

 <b>unesco</b> Intergovernmental Oceanographic Commission	<b>MEETING OF THE INTER-ICG TASK TEAM ON TSUNAMI WATCH OPERATIONS</b> <b>INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC) of UNESCO</b>
	27 - 28 February 2023 - Hybrid

UNESCO-IOC Working Group on Tsunamis and Other Hazards  
 Related to Sea-Level Warning and Mitigation Systems (TOWS-WG):  
**Task Team on Tsunami Watch Operations (TT-TWO)**

**Members, Invited Experts and Secretariat**

Mr. Yuji NISHIMAE (Chair)	ICG/PTWS	Dr. Charles (Chip) McCREERY	ICG/CARIBE-EWS
Dr Dakui Wang (absent)	ICG/PTWS	Ms. Elizabeth VANACORE	ICG/ CARIBE-EWS
Mr. Pattabhi Rama Rao ELURI (online)	ICG/IOTWMS	Mr. Rick BAILEY	UNESCO-IOC Technical Secretary TT TWO Head of Secretariat ICG/IOTWMS
Dr. Mohammad MOKHTARI (Online)	ICG/IOTWMS	Mr. Bernardo Aliaga ROSSEL	UNESCO-IOC Head, IOC Tsunami Resilience Section
Mr. Alessio PIATANESI (Online)	ICG/NEAMTWS	Ms Nora. Gale	UNESCO-IOC Secretariat ICG/IOTWMS
Dr. Hélène HÉBERT	ICG/NEAMTWS	Dr. François SCHINDELÉ	Invited expert Chair <i>Ad Hoc</i> Team Tsunamis Generated by Volcanoes
Alison Brome	ICG/CARIBE-EWS	Mr. Michael ANGOVE	Invited expert Chair <i>Ad Hoc</i> Team on Mete- tsunamis
Dr. Ahmet C. YALCINER	Invited Expert		

## **TASK TEAM ON TSUNAMI WATCH OPERATIONS (TT TWO) AND TASK TEAM ON DISASTER MANAGEMENT AND PREPAREDNESS (TT DMP) JOINT SESSION #1**

(Chaired by Prof Harkunti Pertiwi Rahayu and Mr Yuji Nishimae)

### **J1 WELCOME & INTRODUCTION**

Mr Bernardo Aliaga, Head of Tsunami Unit welcomed all participants to the joint opening session of the UNESCO-IOC Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG) task teams. This is the first face-to-face meeting of the task teams following two-years of meeting online due to COVID. Today marks the commemoration of the 27 February 1960 Chile earthquake and tsunami. Mr Aliaga highlighted the progress since the ITSU (International Tsunami Warning System in the Pacific) was established by IOC in 1965 and the subsequent establishment of the four Intergovernmental Coordination Groups (ICGs) in 2005 following the 2004 Indian Ocean Tsunami for the Indian Ocean, Pacific, Caribbean and Adjacent Seas, NE Atlantic & Mediterranean Seas. The global tsunami warning and mitigation system and its four ICGs have advanced implementation through the work of their task teams and working groups, allowing the expansion and efficiency of the system. Through this time, the development of global standards has been overseen by the TOWS-WG. Looking forward to 2030, the Ocean Decade Tsunami Programme (ODTP) has two goals: 1) Improved timeliness and accuracy of tsunami warnings; and 2) 100% of at-risk communities are prepared for and resilient to tsunamis. Integration of tsunami warning and mitigation into the international development of the global Multi-Hazard Early Warning System (MHEWS) led by the World Meteorological Organization (WMO) is an ongoing focus.

The task team chairs, Dr Harkunti Rahayu (TT-DMP) and Mr Yuji Nishimae (TT-TWO) outlined the overall objectives of the overall two task team meetings, including this joint session.

Mr Yuji Nishimae, Chair of TT-TWO, recalled the experience of the Japan Meteorological Agency (JMA) in implementing its tsunami warning system. He congratulated Mr Aliaga on his promotion to Head of the Tsunami Unit at UNESCO-IOC. He recalled the Turkish earthquake on 20 February 2023 and expressed his sympathies to those affected by this devastating event. He called on the support of all participants for productive discussions.

