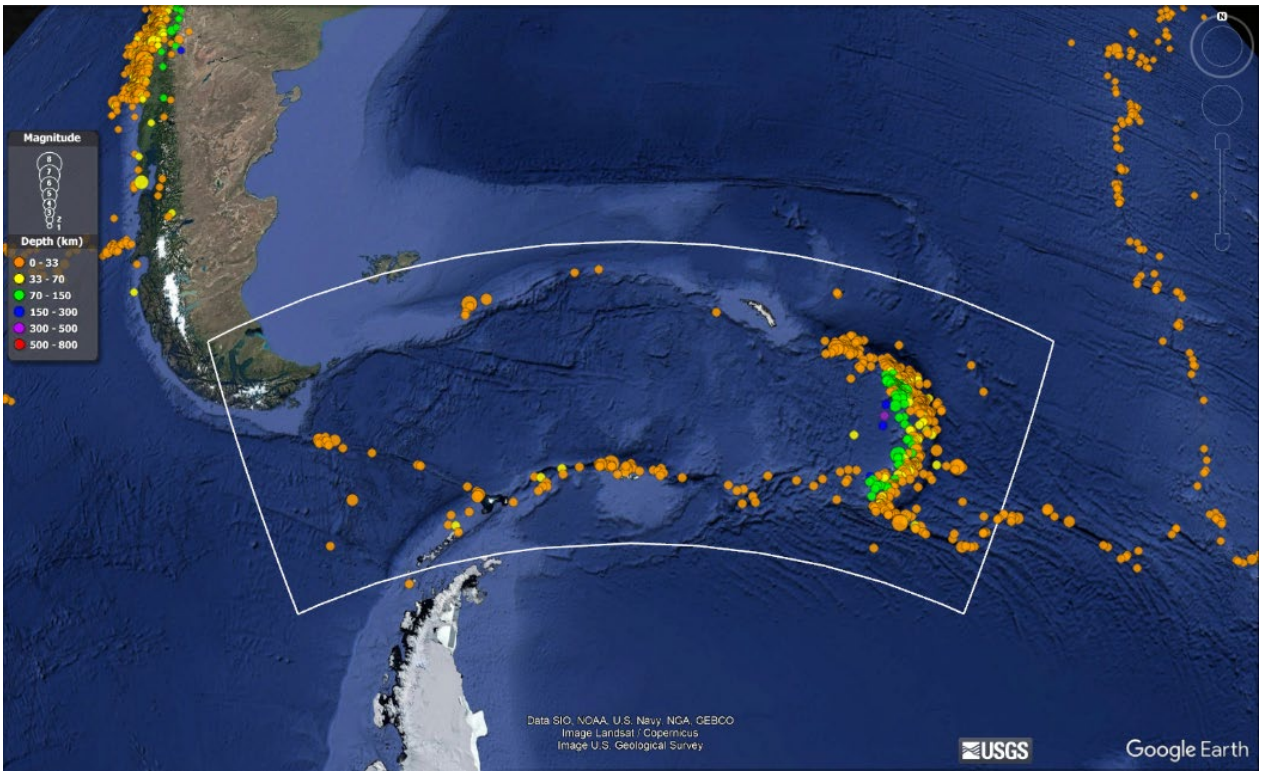

Figure 5. Seismicity in the southern Atlantic Ocean including the Scotia Arc Subduction Zone. The polygon surrounding this seismicity, extending from 63° to 52° South latitude and from 72° to 18° West longitude, is the proposed extension of the PTWS Earthquake Source Zone.

1.1.2 **Proposal for PTWS Maritime Products** (ICG XXX Agenda Item 4.6)

Products to inform ships at sea about tsunami events that may affect them in some way are created and disseminated by NAVAREA Coordinators of the International Hydrographic Organization's (IHO) World Wide Navigational Warning Service (WWNWS). In recent years, representatives of the IHO have requested that TSPs of the IOC's tsunami warning systems create special maritime products with key information about a tsunami threat and send them to appropriate NAVAREA Coordinators for dissemination to ships. This issue has been discussed over several years at meetings of the TOWS-WG and its Task Team on Tsunami Watch Operations with the following related outcomes:

1.1.2.1 The TTTWO in TOWS-WG 12th Session

Recommendation 9: Approve the proposal on TSP Messages for the Maritime Community and requests the ICGs to consider the proposal for implementation in their respective basins. Further, IOC Secretariat is to share the final proposal with WWNWS-SC and facilitate coordination between ICGs and the WWNWS-SC for operationalizing the service.

1.1.2.2 The TOWS-WG 12th Session

The Group approved the proposal on TSP Messages for the Maritime Community and requested the ICGs to consider the proposal for implementation in their respective basins. (see Appendix 4 to Annex IV).

1.1.2.3 The TOWS-WG 16th Session

The Group recommended the IOC Assembly at its 32nd session in 2023 to instruct the regional ICGs: TSPs in collaboration with NAVAREA operators test the tsunami maritime safety products in 2023/24, with a view to operationally implementing in 2024/25;

To date, however, none of the PTWS TSPs have developed the requested maritime products.

At the most recent meeting of the PTWS Steering Committee held in March of 2023, the issue was discussed. A number of concerns were expressed including various situations that could create confusion if multiple TSPs as well as NTWCs were sending their information to the NAVAREA Coordinators. It was also expressed that there is no directory of NAVAREA Coordinators and that this information is essential for addressing the issue. The Pacific has seven NAVAREAs (Fig. 1) and so it has seven NAVAREA Coordinators. The IOC Secretariat noted that the next meeting of the WWNWS would be held September 4-8, 2023, and these concerns could be raised there. The Steering Committee made the following recommendation.

The Group recommended the establishment of a Task Team (TT) on the provision of tsunami information of the TSPs to the maritime community for navigational warning with the following membership: All TSPs (PTWC, NWPTAC, SCSTAC), Chile, Peru and Australia. The Group instructed the Secretariat to send an email to formally launch the TT and support holding of a TT meeting before September 2023.

1.1.2.4 Proposal

Although this special Task Team has not yet been formed, and interaction with the WWNWS in September has not yet taken place, the Task Team of TSPs in their recent meeting on August 1, 2023, agreed on the following general approach, endorsed by WG2:

- PTWC should be the only PTWS TSP to create and provide the special tsunami maritime safety products to all NAVAREA Coordinators in the Pacific.

- With regard to provision of the special tsunami maritime safety products to all NAVAREA Coordinators in the Pacific, PTWC will transmit them to the NTWCs as well as the ordinary tsunami bulletin and the NTWCs will forward it to the NAVAREA Coordinators in their countries.

- In addition, the other TSPs as well as NTWCs can provide their own more specific tsunami information to the NAVAREA Coordinator(s) appropriate for their respective service areas.

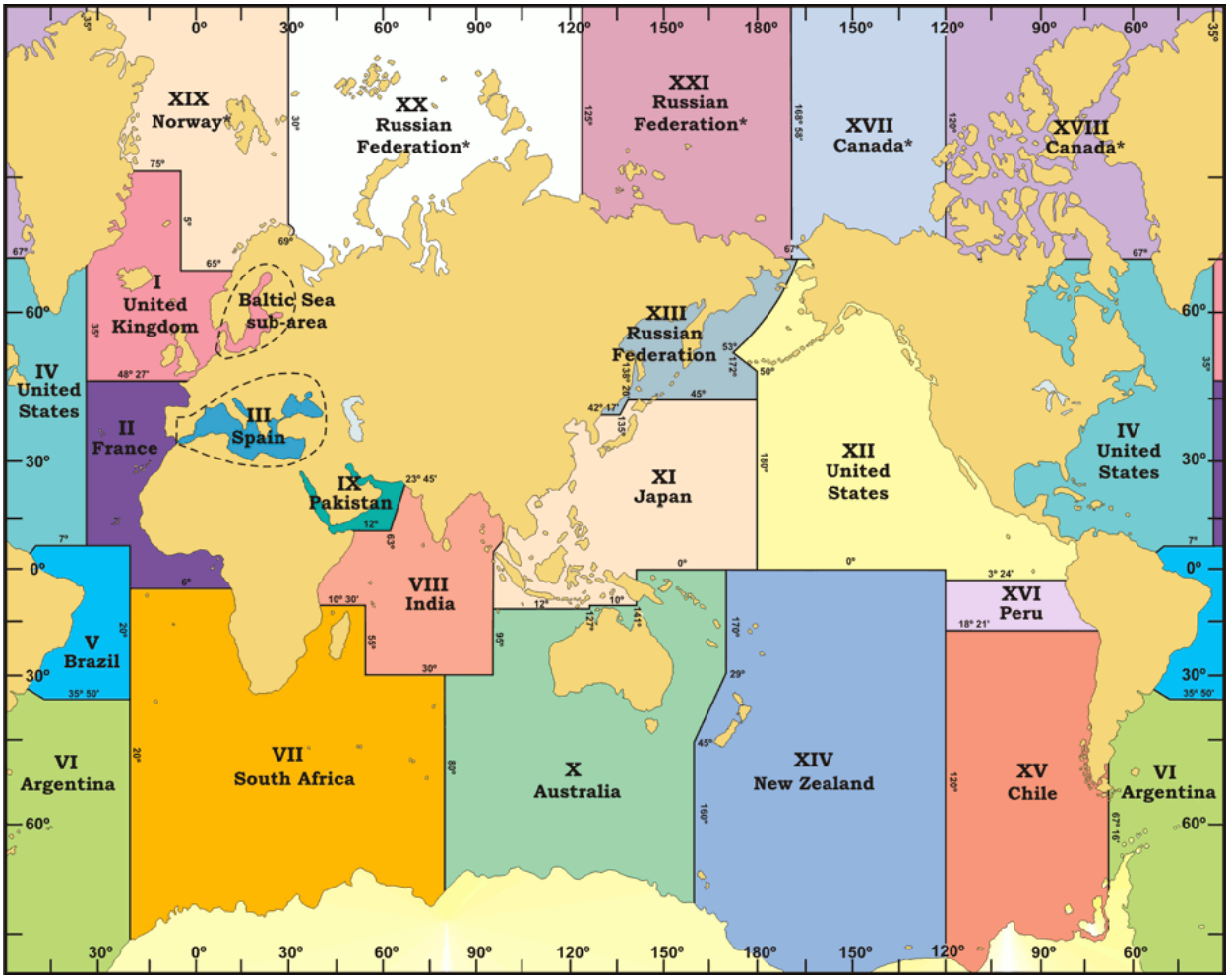

Figure 6. Global map of NAVAREAs. Coasts of the PTWS service area are contained within seven of the NAVAREAs – X, XI, XII, XIII, XIV, XV, and XVI.

1.1.3 **Proposed PTWC Product Changes**

The following are proposed PTWC product changes. These changes have been motivated by feedback from Member States over the past few years. Proposed changes are the following:

1. Put PTWS countries and territories named with a tsunami threat in alphabetical order in the initial threat messages issued before there is a numerical tsunami forecast. This is sometimes a long list, and putting places in alphabetical order will make it a bit easier for countries and territories to see if they have been designated

with a potential threat. Countries and territories are already listed in alphabetical order in products based on numerical forecast models.

2. Organize expected first arrival times (ETAs) by country or territory. The current list of ETAs is ordered only by time, with the earliest arrivals being shown first. The proposed list will be ordered by country and territory and also by time. This is also a change to make it easier for countries and territories to see all their ETAs grouped together.
3. Organize gauge observations by country or territory. The current list is organized by time of the observation, with the most recent measurement showing first. The proposed change will organize the list by country or territory. Again, the purpose of this change is to make it easier for countries or territories to see all of the observations that have been made along their coasts.
4. Designate the type of measurement that was made for gauge observations. Current observations are only indicated as representing the current maximum tsunami amplitude at each gauge. The proposed change is to label each observation as representing a maximum crest relative to the normal tide level, a maximum trough relative to the normal tide level, or half of the maximum crest-to-trough or trough-to-crest of a single wave cycle (Figure 1). This change should provide more

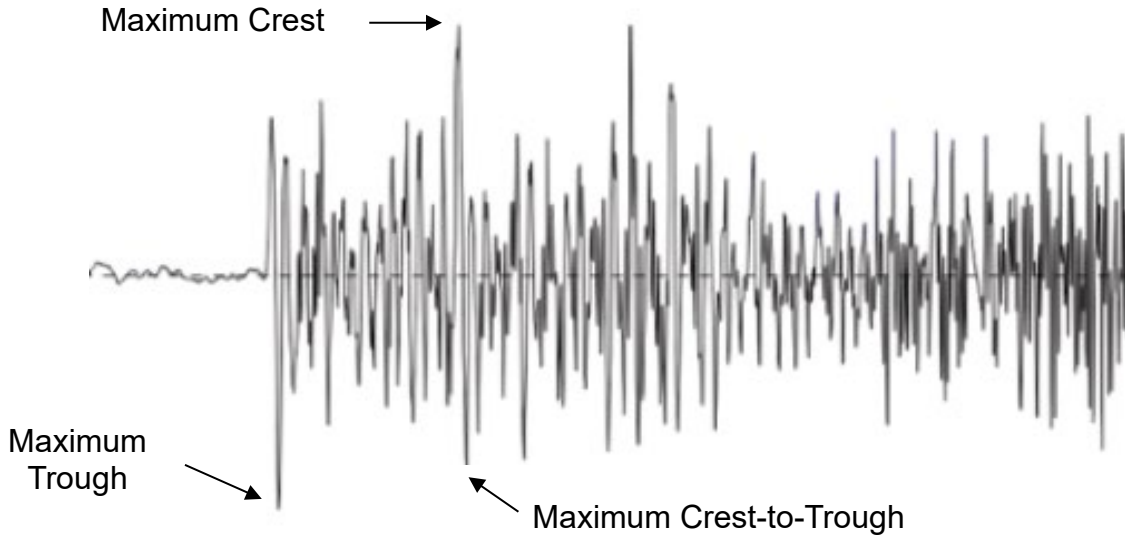

Figure 6. Tsunami recording on a sea level gauge showing the position of the maximum crest, maximum trough, and maximum crest-to-trough.

clarification regarding the type of measurement made and also make it easier to compare measurements made by different TSPs and NTWCs. To make space for the amplitude measurement indicator within the 65-character line length limit, the column for the wave period has been removed. The wave period measurement is the least precise measurement. To further reduce potential confusion, this change also includes the elimination of the term "height" that may be misinterpreted as the total crest-to-trough or trough-to-crest measurement and instead only uses the term "amplitude".

1.1.4 **Common TSP's Users' Guide Table of Contents**

Resulting from discussion within the PTWS Steering Group, the TT TSP undertook work to establish a common format for TSP Users' Guides. The agreed table of contents is presented in Appendix 2.

1.1.4.1 Proposal

WG2 recommends the PTWS accept the updated User Guide table of contents.

1.1.5 **Phasing out of telefaxing messages**

1.1.5.1 Background

To ensure the timely and reliable receipt of tsunami products from PTWS Tsunami Services Providers (TSP), PTWS Member States provide up-to-date contact information for their Tsunami Warning Focal Points (TWFP) and National Tsunami Warning Centers (NTWC) to the IOC Tsunami Unit through diplomatic channels. This information is routinely compiled by the IOC and sent to the TSPs for them to use for product dissemination. The contact information for each TWFP and NTWC typically includes a few email addresses and telefax numbers. Telefax used to be an effective way to disseminate TSP products, but in recent years the failure rate for telefaxes has increased dramatically. In the past few PTWS ICG meetings, PTWC requested that Member States review their need for telefaxes and review the accuracy of their designated telefax numbers. PTWC noted they must use a commercial service for simultaneous telefaxing and that the cost is high – on the order of US$5 per attempt for each fax number. Five attempts are made to each fax number before giving up. This can add up to a significant cost for failed faxes when PTWC issues products for tsunami events as well as for monthly communication tests. Some Member States have kindly removed unnecessary and obsolete telefax numbers, but the list remains long.

1.1.5.2 Current telefaxing of the PTWC

PTWC currently attempts to distribute its text products by telefax to 65 designated numbers of the PTWS Member States. We compiled fax statistics for May of this year when there were 13 instances of PTWC products being disseminated. These included multiple products for the two threat level events in the Loyalty Islands. All telefaxes failed for 44 of the 65 numbers and the success rate for another 4 numbers was less than 25%. Clearly, this communication method is no longer widely effective. We were recently contacted by French Polynesia regarding their non-receipt of PTWC products by telefax. Their four fax numbers are correct and their fax machines are all in operation. PTWC worked with its fax service provider to try and resolve the problem but the effort was unsuccessful. The provider noted there is an overall increasing problem with faxing due to the mix of analog and digital telephone lines along the transmission path causing a degradation of the fax signal. This is ultimately a problem of trying to hang on to old technology that is no longer widely needed or supported.

1.1.5.3 Discussion of the Issue by the PTWS WG2 Task Team of TSPs

This issue was discussed among the PTWS TSPs during their recent Task Team meeting on August 1, 2023. All expressed that faxing has become a problem and is no longer widely effective. The Task Team agreed to propose the phasing out of the fax service except in some cases where faxing remains quick and reliable.

1.1.5.4 Proposal

The PTWS TSPs propose to phase out telefaxing of text products to the PTWS. However, they wish to implement this in a way that does not inadvertently cause any Member State to lose redundant and reliable means for receiving those products. The following steps are proposed:

1. The ICG/PTWS requests the IOC to send a letter to all Member States informing them of the plan to terminate telefaxing as a method of receiving PTWS TSPs text products. The IOC informs that PTWS TSPs will begin to cease attempting to fax to all numbers that now routinely fail.
2. The IOC requests Member States to respond to the IOC if termination of TSP fax services will result in an unacceptable risk of not receiving TSP text products (for example if they would now have only a single method).
3. The PTWS TSPs request the ICG/PTWS to provide suggestions for alternative methods of PTWS TSP text product distribution in order to help ensure that all Member States have reliable and redundant methods.
4. The ICG/PTWS sets a target date to cease all telefaxing by the TSPs except to certain numbers at the discretion of each TSP.
5. The PTWS TSPs and the Member States explore and implement alternative dissemination methods to ensure all Member States continue to have reliable and redundant means for receiving PTWS TSP text products.

WG2 **request** the Secretariat to inform Member States of proposed changes, and **also request** Member States to **indicate** if the changes create unacceptable risks and **recommends** Member States to explore and implement alternative dissemination methods.

2 Task Team on National Tsunami Warning Centre Competency Framework (TT chairs Laura Kong and Ofa Fa'anunu)

2.1 Background

The TT Minimum Competency has completed its work on developing a minimum competency framework for NTWC. This framework is designed to be a dynamic structure in which Member States can adjust required competencies to suit their specific risk reduction needs. It is based on tiered competencies and is presented in Report of the TT for ICG-PTWS Agenda Item 4.3.

2.2 Proposal

WG2 endorses the following recommendations provided by the TT Minimum Competencies :

Recalling the requests from Pacific Island Countries in 2016 and at the Twenty-seventh Session of the ICG/PTWS-XXVII in 2017 for the PTWS Working Group Two to establish minimum competency levels for NTWC operations,

Recalling the Draft NTWC Competency Framework shared at the Twenty-eighth Session of the ICG/PTWS-XVIII in 2019, and the establishment of the Task Team on the Minimum Competency Levels for National Tsunami Warning Centre (NTWC) Operational Staff established under PTWS Working Group Two during this Session,

Recalling further the establishment of the Task Team on Capacity Development established under PTWS Regional Working Group for the Pacific Island Countries and Territories on Tsunami and Mitigation at Twenty-eighth Session of the ICG/PTWS-XXVII in 2019, to continue the development of competency framework for National Tsunami Warning Centres personnel and pilot it in Australia, Vanuatu, Fiji, Samoa and Tonga and report progress and lessons learnt to ICG/PTWS WG 1, 2 and 3,

Appreciating the initiative of Tonga, ITIC, PTWC, and IOC to pilot the Draft NTWC Competency Framework with the Tonga Meteorological and Geological Services and the Solomon Islands Meteorological Services in Nuku'alofa, Tonga in October 2019,

Appreciating feedback to the PTWS NTWC Competency Framework from Task Team on Capacity Development Report to the Ninth Session of PTWS PICT WG in February 2023,

Noting the TOWS WG-XV (2022) request to its Inter-ICG Task Teams on Disaster Management and Preparedness and Tsunami Watch Operations to consider development of guidelines for a global NTWC competency framework based on the available set of documents and Pacific input, noting that implementation can be at a regional level,

Noting the TOWS WG-XVI (2023) appreciation of the intersessional progress of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS) to develop a National Tsunami Warning Centre (NTWC) Competency Framework (2019), and the ITIC's leadership to pilot training courses based on the Framework,

Noting the TOWS WG-XVI (2023) instruction to the regional ICG, notably the PTWS, and the ITIC to pilot the PTWS National Tsunami Warning Centre (NTWC) Competency Framework for endorsement by ICG/PTWS with the goal to develop a global framework for all ICGs to use,

1. Recommends the National Tsunami Warning Centre Competency Framework, described in IOC PTWS-XXX.XX Working Document (Agenda 4.3), is accepted as the framework for minimum competencies for NTWC for the PTWS.

2. Welcomes the ITIC proposal to pilot the PTWS Minimum NTWC Competency Framework through the development and conducting of a training course during the intersessional period, and report back on its outcome to the Thirty-first Session of the ICG-PTWS.

3. WG2 acknowledges that the Minimum Competency TT has satisfied the TOR set for the group and recommends it is disbanded.

3 Task Team on Seismic Data Sharing in the southwest Pacific (Co-chairs Rennie Vaiomounga and Mathew Moihoi)

3.1 Activities during the intersessional period

TT work during the intersessional period resulted in the following proposals by the TT Data Sharing:

1. Facilitate the open sharing of seismic data by ORSNET members to harness the benefit of seismic data centres and services like the International Federation of Digital Seismograph Networks (FDSN) and help contribute towards the achievement of the Ocean Decade Goals

- Encourage partners and countries to collaborate and share seismic data in order to improve tsunami early warning

- Endorse the 7th ORSNET Meeting Outcomes. These are presented in Appendix 4 of this report.

3.2 Proposal

WG2 recommends the following actions:

WG2 **requests** the ICG-PTWS review the outcomes of the 7th ORSNET meeting presented in Appendix 4 of this report.

Noting the complementarity of TT Seismic Data Sharing and ORSNET and noting the regional focus of this task team, WG2 recommends ICG-PTWS **consider** moving the TT Seismic Data Sharing from WG2 to the Pacific Island Countries and Territories Working Group (WG PICT).

4 Matters arising from the Hunga Tonga/Hunga Ha'apai volcanic eruption and tsunami (Chair of ad hoc TT Francois Shindele)

During the intersessional period, WG2 responded to the eruption of the Hunga Tonga/Hunga Ha'apai volcanic eruption and tsunami and subsequent recovery. An ad-hoc Task Team (Chair Francois Shindele) was convened to support monitoring and tsunami early warning from possible continued unrest. An interim operational procedure for the PTWC was developed, accepted by Member States and implemented.

4.1 Proposal

WG2 **recommends** establishment of a permanent HTHH monitoring and warning system based on the products and method in place since March 2022 and presented in the CL 2882 and CL2902.

5 Task Team Integrated PTWS Sensor Networks for Tsunami Detection and Characterisation (Co-chairs Bill Fry and Tim Melbourne).

5.1 Background

Recognizing 1) the proliferation of DART tsunamimeters, 2) the significant potential of SMART Cables to support tsunami monitoring, and 3) advances in the analysis of real-time geodetic data for earthquake monitoring, the 28th session of the ICG-PTWS established the Task Team for Integrated PTWS Sensor Networks for Tsunami Detection and Characterisation. The terms of reference for this TT included the following 3 key aims:

- Developing a methodology for gap and sensitivity analysis that combines multiple sensing technologies for tsunami detection and characterisation.
- Integrating emerging techniques and sensor technologies (e.g. better use of tide gauges; GNSS technology and processing; sensors on telecom cables) with the existing sensing network to meet tsunami warning service requirements.
- Where possible, include cost-benefit analysis of the potential technologies being considered.

In Appendix 4 of this report, we present results of a framework to quantify network sensitivity for deep ocean measurements (e.g. DARTs) and terrestrial (fixed location) GNSS observation sites.

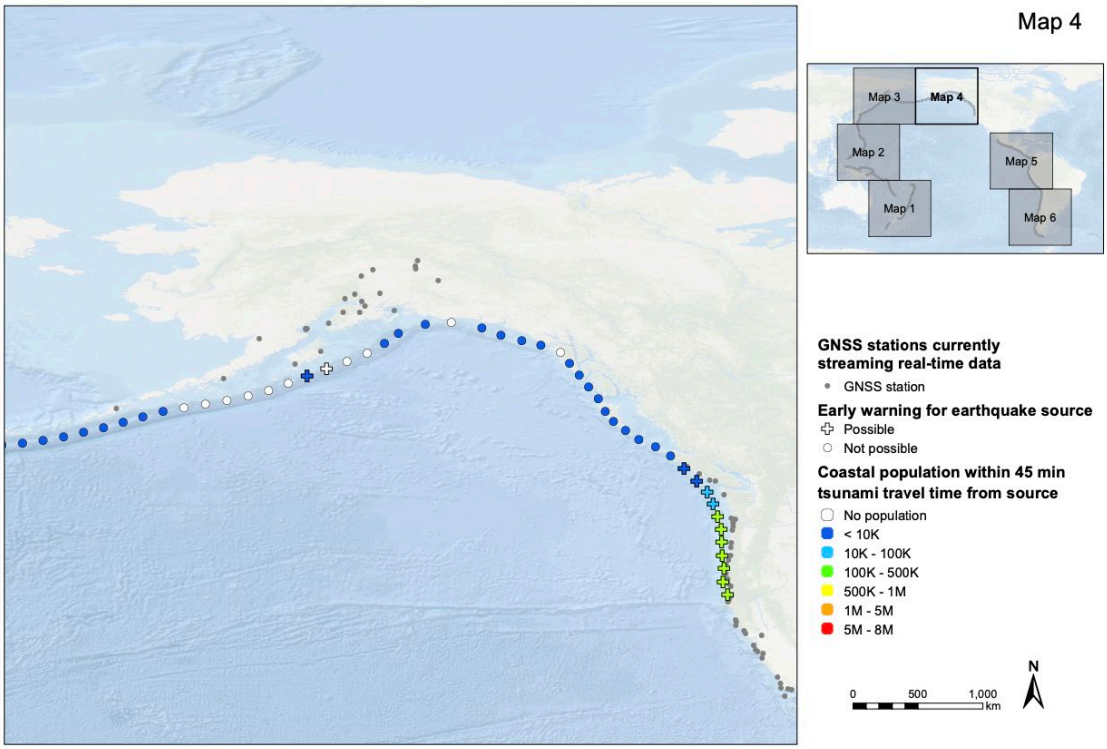

Figure 6, Example analysis of local subduction zone tsunami sources, linked to exposed local populations, for which geodetic coverage of GNSS stations currently streaming real-time data can provide tsunami early warning (shown as "+"). Sources without sufficient proximal geodetic stations are shown as "o". A full suite of maps for the entire circum-pacific is shown in Appendix 4.

Our network analysis is capable of ingesting SMART Cable observations when they are available. This analysis framework is based on time-to-detection. We highlight circum-pacific areas in which the disparate data streams can contribute to instrumental early warning. We attempt to analyse the cost-benefit potential of future technologies by first limiting network gap analysis to travel times > 45 minutes. For typical earthquake sources, 45-minute travel time is approximately the maximum distance that most tsunamigenic earthquakes will be widely and strongly felt.

We further extend the network analysis to define a risk-based framework, also presented in Appendix 4. We do this by defining the number of subduction zone unit sources for which exposed coastal populations could not reasonably expect the development of early warning based on 2-DART analysis of tsunami waves that would provide at least 20 minutes of pre-impact warning time. We developed this approach to address the future possibility of providing source-independent (typical earthquake generated and atypical non-earthquake source) tsunami early warning.