Dr Harkunti Pertiwi Rahayu, Chair of TT-DMP, also congratulated Mr Aliaga on his promotion. She noted her attendance at her first meeting of the TOWS-WG and ongoing contributions as chair of the ICG/IOTWMS Working Group 1, Tsunami Risk, Community Awareness and Preparedness. She recalled the ODTP goal for tsunami resilient coastal communities. In conclusion, Dr Harkunti welcomed all participants and encouraged active discussion during the two task team meetings and joint session.

### **J2 WAVE EXERCISES AND SIGNIFICANT TSUNAMI EVENTS IN EACH ICG (share outcomes, lessons learned)**

Dr Harkunti Rahayu and Mr Yuji Nishimae invited representatives of Tsunami Wave Exercises from each ICG to provide a short summary of recent exercises, share outcomes and lessons learnt, as well as significant events in each region.

## **WAVE EXERCISES**

### **○ ICG/CARIBE-EWS**

Dr Elizabeth Vanacore presented a report on the CaribeWave22 exercise. The CaribeWave22 exercise was conducted on 10 March 2022. It was composed of two earthquake and tsunami scenarios: Western Muertos Trough (south of Hispaniola) and Northern Panama Deformed Belt. The exercise results indicated that the Dummy (Start of Exercise) message was received by 34 Member States, representing 91% of the CARIBE-EWS Member States and Territories. There was a strong dependency on email for the reception of products from the PTWC. The exercise planning went well under extenuating circumstances, resulting in an 88% of satisfaction of Member States and territories, and a total participation of 413,285 people from the Caribbean.

The Caribe Wave23 exercise will take place on 23 March 2023. There will be two scenarios, one based on an earthquake in the Gulf of Honduras and second, for testing of volcano EWS, an eruption and flank collapse of Mount Pelée, Martinique.

### **○ ICG/IOTWMS**

Mr Ardito Kodijat reported there was no IOWAVE exercise in 2022, as in coordination with the ICG/PTWS the ICG/IOTWMS postponed the next IOWAVE exercise until 2023 (IOWAVE23). This was to alleviate the exercise load in any one year for Member States who are members of both the ICG/PPTWS and ICG/IOTWMS.

### **○ ICG/NEAMTWS**

Dr Marinos Charalampakis reported on the development concerning organizing NEAMWave23. The NEAMWave23 exercise is planned either between 30-31 October or 6-7 November 2023. There is a need to have a stronger engagement with the Civil Protection Agencies (CPAs). There is an interest to organize an online meeting between the CPAs and the European Civil Protection Mechanism ahead of the exercise. The TT-TE is preparing informative material (NEAMWave exercise concept papers, best practices, etc.) to share with the national CPAs.

There is an agreement among TSPs to implement two exercise scenarios:

1. North-eastern Atlantic: Conducted by IPMA (Portugal) and CENALT (France)
2. Mediterranean Sea: INGV (Italy), NOA (Greece), KOER (Turkiye).

A key aim of NEAMWave23 exercise is to engage with CoastWAVE Tsunami Ready communities. CoastWAVE project countries will need to decide if they will make the NEAMWave23 exercise an action or not.

### **○ ICG/PTWS**

Dr Laura Kong and Cmdr Carlos Zuniga reported on the PacWave22 exercise. The exercise was organized between September - November 2022 with emphasis on regional cooperation in South America, South China Sea, and Pacific Islands. The TSP live communication test

took place on 13 October 2022 with the participation of 27 countries. All the TSPs that participated in the exercise sent messages according to procedures, 24 respondents reported to have received the message from PTWC correctly, 11 from NWPTAC, 7 from SCSTAC and 3 from CATAC.

The PICT regional exercise took place on 9 November 2022 with the participation of 18 Pacific Islands, countries, and territories. The scenario was the Hunga Tonga Hunga Ha'apai (HTHH) volcanic eruption and tsunami of 15 January 2022. It consisted of a 2-hour live tabletop exercise to test the HTHH PTWC Interim Procedures and PTWS products, and whether the HTHH PTWS products are interpreted by PICT Member States accurately and in a timely manner, and the testing of live information sharing between countries of the region to test its efficacy and value. Controllers simulated four PTWC bulletins sent by e-mail using a Listserv (hosted by ITIC, same as that used for the Tsunami Bulletin Board) and through a WhatsApp group. The use of HF radio was also tested since post-HTHH. HF radio proved to be one of the few (the other being satellite phones) communication methods after the blackout. All information was immediately shared (no delay or review). Only 5 mails were not distributed because they were sent from an unregistered email into Listserv.