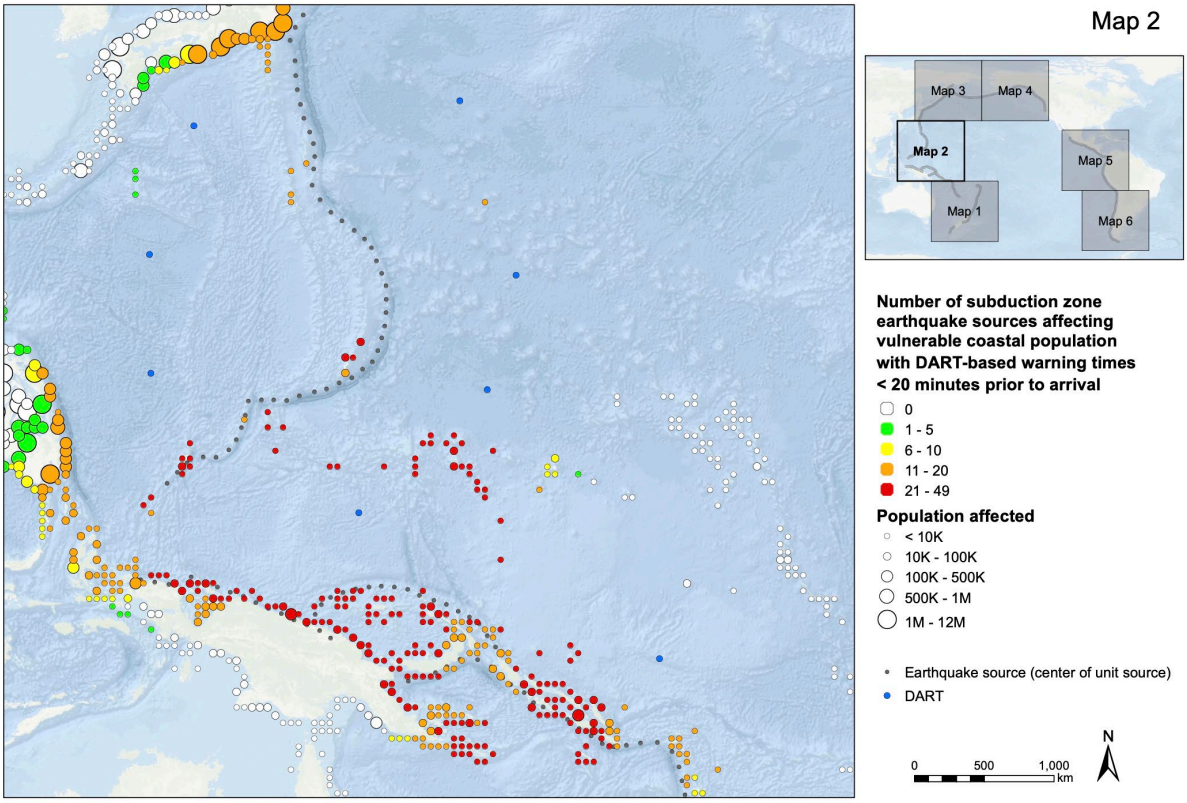

Figure 7, Example analysis of coastal population exposure to subduction zone tsunami sources for which the DART network is not capable of supporting 20-minute pre-impact warning times. A full suite of maps for the entire circum-pacific is shown in Appendix 4.

The TT also recognizes important advances in the possibility of future SMART Cable deployments that could contribute to the PTWS monitoring network. Significant SMART Cable projects include efforts to instrument the seafloor along a route between New Caledonia and Vanuatu and another route between New Zealand and Antarctica. Recent scientific advances have also highlighted the potential for novel measurements from submarine cables including Distributed Acoustic Sensing (DAS), a particularly promising way to use fibre cables as strain meters. The working group is closely following this technology primarily through active involvement in the Joint Task Force of the WMO/IOC/ITU in support of SMART Cables.

The TT also recognizes the scientific gains in the field of geodetic analysis of tsunamis and tsunamigenic earthquakes. The most mature of the geodetic methods is the analysis of geodesy for earthquake source models. We use the sensitivity of this approach to influence our network gap analysis presented in Appendix 4. More emerging techniques using geodetic data to directly measure or infer sea height hold great promise for source independent tsunami early warning. To capitalize on these advances to augment the gtws if/when they are mature enough for operational analysis, we are working closely with the IUGG Geodetic Tsunami Early Warning task team (GeTEWS). However, we note that the path to operationalization of geodetic analysis techniques will be long and complex, requiring significant effort to align IOC and IUGG workstreams.

5.2 Proposal

1. WG2 notes the need to expand our tsunami early warning capabilities to tsunamis generated by sources other than earthquakes. These may include volcanoes, weather systems or submarine landslides.

2. WG2 recommends that the TT on Integrated PTWS Sensor Networks for Tsunami Detection and Characterisation is continued and its terms of reference are expanded to explore options of source-independent tsunami early warning.

3. WG2 recommends the ICG/PTWS adopt the recommendations contained in the TOWS TT on Tsunamis Generated by Volcanoes. We note that the recommendations of establishment of new monitoring infrastructure may be beyond the capabilities of Member States. WG2 therefore recommends the establishment of TT to explore options for developing alternative warning strategies for TGV.

4. WG2 commends advances in SMART Cable initiatives in the Pacific and globally.

5. WG2 recommends the ICG/PTWS continue to work closely with the JTF for SMART Cables to utilise monitoring data from these efforts when they are available.

6. Noting the IUGG expertise in geodesy and geophysics, the establishment of the Geodetic Tsunami Early Warning Systems (GeTEWS) initiative in the southwest Pacific and recognising the complex and broad nature of advance in the field of geodetic monitoring of tsunamis, WG2 requests the ICG/PTWS establish a WG2 TT to support alignment of PTWS and GETWS efforts.

7. WG2 recommends the TT on Integrated networks develop a framework based on the Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme by which member states can contribute instruments/data/telemetry, etc in order to achieve ODTP tsunami detection, measurement and forecasting goals within PTWS. The framework should respect the data policies of each Member State.

8. WG2 recommends that ICG/PTWS continue the Task Team on Integrated PTWS Sensor Networks.

6 WG2 structural recommendations

Noting the large and increasing scope of WG2, we make the following recommendations to add capacity to the WG.

1. Recognising the increase in scope and complexity of WG2 through the requested establishment of an additional 2 TT, bringing the number to 6, and rapid advances in TEW methods, WG2 recommends the addition of 2 vice-chair roles to support the chair in the XXXI intersessional period.

2. WG2 requests the ICG/PTWS solicit confirmation of current members of WG2 and nominations for additional representatives from Member States.

7 Summary Proposal (following feedback from the XXX Session of the ICG/PTWS

WG2, Detection, Warning and Dissemination proposed ICG XXX recommendations

Task Team on National Tsunami Warning Centre Competency Framework (minimum competency).

Recommendations arising from the Minimum Competency Framework

1. **Recommends** the National Tsunami Warning Centre Competency Framework, described in IOC PTWS-XXX.XX Working Document (Agenda 4.5), is accepted as the framework for minimum competencies for NTWC for the PTWS.
2. **Welcomes** the ITIC proposal to pilot the PTWS Minimum NTWC Competency Framework through the development and conduct of a training course during the intersessional period, and report back on its outcome to the Thirty-first Session of the ICG-PTWS.
3. **Recommends** WG2 to report on the use of the Framework by Member States during the intersessional period at the Thirty-first Session of the ICG-PTWS.
4. **WG2** acknowledges that the Minimum Competency TT has satisfied the TOR set for the group and recommends it is disbanded.

Task Team on Tsunami Service Providers

5. WG2 **supports** the recommendation at the PTWS Steering Committee in March 2023 that proposes to expand the PTWS Earthquake Source Zone to include an area extending from 63° to 52° South latitude and from 72° to 18° West longitude.
6. WG2 further **requests** the IOC to change the PTWS Earthquake Source Zone map in the TS 130 (2016 version)

On the phasing out of telefaxing text products:

7. WG2 recommends that the ICG/PTWS requests the IOC to send a letter to all Member States informing them of the plan to terminate telefaxing as a method of receiving PTWS TSPs text products. The IOC informs that PTWS TSPs will begin to cease attempting to fax to all numbers that now routinely fail.
8. WG2 recommends that the IOC requests Member States to respond to the IOC if termination of TSP fax services will result in an unacceptable risk of not receiving TSP text products (for example if they would now have only a single method).
9. WG2 recommends that the ICG/PTWS sets a target date to cease all telefaxing by the TSPs except to certain numbers at the discretion of each TSP.
10. WG2 recommends that the PTWS TSPs and the Member States explore and implement alternative dissemination methods to ensure all Member States continue to have reliable and redundant means for receiving PTWS TSP text products.

On the proposed common framework for the TSP User Guide

11. WG2 recommends that the PTWS TSP adopt a common framework for users' guides as per appendix A to this report. (see appended framework).

Position on Maritime Messages

12. WG2 recommends that the ICG/PTWS establish a WG2 Task Team (TT) on the provision of tsunami information of the TSPs to the maritime community for navigational warning with

the following membership: All TSPs (PTWC, NWPTAC, SCSTAC), Chile, Peru, Russia, Australia and New Zealand

13. Until the formal establishment of procedures are developed by the TT, WG2 recommends the following interim measures regarding maritime messaging:

a. PTWC should be the only PTWS TSP to create and provide the special tsunami maritime safety products through the appropriate NTWC to all NAVAREA Coordinators in the Pacific.

b. With regard to provision of the special tsunami maritime safety products to all NAVAREA Coordinators in the Pacific, PTWC will transmit them to the NTWCs as well as the ordinary tsunami bulletin and the NTWCs will forward it to the NAVAREA Coordinators in their countries.

c. In addition, the other TSPs as well as NTWCs can provide their own more specific tsunami information to the NAVAREA Coordinator(s) appropriate for their respective service areas.

d. NTWCs are responsible for management of the focal point as well as coordination on forwarding methods to the NAVAREA Coordinator covering the country of the NTWC.

Proposed PTWC product changes

14. Responding to feedback from Member States over the last several years, WG2 recommends the following changes to PTWC products:

a. List countries and territories named with a tsunami threat in alphabetical order in the initial threat messages issued before there is a numerical tsunami forecast.

b. Organize expected first arrival times (ETAs) by country or territory.

c. Organize gauge observations by country or territory.

d. Designate the type of measurement that was made for gauge observations. The proposed change is to label each observation as representing a maximum crest relative to the normal tide level, a maximum trough relative to the normal tide level, or half of the maximum crest-to-trough or trough-to-crest of a single wave. To make space for the amplitude measurement indicator within the 65-character line length limit, the column for the wave period has been removed but we are seeking further discussion from the ICG. To further reduce potential confusion, this change also includes the elimination of the term “height” that may be misinterpreted as the total crest-to-trough or trough-to-crest measurement and instead only uses the term “amplitude”.

15. WG2 suggest TSP include detailed explanation of gauge measurements in Users Guides and attempt to coordinate definitions across TSP

16. WG2 requests, where possible, PTWC to distribute planned changes in messaging to TSPs with as much time as possible (preferably > 6 months) prior to release of new products.

Task Team on Seismic Data Sharing in the Southwest Pacific

17. WG2 endorses the recommendation on TT SDS

18. Noting the considerable overlap of the TORE of the SDS TT and the PICT WG, WG2 recommends that the Task Team on Seismic Data Sharing in the SW Pacific is integrated into the PICT.

19. WG2 recommends that the ICG/PTWS consider the 7th ORSNET Meeting Outcomes

20. WG2 requests the ICG/PTWS consider a capacity development programme to strengthen competency and capability of national tsunami warning centres, seismic and volcano observatories including the training and support provided by ITIC, bilateral partners and peer to peer and mentoring exchanges between members.

21. WG2 requests that the ICG/PTWS continue to support the institutional arrangements for early warning including the development of legislation and policies with clearly defined responsibilities between warning centres, observatories, and disaster management

22. WG2 recommends that the ICG/PTWS facilitates a periodic stocktake of the geohazards observatories in the Pacific re: volcano, seismic and tsunami as part of strengthening MHEWS. This should include the services that support early warning such as communication, staff competencies, arrangements

23. WG2 recommends that the ICG/PTWS encourages countries to advocate for the investment in new and emerging technologies such as the Science Monitoring and Reliable Telecommunications (SMART) subsea cable systems and GNSS, to improve early warning

24. Resulting from learnings during the response to the Hunga Tonga Hunga Ha'apai event, WG2 recommends that the ICG-PTWS consider developing guidelines for requesting post event technical assistance to include:

- **a.** the assessment of tsunami warning capability;
- **b.** harmonisation with disaster management protocols for the deployment of goods, personnel and services; and
- **c.** development of National Post-Tsunami Field Survey Guide for PICTs
- d. Develop a web-portal for collaboration & communication solution to secure and storing information which ORSNET members countries can access, upload & download data.
- e. Explore resources available within ORSNET countries and how assistance can be mobilized within to assist member countries that require assistance

25. WG2 commends Geoscience Australia for the technical advice and support to Papua New Guinea to strengthen and extend their national seismic monitoring network and Tonga post HTHH to setup an immediate seismic network, and emphasise that under the data sharing arrangements, data from the new stations are improving earthquake monitoring capability in the region.

26. WG2 notes the research undertaken by GNS/CPPT/GA to improve tsunami early warning in the SW Pacific using Mww and reiterates the dearth of open data in the region increases the uncertainty in earthquake paramaters and tsunami forecasts.

Task team on integrated PTWS sensor networks

27. WG2 notes the need to expand our tsunami early warning capabilities to tsunamis generated by sources other than earthquakes. These may include volcanoes, weather systems or submarine landslides.

28. WG2 recommends that the ICG/PTWS amend the terms of reference of the TT on Integrated PTWS Sensor Networks for Tsunami Detection and Characterisation to explore options of source-independent tsunami early warning and extend its membership to increase TT capability.

29. WG2 recommends the ICG/PTWS adopt the recommendations contained in the TOWS TT on Tsunamis Generated by Volcanoes. We note that the recommendations of establishment of new monitoring infrastructure may be beyond the capabilities of Member States. WG2 therefore recommends the establishment of TT to explore options for developing alternative warning strategies for TGV.

30. WG2 commends advances in SMART Cable initiatives in the Pacific.

31. WG2 recommends the ICG/PTWS continue to work closely with the JTF for SMART Cables to utilise monitoring data from these efforts when they are available.

32. Noting the IUGG expertise in geodesy and geophysics, the establishment of the Geodetic Tsunami Early Warning Systems (GaTEWS) initiative in the southwest Pacific and recognising the complex and broad nature of advance in the field of geodetic monitoring of tsunamis, WG2 requests the ICG/PTWS establish a WG2 TT to support alignment of PTWS and GETWS efforts.

33. WG2 recommends the TT on Integrated networks develop a framework based on the Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme by which member states can contribute instruments/data/telemetry, etc in order to achieve ODTP tsunami detection, measurement and forecasting goals within PTWS. The framework should respect the data policies of each Member State.

34. WG2 recommends that ICG/PTWS continue the Task Team on Integrated PTWS Sensor Networks.

35. WG2 recommends establishment of a permanent HTHH monitoring and warning system based on the products and method in place since March 2022 and presented in the CL 2882 and CL2902.

Recommendations to alter the structure of WG2

36. Recognising the increase in scope and complexity of WG2 through the requested establishment of an additional 2 TT, bringing the number to 6, and rapid advances in TEW methods, WG2 recommends the addition of 2 vice-chair roles to support the chair in the XXXI intersessional period.

37. WG2 requests the ICG/PTWS solicit confirmation of current members of WG2 and nominations for additional representatives from Member States.

Appendix 1. Change examples from TT TSP

Examples of each proposed change, showing the current and proposed message content, are given below.

1. Countries and territories in alphabetical order

Current

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TSUNAMI THREAT FORECAST
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  * HAZARDOUS TSUNAMI WAVES FROM THIS EARTHQUAKE ARE POSSIBLE
    WITHIN THE NEXT THREE HOURS ALONG SOME COASTS OF

      TONGA... NIUE... AMERICAN SAMOA... SAMOA... WALLIS AND
      FUTUNA... KERMADEC ISLANDS... TOKELAU... COOK ISLANDS...
      FIJI... TUVALU... KIRIBATI... NEW ZEALAND AND HOWLAND AND
      BAKER
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Proposed

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TSUNAMI THREAT FORECAST
-----------------------

  * THIS IS A TEST MESSAGE. HAZARDOUS TSUNAMI WAVES FROM THIS
    EARTHQUAKE ARE POSSIBLE WITHIN THE NEXT THREE HOURS ALONG
    SOME COASTS OF

      AMERICAN SAMOA... COOK ISLANDS... FIJI... HOWLAND AND
      BAKER... KERMADEC ISLANDS... KIRIBATI... NEW ZEALAND...
      NIUE... SAMOA... TOKELAU... TONGA... TUVALU AND WALLIS AND
      FUTUNA
```

2. ETAs organized by country or territory

Current

ESTIMATED TIMES OF ARRIVAL

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* ESTIMATED TIMES OF ARRIVAL -ETA- OF THE INITIAL TSUNAMI WAVE FOR PLACES WITH A POTENTIAL TSUNAMI THREAT. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	REGION	COORDINATES	ETA(UTC)
HOLEVA	TONGA	18.6S 173.9W	2135 08/22
NIUE ISLAND	NIUE	19.0S 170.0W	2135 08/22
NUKUALOFA	TONGA	21.0S 175.2W	2143 08/22
NIUATOPUTAPU	TONGA	15.9S 173.8W	2154 08/22
PAGO PAGO	AMERICAN SAMOA	14.3S 170.7W	2156 08/22
APIA	SAMOA	13.8S 171.8W	2209 08/22
WALLIS ISLAND	WALLIS AND FUTUN	13.2S 176.2W	2221 08/22
RAOUL ISLAND	KERMADEC ISLANDS	29.2S 177.9W	2230 08/22
NUKUNONU ISLAND	TOKELAU	9.2S 171.8W	2240 08/22
PUKAPUKA ISLAND	COOK ISLANDS	10.8S 165.9W	2243 08/22
FUTUNA ISLAND	WALLIS AND FUTUN	14.3S 178.2W	2244 08/22
RAROTONGA	COOK ISLANDS	21.2S 159.8W	2253 08/22
SUVA	FIJI	18.1S 178.4E	2319 08/22
FUNAFUTI ISLAND	TUVALU	7.9S 178.5E	2328 08/22
KANTON ISLAND	KIRIBATI	2.8S 171.7W	2333 08/22
LOTTIN POINT	NEW ZEALAND	37.5S 178.2E	2334 08/22
PENRYN ISLAND	COOK ISLANDS	8.9S 157.8W	2348 08/22
GISBORNE	NEW ZEALAND	38.7S 178.0E	2355 08/22
HOWLAND ISLAND	HOWLAND AND BAKE	0.6N 176.6W	0000 08/23
NORTH CAPE	NEW ZEALAND	34.4S 173.3E	0004 08/23
MOUNT MAUNGANUI	NEW ZEALAND	37.6S 176.2E	0004 08/23

Proposed

ESTIMATED TIMES OF ARRIVAL

---

* ESTIMATED TIMES OF ARRIVAL -ETA- OF THE INITIAL TSUNAMI WAVE FOR PLACES WITH A POTENTIAL TSUNAMI THREAT. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	COORDINATES	ETA(UTC)
TONGA		
HOLEVA	18.6S 173.9W	2135 08/22
NUKUALOFA	21.0S 175.2W	2143 08/22
NIUATOPUTAPU	15.9S 173.8W	2154 08/22
NIUE		
NIUE ISLAND	19.0S 170.0W	2135 08/22
AMERICAN SAMOA		
PAGO PAGO	14.3S 170.7W	2156 08/22
SAMOA		
APIA	13.8S 171.8W	2209 08/22
WALLIS AND FUTUNA		
WALLIS ISLAND	13.2S 176.2W	2221 08/22
FUTUNA ISLAND	14.3S 178.2W	2244 08/22
KERMADEC ISLANDS		
RAOUL ISLAND	29.2S 177.9W	2230 08/22
TOKELAU		
NUKUNONU ISLAND	9.2S 171.8W	2240 08/22
COOK ISLANDS		
PUKAPUKA ISLAND	10.8S 165.9W	2243 08/22
RAROTONGA	21.2S 159.8W	2253 08/22
PENRYN ISLAND	8.9S 157.8W	2348 08/22
FIJI		
SUVA	18.1S 178.4E	2319 08/22

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TUVALU
  FUNAFUTI ISLAND              7.9S 178.5E   2328 08/22
KIRIBATI
  KANTON ISLAND                2.8S 171.7W   2333 08/22
NEW ZEALAND
  LOTTIN POINT                37.5S 178.2E   2334 08/22
  GISBORNE                    38.7S 178.0E   2355 08/22
  NORTH CAPE                  34.4S 173.3E   0004 08/23
  MOUNT MAUNGANUI             37.6S 176.2E   0004 08/23
HOWLAND AND BAKER
  HOWLAND ISLAND               0.6N 176.6W   0000 08/23
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3. Organize gauge observations by country or territory, and
4. Designate the type of measurement made for each gauge and eliminate the term “height”.

Current

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TSUNAMI OBSERVATIONS
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  * THE FOLLOWING ARE TSUNAMI WAVE OBSERVATIONS FROM COASTAL
    AND/OR DEEP-OCEAN SEA LEVEL GAUGES AT THE INDICATED LOCATIONS.
    THE MAXIMUM TSUNAMI HEIGHT IS MEASURED WITH RESPECT TO THE
    NORMAL TIDE LEVEL.
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GAUGE LOCATION	GAUGE COORDINATES LAT	LON	TIME OF MEASURE (UTC)	MAXIMUM TSUNAMI HEIGHT	WAVE PERIOD (MIN)
BETIO TARAWA KI	1.4N	172.9E	0128	0.94M/ 3.1FT	28
OWENGA CHATHAM NZ	44.0S	176.4W	0122	0.58M/ 1.9FT	28
OWENGA NZ	44.0S	176.4W	0120	0.58M/ 1.9FT	28
DART 01005	26.7S	164.0E	0119	0.08M/ 0.3FT	16
LITZLITZ VU	16.1S	167.4E	0122	0.57M/ 1.9FT	18
LUGANVILLE VU	15.5S	167.2E	0119	0.74M/ 2.4FT	28
NUMBO NEW CALEDONIA	22.2S	166.4E	0110	0.55M/ 1.8FT	26

PALMYRA ISLAND US	5.9N	162.1W	0109	0.51M/ 1.7FT	28
CHRISTMAS KI	2.0N	157.5W	0110	0.78M/ 2.6FT	26
HIENGHENE NEW CALED	20.7S	164.9E	0108	0.42M/ 1.4FT	22
THIO NEW CALEDONIA	21.6S	166.2E	0104	0.73M/ 2.4FT	28
RANGIROA PF	14.9S	147.7W	0104	1.57M/ 5.2FT	24
KINGSTON NORFOLK IS	29.1S	168.0E	0056	0.68M/ 2.2FT	20
OUINNE NEW CALEDONI	22.0S	166.7E	0052	0.74M/ 2.4FT	26
VANUATU	17.8S	168.3E	0052	0.90M/ 2.9FT	20
OUVEA NEW CALEDONIA	20.5S	166.6E	0053	0.89M/ 2.9FT	16
KAIKOURA NZ	42.4S	173.7E	0050	0.30M/ 1.0FT	20
DART 01007	19.3S	166.8E	0047	0.06M/ 0.2FT	20
LENAKEL VU	19.5S	169.3E	0040	0.93M/ 3.0FT	18
PORT NAPIER NZ	39.5S	176.9E	0044	0.86M/ 2.8FT	18
NAPIER NZ	39.5S	176.9E	0037	0.86M/ 2.8FT	24
LIFOU NEW CALEDONIA	20.9S	167.3E	0035	0.69M/ 2.3FT	18
MARE NEW CALEDONIA	21.5S	167.9E	0035	0.85M/ 2.8FT	28
PAPEETE TAHITI	17.5S	149.6W	0035	3.33M/10.9FT	18
VAIRAO FP FR	17.8S	149.3W	0038	5.80M/19.0FT	20
NORTH CAPE NZ	34.4S	173.0E	0032	0.86M/ 2.8FT	22
NORTH CAPE NZ	34.4S	173.0E	0029	0.86M/ 2.8FT	26
GREAT BARRIER IS NZ	36.2S	175.5E	0025	1.26M/ 4.1FT	22
GREAT BARRIER IS NZ	36.2S	175.5E	0023	1.26M/ 4.1FT	24
TUBUAI PF	23.3S	149.5W	0024	4.71M/15.5FT	28
CASTLEPOINT NZ	40.9S	176.2E	0030	0.70M/ 2.3FT	18
CASTLE POINT NZ	40.9S	176.2E	0024	0.70M/ 2.3FT	14
HUAHINE PF	16.7S	151.0W	0020	2.23M/ 7.3FT	18
PORT TAURANGA NZ	37.6S	176.2E	0019	1.02M/ 3.3FT	24
PORT TAURANGA NZ	37.6S	176.2E	0023	1.02M/ 3.3FT	26
DART 01002	42.4S	176.9E	0021	0.08M/ 0.3FT	22
DART 01006	24.3S	169.5E	0017	0.09M/ 0.3FT	22
VATIA VITI LEVU FJ	17.4S	177.8E	0013	1.09M/ 3.6FT	26
LAUTOKA FJ	17.6S	177.4E	0008	0.81M/ 2.7FT	16