A PacWave22 PICT Cold wash debrief took place on 16 November 2022. Participants noted the email communication method as the most important for the Live TSP test. For the HTHH scenario, the PTWC products were understood and useful, and the live information sharing overwhelmingly endorsed as highly useful, with the greatest interest in sharing via WhatsApp communications in future exercises. It was noted that if Tonga had been able to share what was observed (seen) '*natural massive eruption warning signs*' and issued a national tsunami warning minutes later, this would have significantly helped neighboring countries in their tsunami warning decision-making.

As a further indication of its usefulness, the WhatsApp tool was used in 3 real events soon after, including one on which Tonga was only able to receive the PTWC messages through WhatsApp because their email server was down at that moment.

Cdr Zuniga shared information of the Southeast Pacific (South America) regional exercise, which consisted of two exercises.

### **Recommendations to TOWS-WG**

**Commends** the PTWS Pacific Islands and Southeast Pacific for testing and enabling communication methods by which to share key tsunami information regionally to assist neighboring countries in their national tsunami warning decision-making.

**Recommends** ICGs to align Wave exercises with World Tsunami Awareness Day and UNESCO/IOC Tsunami Ready implementation.

## **SIGNIFICANT TSUNAMI EVENTS**

### **○ ICG/CARIBE EWS**

Dr Chip McCreery reported that four or five events have been reported in the Caribbean region, but with no threat messages being required to be issued.

### **○ ICG/IOTWMS**

Mr Pattabhi Rama Rao reported that in the Indian Ocean region two (2) events over the required earthquake thresholds were responded to. For both events, the three Indian Ocean Tsunami Service providers (TSPs) issued no threat bulletins to the Indian Ocean region.

### **○ ICG/NEAMTWS**

Dr H el ene H ebert reported seventeen earthquakes were monitored in 2022 and five in 2023.

Ms Christa von Hillebrandt-Andrade noted that the ICG/NEAMTWS threshold magnitude for reporting events could result in public enquiry if they are different and below the threshold of the ICG/PTWS.

Mr Francois Schindele commented that the Earthquake Source Zone (ESZ) southern latitude for the South Atlantic may not include all events south of that, which could generate tsunamis that could impact coastlines of the South Atlantic, Pacific and Indian oceans.

Prof. Ahmet Cevdet Yalciner was invited to report on the T urkiye earthquakes and sea level anomalies, starting on 6 February 2023. His presentation focused on the coastal structure of the Gulf of Iskenderun and tsunamis in the Eastern Mediterranean, where the death toll has exceeded 50,000 persons due to the earthquakes. The magnitude 7.7 earthquake, which occurred on 20 February 2023, resulted in a small tsunami in the Gulf of Iskenderun. The earthquake was associated with a significant magnitude 6.6 foreshock (6 February 2023) and many aftershocks. Initial assessments of coastal structures in the Gulf of Iskenderun indicate local subsidence and damage, which includes four tide gauge stations and other structures. Further investigations are being conducted to better understand the resulting tsunami.

Mr Rick Bailey, IOC-UNESCO Secretariat, enquired about the lessons learnt in tsunami and community education. Dr Yalciner responded that the NEAMTWS is working well. Regional awareness has been increased through the warning messages.

Dr Silvia Chacon Barrantes asked about the community response. Dr Yalciner replied that there was much interest from the community and a desire to learn how to respond to tsunami threats. Dr Musavver Didem Cambaz expanded that the local people left their homes as a response to the earthquake and wanted to learn the appropriate tsunami response.

Dr Harkunti Rahayu asked if the coastal infrastructure damage was due to subsidence or the earthquake. Dr Yalciner responded damages to structures resulted from subsidence as well as fire.

Dr Denis Chang-Seng raised the importance of evacuating buildings in response to

earthquakes and noted renewed interest in countries joining the ICG/NEAMTWS.

Mr Alejandro Rojas Aldana asked about the communication surrounding the earthquake. Dr Yalciner noted an important lesson that the people in the damage zone could not send messages, and communication failures resulted in confusion.

Dr Mohammad Mokhtari enquired about prior tsunami events. Mr Yalciner responded that a tsunami in 2020 resulted in wave damage and one fatality. A DART (*Deep-ocean Assessment and Reporting of Tsunamis*) system could be implemented to improve the warning system.

- **ICG/PTWS**

Dr Chip McCreery noted since the last TOWS-WG meeting, twenty-seven (27) tsunami information statements and twelve (12) tsunami threat sequences have been issued in the Pacific region. The Hunga Tonga Hunga Ha'apai (HTHH) volcanic event (prior to last meeting) was included in the count due to its significance and follow-up work, which has raised awareness on non-seismic tsunami generation.

Dr McCreery reviewed the response to the HTHH event. The resulting tsunami was detected in all ocean basins and the precise mechanism is under investigation. The PTWS has developed and implemented new interim products (subject to ICG/PTWS approval at its next session) in case of similar future events. In response to the HTHH event in the Pacific Ocean and two non-seismic and complex source events in Indonesia in the Indian Ocean and connecting seas, TOWS-WG has formed two *ad hoc* teams, one on tsunamis generated by volcanoes and another on meteo-tsunamis.

Dr Mohammad Mokhtari asked about detection of non-seismic events in other ocean basins, with reference to the Makran region. Mr McCreery noted that the coastal sea-level gauges are not well set-up to alert for significant wave heights due to possibility for sea-level noise also triggering. However, during the precursory activity in Hunga Tonga a trigger was programmed on the nearby sea-level gauge. This gauge and a nearby DART signal were used to action the response. Something similar may be able to be implemented in the Makran region.

### **Recommendations to TOWS-WG:**

- TOWS-WG, given the critical need to resolve and understand the near-field threat to high at-risk communities where a tsunami may arrive in 5-30 minutes, reiterate the urgent need for all Member States to sample sea level data at one second intervals and transmit this in real-time.
- TOWS-WG request IOC Assembly at its next session to reconsider the request to extend the Pacific Earthquake Observing Zone to include the South Atlantic, given the ongoing threat in this region to generate tsunamis that also impact the Pacific and Indian Oceans (eg South Sandwich Islands event, 12 August 2021)

### **J3 REPORT FROM AD HOC TEAM ON TSUNAMIS GENERATED BY VOLCANOES**

Dr Francois Schindele (France), Dr Raphael Paris (France) and Dr Laura Kong (United States of America) reported on the *Ad Hoc* Team on Tsunamis Generated by Volcanoes (TGV)

under the TT TWO. The scientists on the team also included Emily Lane (New Zealand), Maurizio Ripepe (Italy) and Vasily Titov (United States of America). A survey on volcano observatory activities with regards volcanic activity hazard assessment and related tsunami monitoring and warning systems was circulated to volcanic observatories and relevant institutes. The *Ad Hoc* Team TGV report is being finalised and includes chapters on tsunamis generated by volcanic activity, numerical modeling of volcanic tsunamis, volcanic tsunami hazard assessment, volcano monitoring requirements for tsunami warning, volcanic tsunami warning systems and standard operating procedures, and recommendations. A draft of the report was tabled at the meeting.

Dr Raphael Paris reported on the first two chapters of the report: 'Tsunamis generated by volcano activity and instability' and 'Numerical modeling of volcanic tsunamis'.

Dr Francois Schindele reported on the three different volcanic tsunami hazard assessments with an example of the worst-case scenario for Stromboli. The Stromboli volcanic tsunami warning system has been long standing with tsunami beacons in the seas on the southern and northern volcanic flanks. The system was successful in detecting the Stromboli event on 4 December 2022. The signage at Stromboli shows the hazard zone and evacuation routes for tsunami events.

Dr Laura Kong noted that of the twenty-five (25) volcano observatories surveyed, fifteen (15) countries have responded to the volcano observatory questionnaire. The current practice is to detect and then warn. There are two possible triggers for tsunami warnings: Volcanic Ash Advisory Centre (VAAC) notices of activity and actual tsunami wave detection. Most volcano observatories do not have sea level stations. Since most volcanic observatories do not have 24x7 operations, they cannot be tsunami warning centres.