GISBORNE EASTLAND N	38.7S	178.0E	0004	0.85M/ 2.8FT	22
GISBORNE NZ	38.7S	178.0E	0004	0.85M/ 2.8FT	26

PENRHYN CK	9.0S	158.1W	2355	0.96M/ 3.1FT	22
DART 01003	40.6S	179.1E	2351	0.08M/ 0.3FT	18
FONGAFALE TV	8.5S	179.2E	2350	0.98M/ 3.2FT	28
EAST CAPE NZ	37.6S	178.2E	2348	1.22M/ 4.0FT	24
LOTTIN PT NZ	37.6S	178.2E	2341	1.22M/ 4.0FT	14
KANTON KI	2.8S	171.7W	2345	0.63M/ 2.1FT	26
SUVA VITI LEVU FJ	18.1S	178.4E	2329	1.26M/ 4.2FT	28
DART 01000	38.2S	179.8W	2326	0.12M/ 0.4FT	28
DART 01004	36.1S	178.6E	2323	0.16M/ 0.5FT	22
DART 01001	36.0S	177.7W	2306	0.08M/ 0.3FT	16
RAROTONGA CK	21.2S	159.8W	2301	5.48M/18.0FT	28
DART 51425	9.5S	176.2W	2300	0.15M/ 0.5FT	22
FUTUNA IS FR	14.3S	178.2W	2257	3.57M/11.7FT	28
FISHING ROCK RAOUL	29.3S	177.9W	2238	1.70M/ 5.6FT	16
FISHING ROCK RAOUL	29.3S	177.9W	2239	1.70M/ 5.6FT	18
RAOUL IS BOAT COVE	29.3S	177.9W	2237	1.37M/ 4.5FT	20
BOAT COVE RAOUL IS	29.3S	177.9W	2235	1.37M/ 4.5FT	24
WALLIS IS FR	13.2S	176.1W	2234	1.26M/ 4.1FT	26
DART 01002	29.7S	175.0W	2224	0.08M/ 0.3FT	18
APIA UPOLU WS	13.8S	171.8W	2221	1.15M/ 3.8FT	26
OFU AS	14.2S	169.7W	2209	1.36M/ 4.5FT	26
TAU AS	14.2S	169.5W	2217	1.27M/ 4.2FT	26
AUNUU AS	14.3S	170.6W	2211	1.08M/ 3.5FT	20
AUASI AS	14.3S	170.6W	2213	1.08M/ 3.5FT	22
PAGO PAGO AS	14.3S	170.7W	2211	1.46M/ 4.8FT	22
PAGO PAGO AS	14.3S	170.7W	2208	1.46M/ 4.8FT	16
NUKUALOFA TO	21.1S	175.2W	2159	3.88M/12.7FT	24
NUKUALOFA TO	21.1S	175.2W	2201	3.88M/12.7FT	14
DART 01005	16.9S	171.2W	2151	0.30M/ 1.0FT	20
ALOFI NU	19.1S	169.9W	2141	10.00M/32.8FT	24
DART 01003	23.4S	173.4W	2141	0.31M/ 1.0FT	22
DART 01004	20.1S	171.9W	2124	1.38M/ 4.5FT	16

Proposed

TSUNAMI OBSERVATIONS

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* THE FOLLOWING ARE TSUNAMI WAVE OBSERVATIONS FROM COASTAL AND/OR DEEP-OCEAN SEA LEVEL GAUGES AT THE INDICATED LOCATIONS. THE TYPE OF MEASUREMENT OF MAXIMUM TSUNAMI AMPLITUDE IS INDICATED WITH THE FOLLOWING CODE.

  HF - HALF THE MAXIMUM CREST-TO-TROUGH OR TROUGH-TO-CREST

  CR – MAXIMUM CREST RELATIVE TO THE NORMAL TIDE LEVEL

  TR – MAXIMUM TROUGH RELATIVE TO THE NORMAL TIDE LEVEL

GAUGE LOCATION	GAUGE COORDINATES LAT	LON	TIME UTC	MAXIMUM TSUNAMI AMPLITUDE	MEAS TYPE
KIRIBATI					
BETIO TARAWA	1.4N	172.9E	0128	1.88M/ 6.2FT	HF
CHRISTMAS	2.0N	157.5W	0110	1.56M/ 5.1FT	CR
KANTON	2.8S	171.7W	2345	1.25M/ 4.1FT	HF
NEW_ZEALAND					
OWENGA CHATHAM	44.0S	176.4W	0122	1.15M/ 3.8FT	TR
OWENGA	44.0S	176.4W	0120	1.15M/ 3.8FT	HF
KAIKOURA	42.4S	173.7E	0050	0.60M/ 2.0FT	HF
PORT NAPIER	39.5S	176.9E	0044	1.73M/ 5.7FT	CR
NAPIER	39.5S	176.9E	0037	1.73M/ 5.7FT	CR
NORTH CAPE	34.4S	173.0E	0032	1.72M/ 5.6FT	TR
NORTH CAPE	34.4S	173.0E	0029	1.72M/ 5.6FT	HF
GREAT BARRIER IS	36.2S	175.5E	0025	2.52M/ 8.3FT	HF
GREAT BARRIER IS	36.2S	175.5E	0023	2.52M/ 8.3FT	HF
CASTLEPOINT	40.9S	176.2E	0030	1.39M/ 4.6FT	TR
CASTLE POINT	40.9S	176.2E	0024	1.39M/ 4.6FT	HF
PORT TAURANGA	37.6S	176.2E	0019	2.04M/ 6.7FT	HF
PORT TAURANGA	37.6S	176.2E	0023	2.04M/ 6.7FT	CR
GISBORNE EASTLAND	38.7S	178.0E	0004	1.71M/ 5.6FT	HF

GISBORNE	38.7S	178.0E	0004	1.71M/ 5.6FT	HF
EAST CAPE	37.6S	178.2E	2348	2.44M/ 8.0FT	HF
LOTTIN PT	37.6S	178.2E	2341	2.44M/ 8.0FT	TR
FISHING ROCK RAOUL I	29.3S	177.9W	2238	3.40M/11.2FT	HF
FISHING ROCK RAOUL I	29.3S	177.9W	2239	3.40M/11.2FT	TR
RAOUL IS BOAT COVE	29.3S	177.9W	2237	2.75M/ 9.0FT	HF
BOAT COVE RAOUL IS	29.3S	177.9W	2235	2.75M/ 9.0FT	HF
DART					
4G 5501005	26.7S	164.0E	0119	0.17M/ 0.6FT	HF
4G 5501007	19.3S	166.8E	0047	0.13M/ 0.4FT	HF
4G NZ E COAST 550100	42.4S	176.9E	0021	0.17M/ 0.6FT	HF
4G 5501006	24.3S	169.5E	0017	0.17M/ 0.6FT	HF
4G NZ E COAST 550100	40.6S	179.1E	2351	0.16M/ 0.5FT	CR
4G NZ E COAST 540100	38.2S	179.8W	2326	0.24M/ 0.8FT	HF
4G 5501004	36.1S	178.6E	2323	0.31M/ 1.0FT	HF
4G NZ E COAST 540100	36.0S	177.7W	2306	0.16M/ 0.5FT	HF
APIA 51425	9.5S	176.2W	2300	0.30M/ 1.0FT	HF
4G TONGA 5401002	29.7S	175.0W	2224	0.17M/ 0.6FT	CR
4G TONGA 5401005	16.9S	171.2W	2151	0.60M/ 2.0FT	HF
4G TONGA 5401003	23.4S	173.4W	2141	0.62M/ 2.1FT	HF
4G TONGA 5401004	20.1S	171.9W	2124	2.75M/ 9.0FT	HF
VANUATU					
LITZLITZ	16.1S	167.4E	0122	1.13M/ 3.7FT	HF
LUGANVILLE	15.5S	167.2E	0119	1.48M/ 4.8FT	TR
LENAKEL	19.5S	169.3E	0040	1.86M/ 6.1FT	TR
FRANCE					
NUMBO NEW CALEDONIA	22.2S	166.4E	0110	1.09M/ 3.6FT	HF
THIO NEW CALEDONIA	21.6S	166.2E	0104	1.46M/ 4.8FT	HF
OUINNE NEW CALEDONIA	22.0S	166.7E	0052	1.49M/ 4.9FT	CR
OUVEA NEW CALEDONIA	20.5S	166.6E	0053	1.77M/ 5.8FT	HF
LIFOU NEW CALEDONIA	20.9S	167.3E	0035	1.38M/ 4.5FT	CR
VAIRAO FP	17.8S	149.3W	0038	11.60M/38.1FT	HF
FUTUNA IS	14.3S	178.2W	2257	7.14M/23.4FT	TR
WALLIS IS	13.2S	176.1W	2234	2.53M/ 8.3FT	HF

USA

PALMYRA ISLAND	5.9N	162.1W	0109	1.02M/ 3.4FT	HF

OTHER

HIENGHENE NEW CALEDO	20.7S	164.9E	0108	0.83M/ 2.7FT	HF
VANUATU	17.8S	168.3E	0052	1.79M/ 5.9FT	HF
MARE NEW CALEDONIA F	21.5S	167.9E	0035	1.70M/ 5.6FT	CR
PAPEETE TAHITI	17.5S	149.6W	0035	6.66M/21.9FT	HF

FRENCH_POLYNESIA

RANGIROA	14.9S	147.7W	0104	3.15M/10.3FT	HF
TUBUAI	23.3S	149.5W	0024	9.43M/30.9FT	CR
HUAHINE	16.7S	151.0W	0020	4.45M/14.6FT	HF

AUSTRALIA

KINGSTON NORFOLK IS	29.1S	168.0E	0056	1.36M/ 4.4FT	HF

FIJI

VATIA VITI LEVU	17.4S	177.8E	0013	2.17M/ 7.1FT	HF
LAUTOKA	17.6S	177.4E	0008	1.62M/ 5.3FT	TR
SUVA VITI LEVU	18.1S	178.4E	2329	2.53M/ 8.3FT	HF

COOK_ISLANDS

PENRHYN	9.0S	158.1W	2355	1.92M/ 6.3FT	HF
RAROTONGA	21.2S	159.8W	2301	10.96M/36.0FT	HF

TUVALU

FONGAFALE	8.5S	179.2E	2350	1.97M/ 6.5FT	HF

SAMOA

APIA UPOLU	13.8S	171.8W	2221	2.30M/ 7.5FT	HF

AMERICAN_SAMOA

OFU	14.2S	169.7W	2209	2.71M/ 8.9FT	HF
TAU	14.2S	169.5W	2217	2.54M/ 8.3FT	CR
AUNUU	14.3S	170.6W	2211	2.16M/ 7.1FT	CR
AUASI	14.3S	170.6W	2213	2.16M/ 7.1FT	HF
PAGO PAGO	14.3S	170.7W	2211	2.93M/ 9.6FT	HF
PAGO PAGO	14.3S	170.7W	2208	2.93M/ 9.6FT	HF

TONGA

NUKUALOFA	21.1S	175.2W	2159	7.77M/25.5FT	HF
NUKUALOFA	21.1S	175.2W	2201	7.77M/25.5FT	HF

NIUE

ALOFI	19.1S	169.9W	2141	20.01M/65.6FT HF

Appendix 2. Proposed Common PTWS TSP Users' Guide Table of Contents

In bold below is the structure and the main headings and sub-headings that should be included in all TSP Users' Guides. Other sub-headings, if necessary, would be at the discretion of individual TSPs based upon their unique capabilities, procedures, and products. Other common headings in all TSP User's Guides may be included, if necessary, with a consensus among the TSPs.

Change Log

The User's Guide is a living document that may require changes over time to reflect changes in TSP services, products, or other information. This section includes a table providing a brief description of any changes made, and the date of the change.

Executive Summary

This section may include some background information about the TSP, why the document exists, and a general summary of the document content.

1. Overview

1.1. Background

This section should contain background information about the country and organization that operates the TSP, why there is a need for the TSP, and how and when the TSP came into existence and how it is governed within the processes of IOC Tsunami Unit and the ICG/PTWS as well as within its own national organization.

1.2. Area of Service

This section should describe the coastal areas covered by the TSP and include a map indicating those coastal areas.

1.3. Earthquake Source Zone

This section should describe the seismic source area covered by the TSP and include a map of that area, ideally showing the seismicity and other potential tsunami sources such as active volcanoes. The section should note if sources other than earthquakes are also covered in some way. It should also note if any tsunami sources outside the normal Earthquake Source Zone will be covered if they produce tsunamis affecting the Area of Service.

1.4. Tsunami Hazard

This section should provide an overview of the known tsunami hazard for the Area of Service. It should include information about any significant historical tsunamis affecting the region as well as potential tsunamis that are not yet in the historical record.

2. Operations

2.1. TSP Facility

This section should contain information about the TSP operational facility including where it is located, what it contains in terms of an operations center, offices, IT and communications, how it is staffed overall and for 24x7 operations, and how it is backed up.

2.2. Operational Tools and Procedures

2.2.1. Tsunami Source Detection and Characterization

This section should primarily and generally describe the capabilities and procedures for rapidly detecting and characterizing large earthquakes and determining their tsunamigenic potential. The section should include a map of the seismic stations and any other sensors such as GNSS stations used for this task. It may also describe the same for other tsunami sources such as volcanoes or landslides if such capabilities and procedures exist.

2.2.2. Tsunami Wave Observations

This section should generally describe the capability for rapidly detecting and measuring tsunami waves that may produce hazardous impacts within the Area of Service, and also for monitoring tsunami waves impacting coasts within that area. It should include a map of those sensors that may be coastal sea level gauges, deep-ocean tsunameters, or other sensors.

2.2.3. Tsunami Forecasting

This section should generally describe tools such as those for tsunami travel time calculations and real-time or pre-run hydrodynamic models used for forecasting tsunami amplitudes and other impacts. It should include a brief description of their methodologies, constraining data, assumptions, strengths and weaknesses, and other characteristics.

2.2.4. Decision Support

This section should describe any tools employed by the analysts on duty at the TSP to aid them in maintaining situational awareness as an event unfolds in order to make soundly-based decisions regarding the tsunami forecasts, the types of products to be issued, and the content of those products.

2.2.5. Product Creation and Dissemination

This section should generally describe how the TSP products are created and disseminated. More detail about the products and dissemination methods is contained in later sections of the Guide.

2.2.6. Timeline

This section provides a general timeline and description of events that occur in carrying out TSP critical operations: from the source event (usually an earthquake), to the source detection and alarms, source characterization and evaluation of hazardous tsunamigenic potential, travel time determinations, issuance of initial products, tsunami wave confirmation and measurement, tsunami impact forecasting, issuance of subsequent products with forecasts and observations, and issuance of a final product.

3. Products

3.1. Product Types and Criteria

3.1.1. Informational

This section should note that the TSP will issue products for large earthquakes that have occurred but that present no tsunami threat to the Area of Service. It should indicate the criteria for those products such as magnitude and depth thresholds. It should also contain information about any other situations when an informational

statement would be issued – for example in the case of a very distant source when the tsunami threat to the Area of Service is still under evaluation. It could be noted that informational products will be the most frequent products and provide a general idea of their frequency based on the historical seismicity and how often it meets informational product criteria.

3.1.2. Threat

This section should contain basic information about how the TSP handles tsunami threat situations. The section may be divided into sub-headings that describe the different stages of the crisis through time that include: rapid source detection with a potential tsunami threat, a confirmed tsunami, a validated tsunami forecast, observed tsunami impacts, and the end of the tsunami threat. Included should be the criteria for issuing initial tsunami threat products such as the earthquake magnitude, depth, and onshore-offshore thresholds, and how those criteria map into the coastal areas named with a potential threat. It should also describe the criteria for issuing subsequent threat products based upon tsunami wave observations and on numerical forecast information, and again describe how this information is applied to indicate the level of impact along various coasts. If there are categories of threat such as a threat to marine areas, coastal flooding threat, or major tsunami threat, then the criteria for those categories should be defined. This section should also contain the criteria for issuing a final threat product indicating that the threat is largely over.

3.2. Product Content

3.2.1. Text Products