Dr Laura Kong then presented the preliminary recommendations and gaps for warning of tsunamis generated by volcanoes. These recommendations were further discussed later in the day and the final recommendations presented to the joint session of the task teams on Day 2 of the meetings.

Cmdr Carlos Zuniga asked about Deception Island in Antarctica, which is outside of the monitored networks. Dr Raphael Paris responded that this can be included in the report.

Dr Chip McCreery noted that low-cost flood sensors have been installed in key localities on land to monitor for inundation. These 'wet sensors' are easy to deploy, and have been reliably detecting flooding at a given elevations for the past 10+ years.

## **Recommendations to Member States**

### *Monitoring and Warning:*

1. As a first step, organization(s) should be designated for monitoring and warning of Tsunamis Generated by Volcanoes (TGV). The second and third steps are to install monitoring instrumentation and develop Standard Operating Procedures (SOPs) to handle volcanic tsunamis.

2. The TGV monitoring and warning system should be implemented by, or in cooperation with the National Tsunami Warning Centre (NTWC) and regional Tsunami Service Provider and national and regional Volcano Service Providers, where such exist.
3. All volcanoes mentioned in the TGV report should be monitored and have processes in place to warn for tsunamis. Should other, potentially tsunamigenic volcanoes begin erupting, these should also be monitored and included within the tsunami warning process.
4. Detect/warn geophysical (seismology, GNSS, tiltmeter, barometric and sea level data streams need to be available to the designated tsunami monitoring/warning agency (and possibly also to the volcano monitoring agency)
5. As well as monitoring systems for volcano activity and potential far-field propagation of sea level signal, a sea level gauges network with real-time continuous data transmission should be deployed close to each identified volcano to verify risk and then ongoing monitoring and warning. One second sampling with 1 cm accuracy (< 1 mm sampling) is recommended for recording and automatic detection. Data transmission through radio or microwave links, fiber optic, or dedicated telephone lines, or other modes should be implemented to ensure the data is transmitted and received and widely shared with the international community in a timely manner.
6. Methods to also specifically alert persons in remote areas (such as scientific teams in the field, or recreational hikers) should be considered.
7. TGV SOPs for tsunami warning should be linked with existing Volcano Alert Activity scales.

*Risk Assessment and Preparedness:*

8. TGV hazard and risk assessment should be undertaken to determine vulnerable areas.
9. For TGV, multi-stakeholder meetings should be convened that included science agencies, volcano and tsunami warning operations centres, and disaster management agencies. For each identified potential source, worst-case and credible scenario planning discussions should start as soon as possible.
10. During a period of heightened TGV hazard, consider closing access to vulnerable areas. When an eruption is imminent and the tsunami hazard is high, consider evacuating populations from vulnerable locations.
11. Specific TGV signage and evacuation routes should be implemented in all areas that may be impacted by tsunamis generated by volcanoes.
12. TGV public awareness campaigns should be conducted regularly – the type and frequency of awareness activities may be different for the local population compared to transient populations such as tourists.

**Recommendations to TOWS-WG**

1. TGV warning notification systems should be considered and coordinated as part of the IOC-UNESCO Global Tsunami Warning and Mitigation System, and also when possible be part of a Multi-Hazard Early Warning System (MHEWS).
2. TOWS-WGs recommend ICGs examine TGVs in the region of responsibility and review TGV hazard monitoring and warning requirements, including costs of



- deploying and maintaining such systems.
3. TOWS-WG recommend, where identified TGVs may impact multiple Member States, Tsunami Service Providers (TSPs) for the relevant ocean basin tsunami warning and mitigation systems consider if they need to be involved in monitoring and provision of threat advice.
  4. IOC-UNESCO Ad hoc Team on TGV should continue and finalize the TGV Report by mid-2023.