The categories of information and how it is organized in text products is described in this section. Each category may warrant its own sub-heading in the Table of Contents. These might include: Product Heading, Product Title, Earthquake Parameters, Current State of the Tsunami Evaluation, Threatened Coastal Areas, Forecast Arrival Times, Forecast Amplitudes, Tsunami Observations, and Tsunami Safety Information. Each of those sub-sections should provide sufficient detail to enable recipients to properly understand the text product and to base actions on the text product if necessary.

3.2.2. Graphical Products

This section should describe any graphical products that would be issued. Usually this would only be for threat messages. Each type of graphical product should be under its own sub-heading. These could include a forecast tsunami travel-time map, a tsunami propagation map showing forecast maximum amplitudes across the ocean basin, a coastal forecast maximum amplitudes map, and a tsunami gauge observations map. Each of those sub-sections should provide sufficient detail about each graphical product to enable recipients to properly understand them and use them to inform their actions if necessary.

4. Dissemination

4.1. Methodologies

This section needs to describe the various ways that TSP information about a potential or actual tsunami threat reaches Member State TWFPs and NTWCs as well as how any public information is more widely disseminated.

4.1.1. Products

TSP text and graphical products are disseminated by various electronic communication methods and each of these should be described in its own sub-heading. Only communication links and methods that are under the control of the TSP or related government or international organizations such as the WMO are included. Dissemination by commercial third parties is useful, of course, but unless the third party is intentionally fed products by the TSP, such as might be the case with social media outlets like Facebook, then they are not necessary to be included. Key methods such as the GTS, AFTN, email, fax, SMS, website, CISN, etc. should be included and described under their own sub-headings.

4.1.2. Customer Decision Support

TSP staff may reach out to customers during events to ensure they are aware of a tsunami situation and ensure they have received any TSP products issued. They may also provide additional information to help with customer decision-making. Any such procedures should be described in this section and listed under separate sub-headings when appropriate. Procedures of this sort might include: call-down lists, conference calls, chat rooms, social media, and mass media interactions. It should be noted if such procedures are prescribed procedures or are ad-hoc and voluntary depending on staff availability.

4.2. Communication Testing

This section describes how TSPs routinely ensure that their products are reaching Member State TWFPs and NTWCs in a reliable and timely manner and that they are able to quickly recognize and respond to those products when their coasts are threatened by a tsunami. Testing is typically accomplished by a variety of means including routine and/or surprise communication tests, tsunami exercises, electronic product receipt verification, and by other means. Each method employed by the TSP should be named in its own sub-heading and described there. Part of ensuring that TSP products sent to TWFPs and NTWCs are recognized and viewed quickly also rests with The Member States. Their responsibility for responding to communication tests when necessary should be described and emphasized in this section. The IOC process for keeping their contact information up-to-date should also be described and emphasized.

4.3. Contact Information

This section should contain the contact information of the designated contact person(s) for the TSP including their name, physical address, email address, telephone number(s), and telefax number(s) if available. It should also include for reference similar contact information for the International Tsunami Information Center.

ANNEXES

I. Example Products

This annex should contain examples of TSP text and graphical products that cover the general range of what the TSP might issue – sample informational products, sample initial threat products, sample threat products with a forecast, sample threat products with observations, and sample final threat products. It could contain that sample threat suite for

multiple source event scenarios if that would be useful. This section could contain sub-headings to make it easier for the user to locate particular sample products.

II. Forecast Points

This annex should contain a map or maps and table with the names and coordinates of geographical points used for forecast arrival times that may appear in text products. The annex should a table also contain a map or maps with the names and locations of points and/or coastal segments used for forecast maximum tsunami amplitudes given in products.

III. Observation Sites

This annex should provide maps and tables with the locations and key characteristics of the seismic, sea level, and any other observational stations that support their operation. This information will need to be only a snapshot of these stations at a given time since these data sources change frequently.

Appendix 3. Key outcomes from the TT Seismic Data Sharing and 7th Meeting of ORSNET

- the key observations and recommendations from the 7th ORSNET Meeting (Annex 1) which include:
    - Develop a capacity development programme to strengthen competency and capability of national tsunami warning centres, seismic and volcano observatories including the training and support provided by ITIC, bilateral partners and peer to peer and mentoring exchanges between members
    - Strengthen the institutional arrangements for early warning including the development of legislation and policies with clearly defined responsibilities between warning centres, observatories, and disaster management
    - Undertake a periodic stocktake of the geohazards observatories in the Pacific re: volcano, seismic and tsunami as part of strengthening MHEWS. This should include the services that support early warning such as communication, staff competencies, arrangements
    - Encourage countries to advocate for the investment in new and emerging technologies such as the Science Monitoring and Reliable Telecommunications (SMART) subsea cable systems and GNSS, to improve early warning
    - Learning from the Hunga Tonga Hunga Ha'apai event, develop guidelines for requesting post event technical assistance to include:
        - the assessment of tsunami warning capability;
        - harmonisation with disaster management protocols for the deployment of goods, personnel and services; and
        - development of National Post-Tsunami Field Survey Guide for PICTs
    - Develop a web-portal for collaboration & communication solution to secure and storing information which ORSNET members countries can access, upload & download data.
    - Explore resources available within ORSNET countries and how assistance can be mobilized within to assist member countries that require assistance
- the opportunities presented by U.S. Geological Survey National Earthquake Information Center of the benefits of seismic data sharing which included
    - leveraging external data centers to archive and access data and allow for the use of standard web services which can improve seismic station quality control,
    - the potential for research collaboration, and
    - improving the timeliness and accuracy of earthquake characteristic products from global and regional monitoring agencies including the FDSN as the international standard for seismic data sharing and gave examples of seismic analysis tools available through the IRIS DMC, such as MUSTANG quality control tools

- the extension of the seismic network in Australia through the strategic collaboration with states and agencies and commended Geoscience Australia on the technical advice and support to Papua New Guinea to strengthen and extend their national seismic monitoring network and Tonga post HTHH to setup an immediate seismic network, and emphasised that under the data sharing arrangements, data from the new stations are improving earthquake monitoring capability in the region
- the deployment of the twelve dart buoys in the SW Pacific by New Zealand and thanked GNS for re-establishing the buoy network to full functionality closest to the Tonga Trench, noting that the real-time data is accessible online and feeding into warning centres.
- the research undertaken by GNS/CPPT/GA to improve tsunami early warning in the SW Pacific using Mww and reiterated the dearth of open data in the region constrained the results. We note that limitations of availability in the data currently precludes target forecasting goals targeted for the Decade of Ocean Science.
- JICA's technical assistance programme in the Pacific and the significant number of natural hazard experts deployed and training delivered to Pacific Island Countries
- the opportunity to train and develop the capacity of staffs of seismic observatories in the south west Pacific and requested JICA to work with countries to help bridge the minimum qualification requirements with supplementary accredited training.
- the Terms of Reference for the Task Team on Seismic Data Sharing in the Southwest Pacific and reviewed the objectives to reflect the use of other technologies than seismic in tsunami warning
- the need for continuity in the office bearers and re-elected Rennie Vaiomounga from Tonga as Chair, Mathew Moihoi from Papua New Guinea as Vice Chair for the next intersessional period.

Appendix 4. Graphical results from TT Network

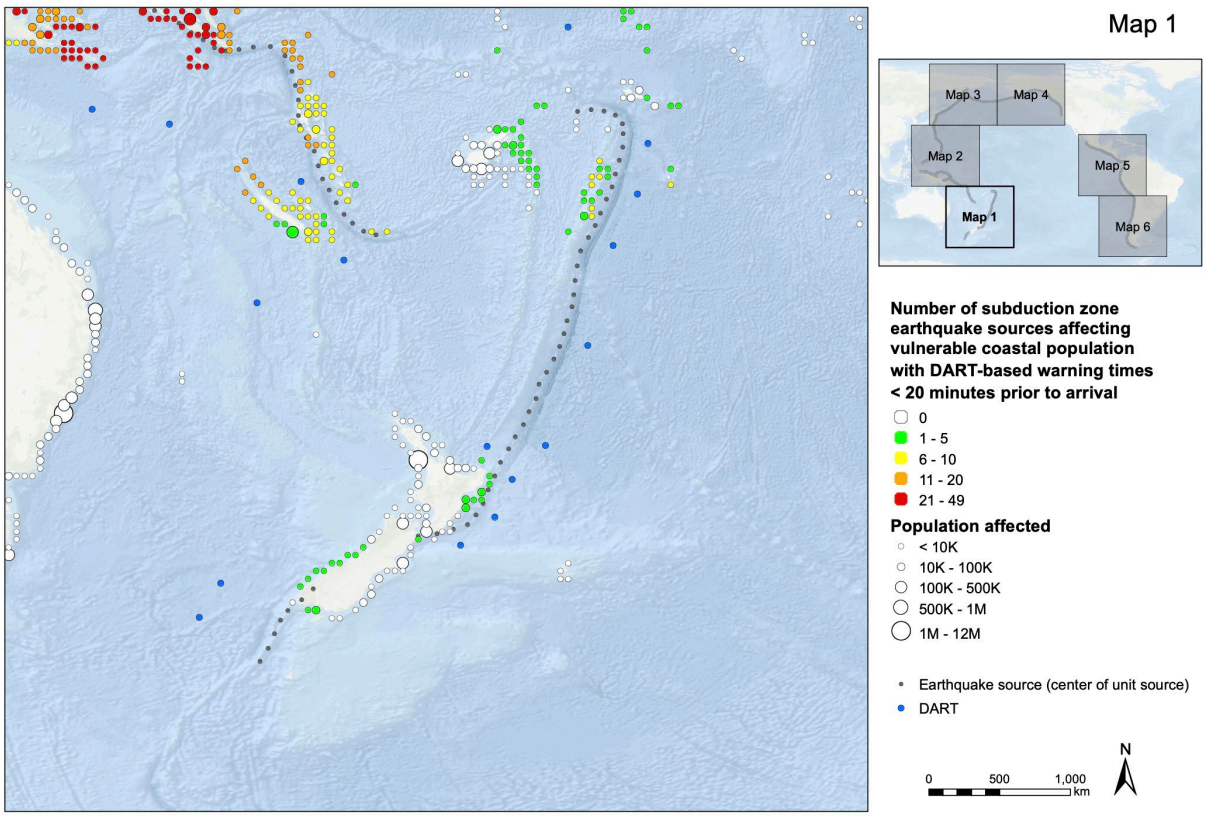

Figure 4.1 Graphical analysis of exposure of coastal population to regional subduction zone tsunamis for which the PTWS monitoring network cannot support at least 20 minutes of pre-impact warning through the analysis of 2 ocean height observations.

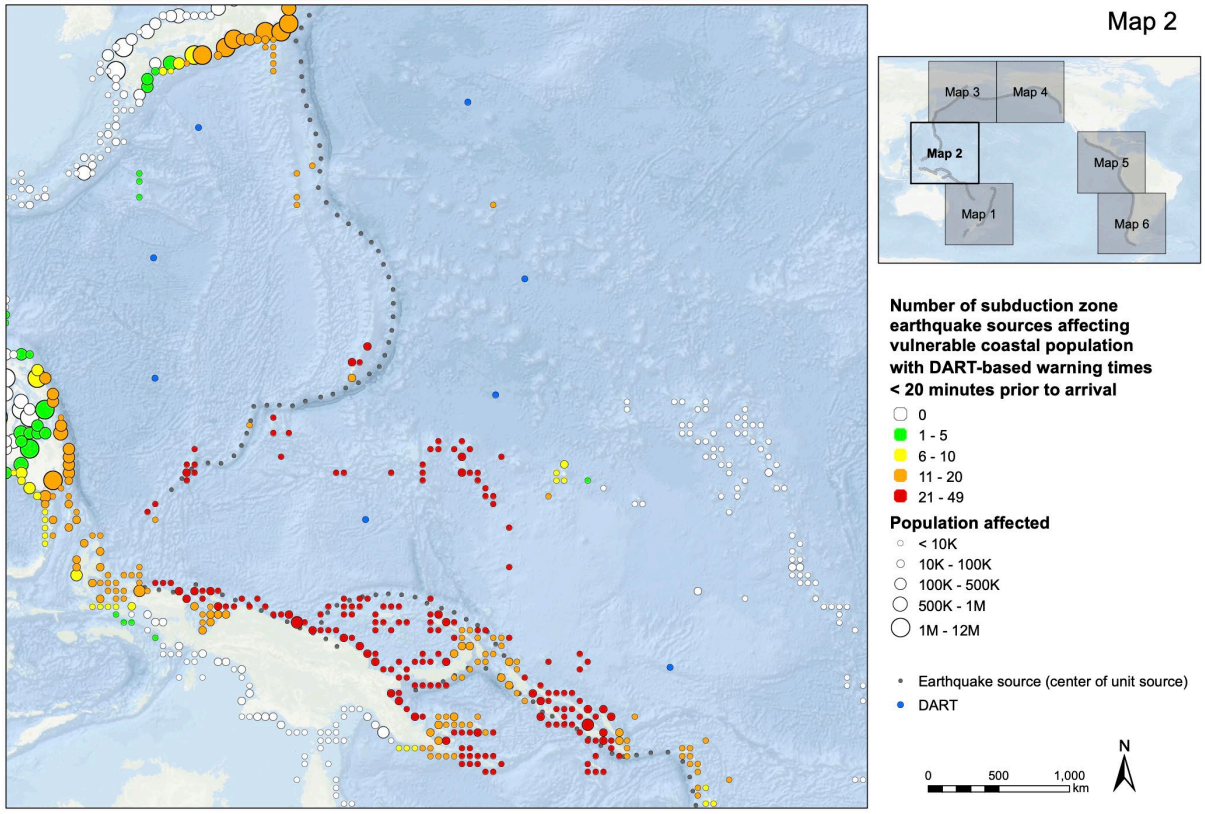

Figure 4.2. As Figure 4.1, but for a different geographical region.

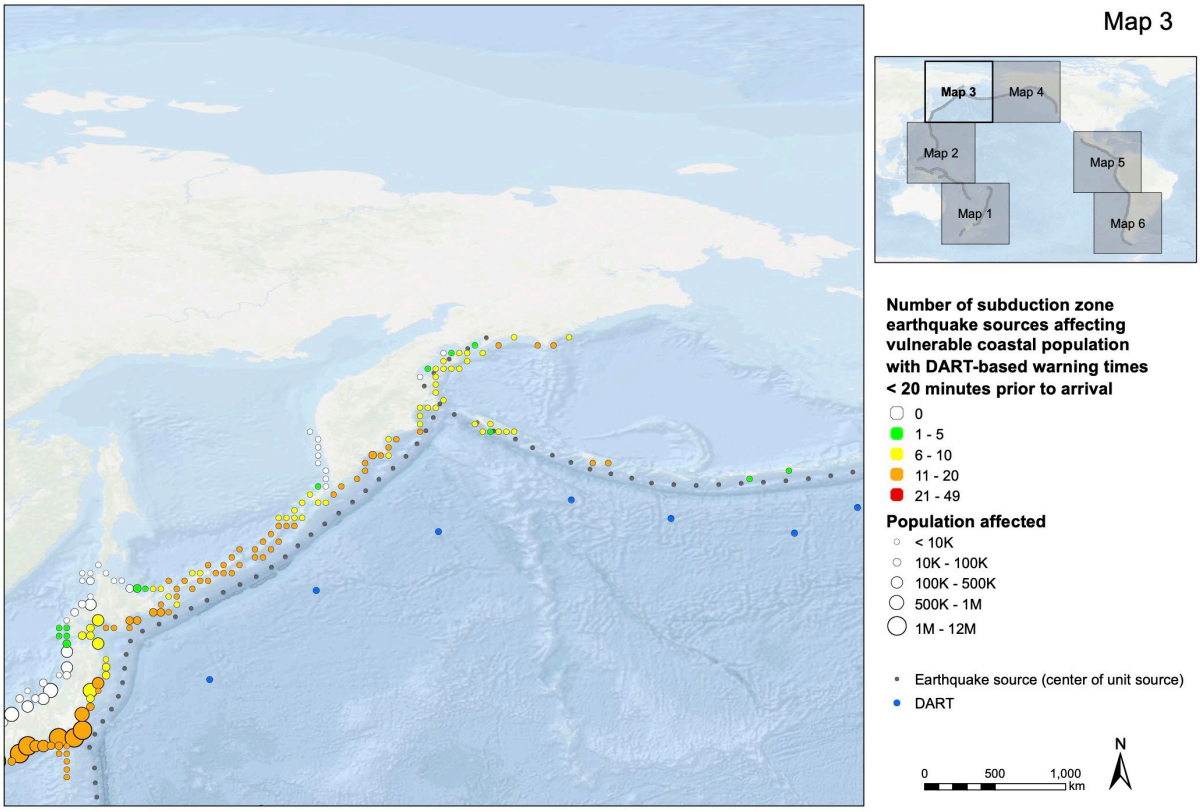

Figure 4.3. As Figure 4.1, but for a different geographical region.

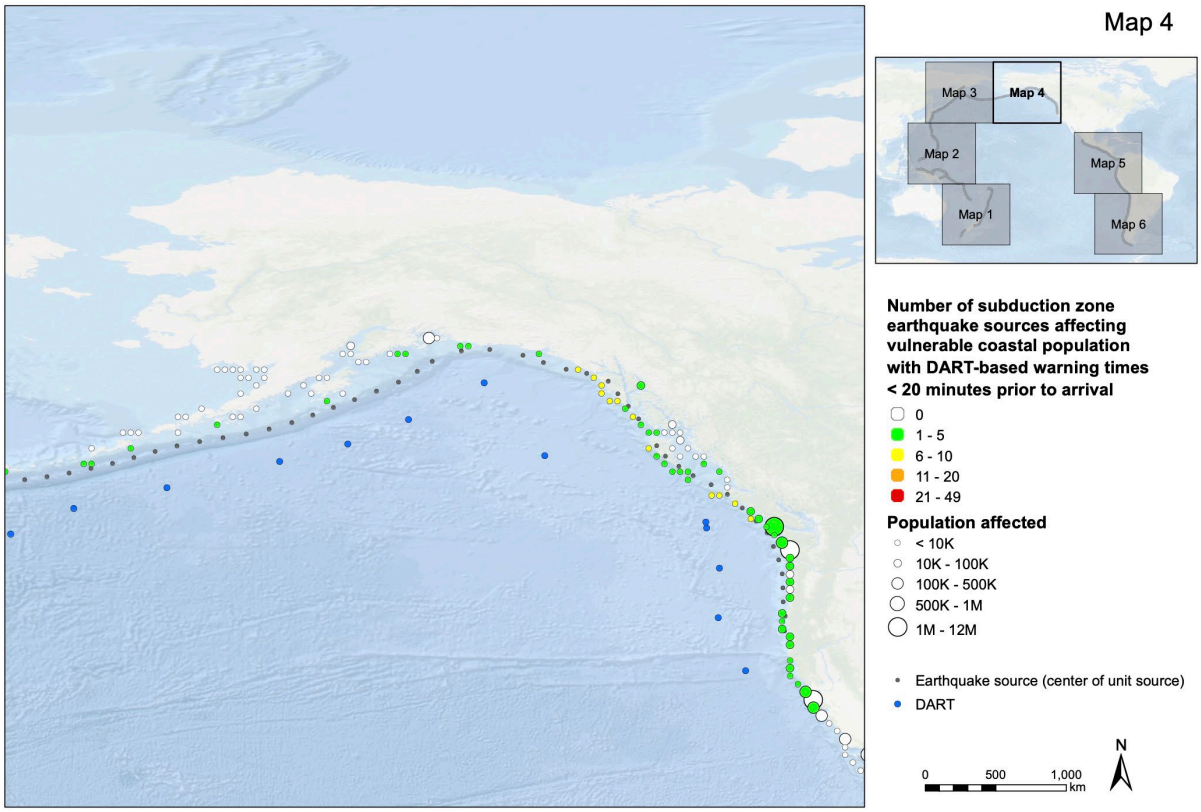

Figure 4.4. As Figure 4.1, but for a different geographical region.

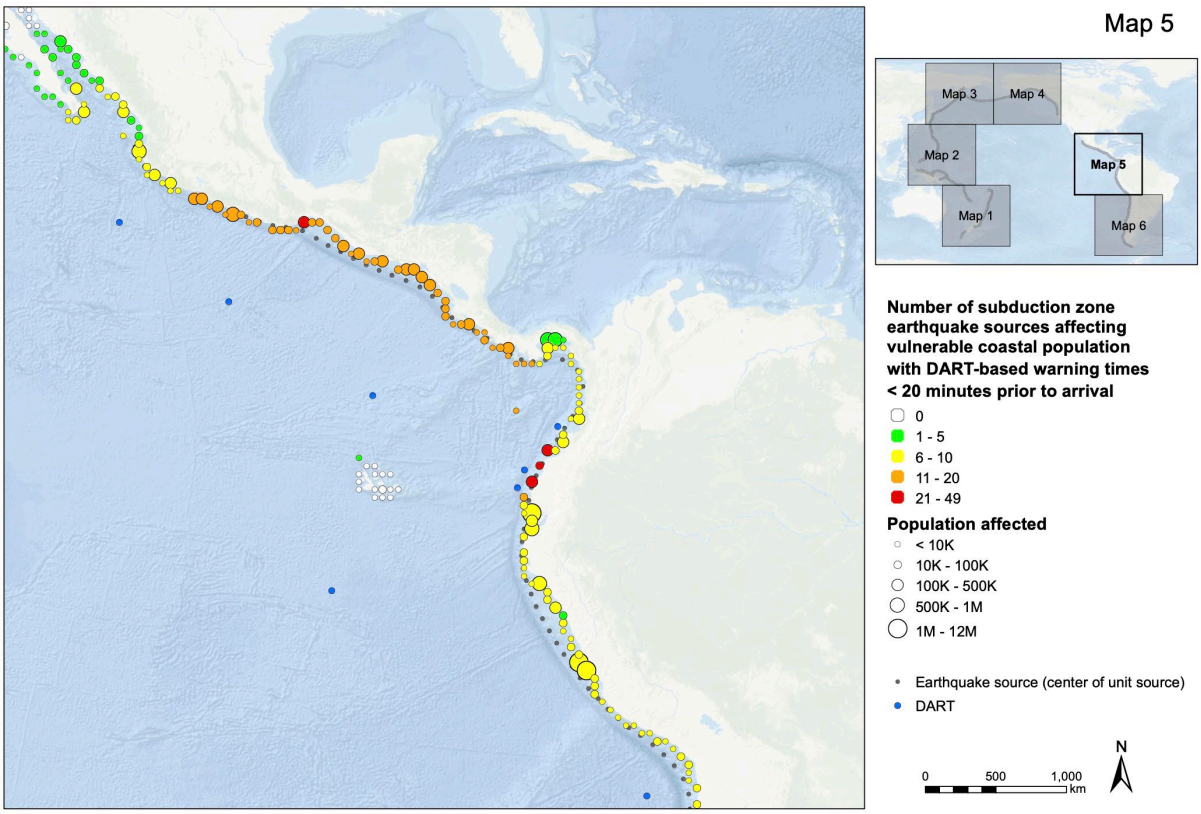

Figure 4.5. As Figure 4.1, but for a different geographical region.

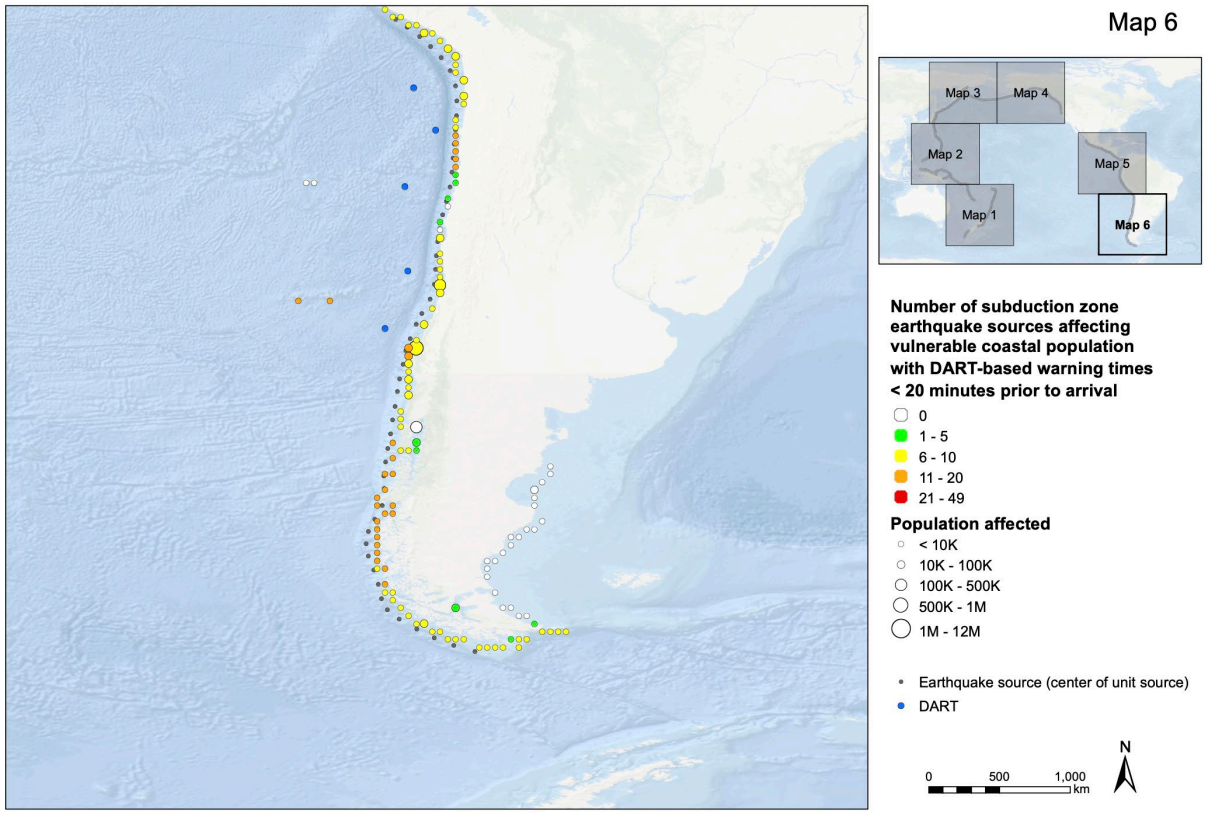

Figure 4.6. As Figure 4.1, but for a different geographical region.

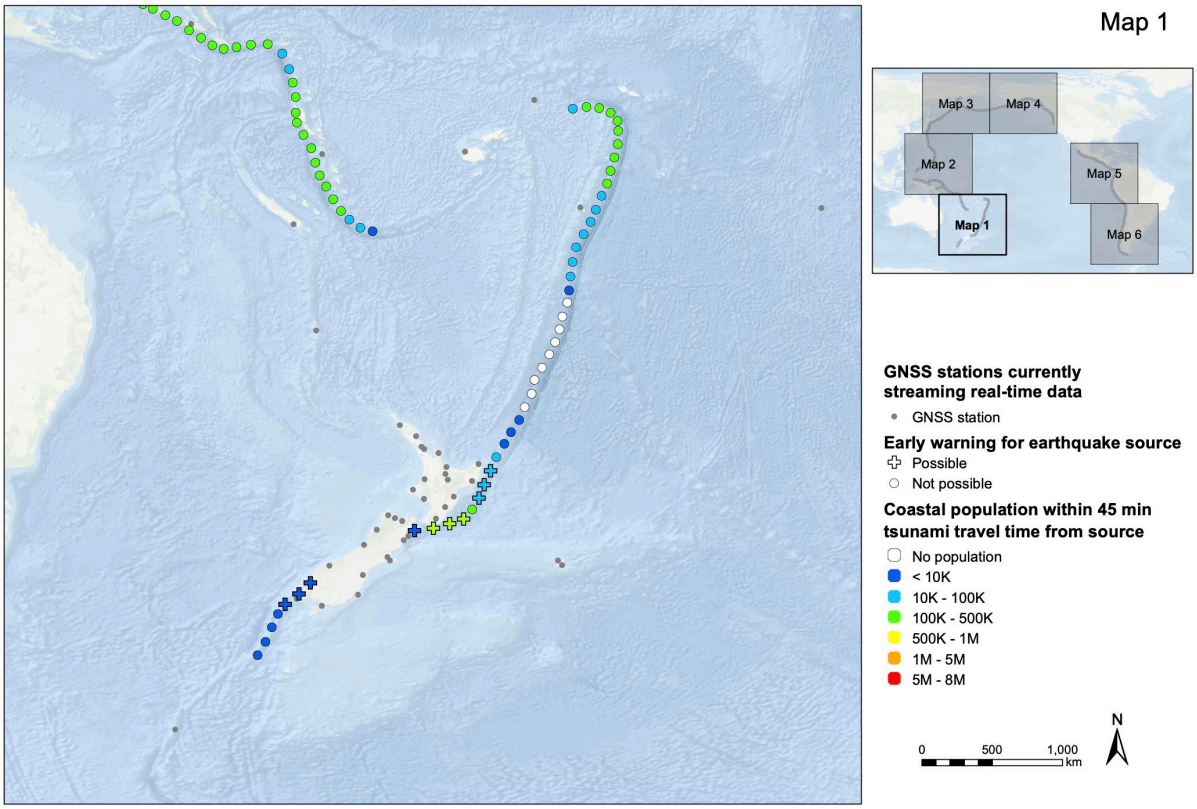

Figure 4.7 Graphical analysis of the ability of GNSS to support TEW for local events. The GNSS network is deemed adequate if at least 5 active GNSS receivers exist within a 200km radius of the subduction zone tsunami source and the minimum aperture of the 5 stations is at least 100km. We note that this is a conservative estimate and likely overestimates the ability of the current network to underpin TEW.

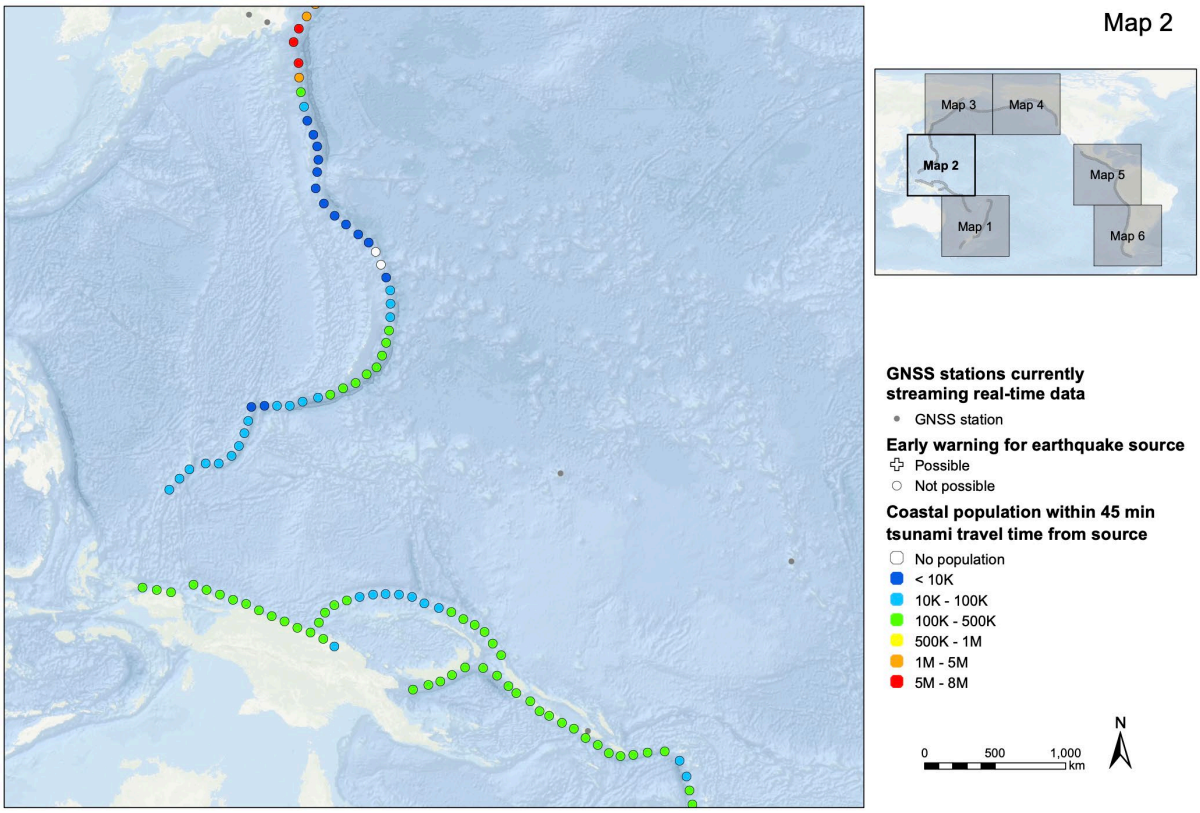

Figure 4.8. As Figure 4.7, but for a different geographical region.

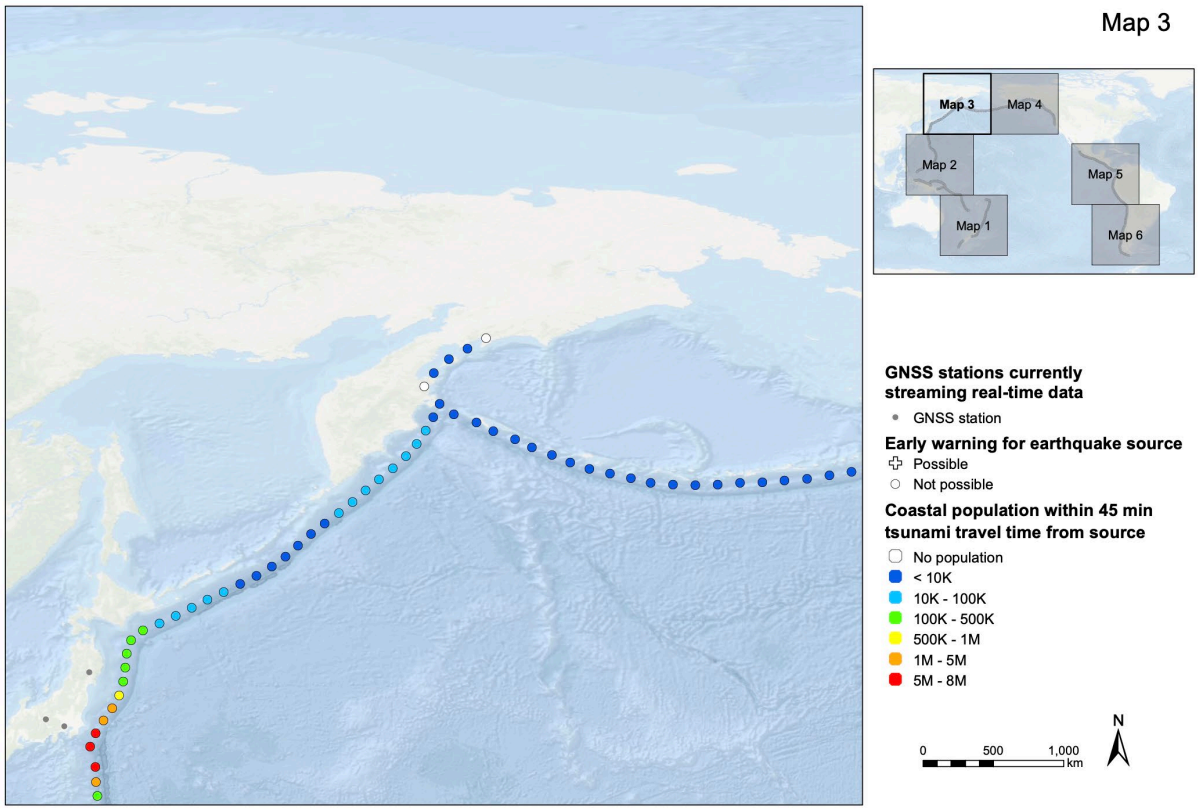

Figure 4.9. As Figure 4.7, but for a different geographical region.

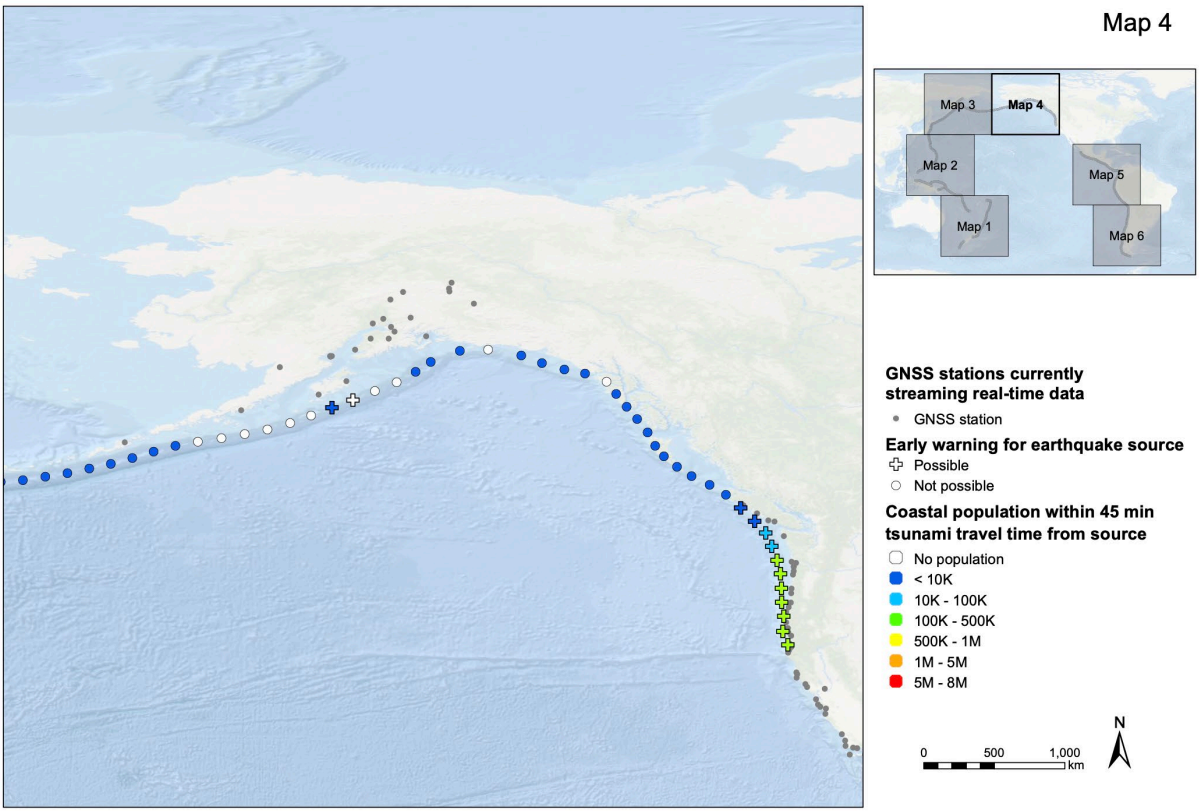

Figure 4.10. As Figure 4.7, but for a different geographical region.

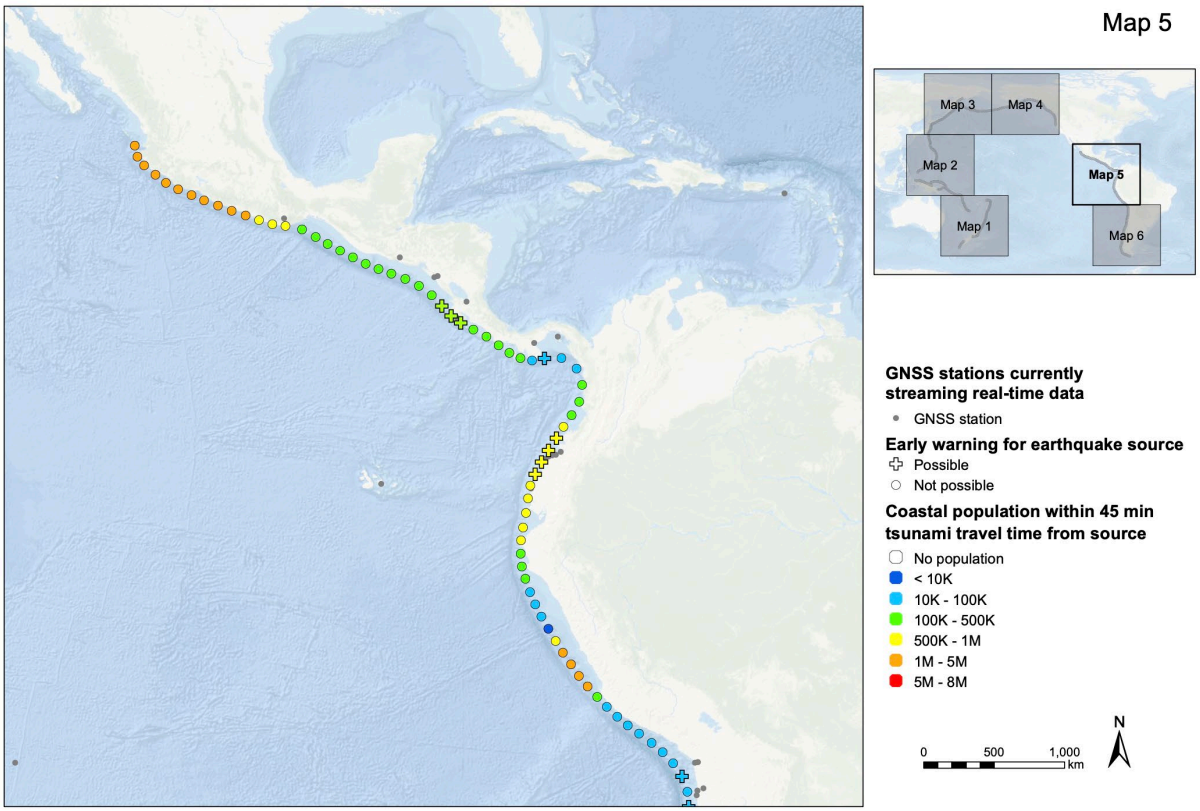

Figure 4.11. As Figure 4.7, but for a different geographical region.

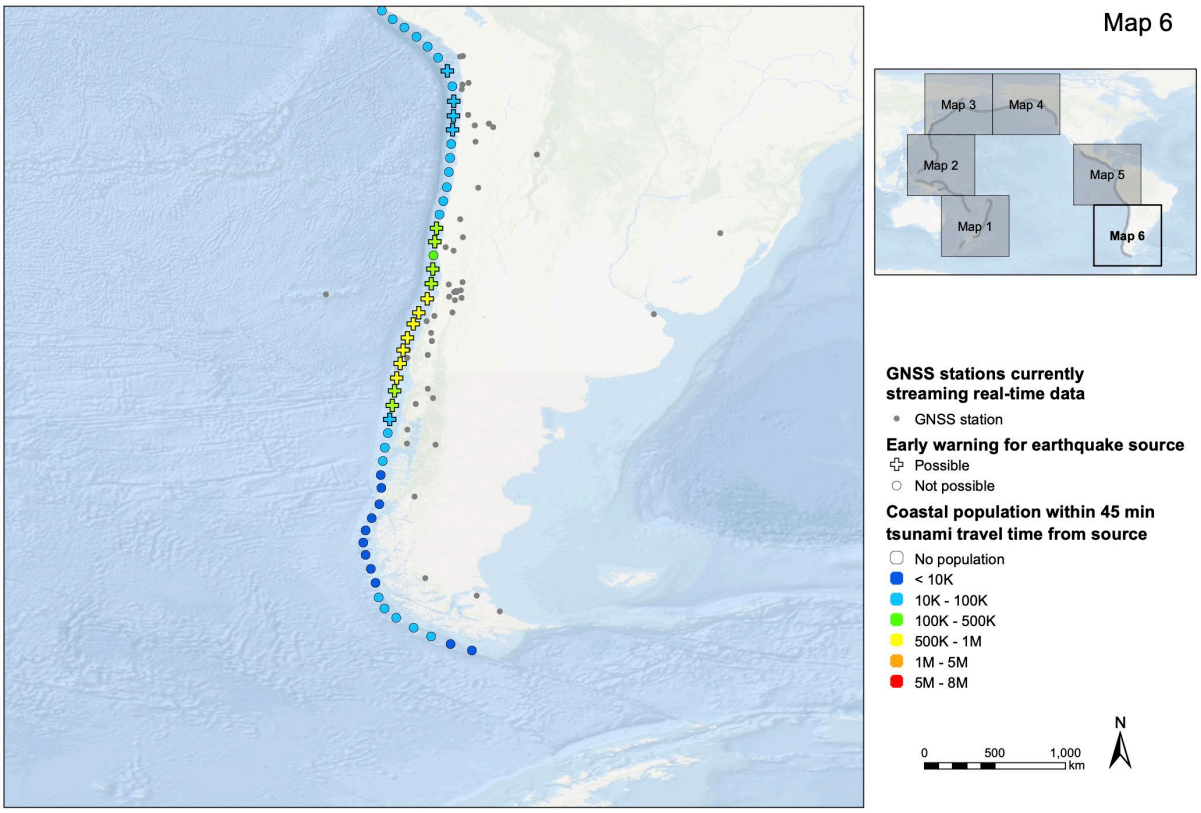

Figure 4.12. As Figure 4.7, but for a different geographical region.

Appendix 5. Response from the Delegation of Chile to the proposal on Maritime Products

Chair, Chile would like to Take Note that the expansion of the Earthquake Source Zone (ESZ) is crucial for our country and all the PTWS member states. However the specific boundaries of this area is not related to the Atlantic Ocean, in the good understanding that is only the geological feature related to the tectonic plates of the "SCOTIA ARC", the specific area where earthquakes may lead to generate a tsunami threat to the countries within the Pacific RIM. Therefore we recommend that the expansion of the Earthquake Source Zone should be referred only to as the "SCOTIA ARC" and not the Southern Atlantic ocean, because the area of monitoring interest also covers other oceans (Pacific, Atlantic and Southern Ocean) and therefore is more accurate to establish a clear boundary related to where earthquakes really occur, such as in this case, the "SCOTIA ARC" that refers to the geological limits of the tectonic plates within this arc, that are clearly identified and demarcated, and also well known and recognized by all member states.

Appendix 6. Response from JTF SMART Cable to WG2 recommendations:

The Joint Task Force for SMART Cable development (JTF) has requested WG2 coordination of SMART activities across ICGs. Further, the JTF has requested that WG2 facilitate engagement with the GOOS and IODTP.