### **Recommendations to IOC-UNESCO Secretariat**

IOC Secretariat to help inform Member States widely on the potential tsunami hazard from volcanoes:

1. Publish the TGV report as an IOC-UNESCO publication in 2023
2. Provide the TGV Report, including the List of Tsunamigenic Volcanoes to Volcano Observatories
3. Provide the TGV Report, including the List of Tsunamigenic Volcanoes to IOC-UNESCO Member States

### **J4 REPORT FROM AD-HOC TEAM ON METEO-TSUNAMIS**

Mr Mike Angove reported on the work of the *Ad-Hoc* Team on Meteo-tsunamis under TOWS-WG TT TWO. The report assessed the current global status and advised on gaps related to meteo-tsunami monitoring and warning systems. It also identified guidelines for Standard Operating Procedures (SOP) development to monitor and warn for meteo-tsunamis, and reviewed relationships and coordination requirements between TSPs/NTWCs and regional/national meteorological services to monitor and warn for meteo-tsunamis.

Where they exist, meteo-tsunami alert products are currently addressed within the SOPs of national or regional meteorological services. Meteo-tsunami are common in some parts of the world where the required conditions occur, happen infrequently, but can cause a significant risk to life and property (i.e., Balearic Island region in Mediterranean Sea). The global tsunami warning system can play a supporting role in direct tsunami detection. A future unified system with a combination of direct tsunami detection and NWP-based meteo-tsunami forecasts is considered worthwhile. Local understanding of the meteo-tsunami threat is critical.

Observed significant meteo-tsunami occurrences are typically mid-latitude features related to fast moving (i.e., over 30 nautical miles) mesoscale complexes. They have been observed in the Adriatic Sea, Mediterranean Sea, Nagasaki Bay, Lake Michigan, and the Persian Gulf. Mr Rick Bailey also noted they have been observed off the west coast of Australia, causing a ship to break its moorings and nearly collide with a major road bridge.

Dedicated meteo-tsunami alerting systems are in place in the Balearic Islands, Adriatic Sea, and South Korean Peninsula. Other areas have more generalized systems based on detection of flooding.

Using the global tsunami warning system for meteo-tsunami may be considered. However,

rethinking of global tsunami observation may allow for instrumentation specifically tuned for meteo-tsunami.

Generalized SOPs for meteo-tsunami have been developed by the *ad hoc* team.

Further discussion is needed on preferred forecasting and warning organisations (i.e., organisations responsible for meteorology and/or tsunami warnings). It is recommended that meteo-tsunami alerting is jointly coordinated by WMO and IOC-UNESCO. A new instrumentation strategy should be considered and a framework for a unified meteo-tsunami system should be established.

### Recommendations to TOWS-WG

**Noting** the report from the *Ad Hoc* Team on Meteo-tsunamis initially sought to look at meteotsunami the perspective of global tsunami services;

**Further noting** the report from the *Ad Hoc* Team on Meteo-tsunamis discovered responsibility for issuing public alerts related to meteotsunami currently is typically addressed by national or regional Met services offices, but usually in the context of storm surge or anomalous coastal flooding event;

**Further noting** as tsunami detection and measurement capabilities are rapidly improving and this is expected to accelerate under the UN Ocean Decade, it is now possible to consider non-seismic tsunami sources in the global instrumentation strategy, including volcanoes and meteotsunami, among others;

**Further noting** combining the direct tsunami detection capability of the GTWS with the NWP-based algorithms tuned to meteo-tsunami prediction could deliver significant advances in global capability at minimal cost;

1. TOWS-WG initiates a comprehensive dialogue between the IOC and WMO to ensure full exchange of information in support of a robust international alerting system for meteo-tsunamis is achieved. It is the *Ad Hoc* Team for Meteo-tsunami's recommendation that this report be used as a starting point of those discussions.
2. TOWS-WG to establish a mechanism for input from national and regional meteorological services offices on data needs for meteo-tsunami monitoring and alerting as the Global Tsunami Early Warning System (GTEWS) considers a new generation of tsunami detection and measurement networks.
3. TOWS-WG to establish a task team made up of experts from both GETWS and NWP systems be formed with the expressed intent of outlining the potential construction of an integrated meteo-tsunami prediction system.
4. TOWS-WG establish an *ad-hoc* team to conduct a global meteotsunami hazard assessment to provide all MS advice on the meteotsunami hazard and risks on their coasts.

**Recommends** the *ad-hoc* team on Meteotsunami continue through 2023, including WMO representatives for the purpose of recommending a global alerting strategy to include specific roles of met services and TSPs/NTWCs.

**Recommends** the establishment of an *ad-hoc* team to conduct a global meteotsunami hazard assessment to provide all MS advice on the meteotsunami hazard and risks on their coasts.

## **J5 PLANNING FOR OCEAN DECADE**

The Chair asked the Secretariat to report on the work on the status, activities, and plans for the Ocean Decade.

- **Ocean Decade Tsunami Programme Endorsement**

Mr Mike Angove reported on the instrumentation and warning vision to build off the legacy seismic analysis capability, with a view to combine this with more direct in-situ tsunami measurement, in order to enable positive confirmation of tsunami generation from a source event to provide more accurate forecast information. The identification of a global sensor strategy to achieve these goals would include many sources of measurement and detection. This will require Member State to enhance current monitoring coverage. The recommended enhanced global monitoring systems would go to the ICGs and/or TOWS-WG to coordinate implementation.

Dr Harkunti Rahayu noted that the goal of 100% of communities at risk to be prepared and resilient to tsunami will be first discussed by the TT-DMO.

- **Draft of the 10—year research and development implementation plan for the ODTP**

The Scientific Committee has met three times over the last year. The first draft of the Ocean Decade Tsunami Programme Research and Development Implementation Plan was released in November 2022 for Member State comments. The second draft was released on 13 February 2023 for review by the TOWS-WG and its task teams. Following this review and feedback, the Scientific Committee will finalize the report for the UNESCO-IOC Assembly in June 2023 and seek endorsement from Member States.

- **Progress report of the Tsunami Ready Coalition**

Mr Bernardo Aliaga, new Head of the IOC Tsunami Unit announced the appointment of Dr Laura Kong as the Chair of the Tsunami Ready Coalition. She was nominated by the by the TOWS Task Team Chairs and endorsed by TOWS WG Chair. Dr Kong has a strong background and experience in tsunami warning and mitigation, and preparedness. The goal of the Coalition is to “Contribute to increasing the number of Tsunami Ready communities as part of the Ocean Decade” through the following objectives:

- a. Raising the profile of UNESCO Tsunami Ready in collaboration with critical stakeholders across the UN system, interested regional organizations, national disaster management agencies and the public,
- b. Increasing funding resources for the implementation of Tsunami Ready,
- c. Advising the IOC TOWS-WG, TT-DMP, and TT-TWO on the implementation of UNESCO Tsunami Ready, including on: i) Flexibility with regards to accomplishing the

indicators to allow for circumstances where formal bureaucratic frameworks/requirements may pose barriers; and ii) Consideration of unique regional and/or local circumstances.

- **Plans for the 2nd UNESCO-IOC Science Symposium on advances in tsunami warning to enhance community responses:**

Dr Harkunti Rahayu, chair of the 2nd UNESCO-IOC Science Symposium Organizing Committee, reported that Indonesia and the ICG/IOTWMS plans to host an Indian Ocean Tsunami Symposium in the first week of December 2024 in Aceh, Indonesia, back-to-back with the 14<sup>th</sup> Session of the ICG/IOTWMS in Jakarta. The year 2024 will mark the 20th commemoration since the Indian Ocean Tsunami of 2004 killed nearly 200,000 people in Indonesia and in total more than 230,000 across the Indian Ocean. The Government of the Republic of Indonesia, through the Head of the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG and Chair of the ICG/IOTWMS, Dr Dwikorita Karnawati, has offered to make the symposium global and accordingly host the 2nd UNESCO-IOC Science Symposium on advances in tsunami warning to enhance community responses.

The TT-DMP recommended having discussions about the nomination of a Tsunami Symposium vice-chair and members of the committee.

### **Recommendations to TOWS-WG**

**Noted** with appreciation the nomination of Dr Laura Kong as the chair of the UNESCO/IOC Tsunami Ready Coalition;

**Accepts** with appreciation the offer of the Government of the Republic of Indonesia to host the Global Symposium in December 2024 as part of the plans by the ICG/IOTWMS to commemorate the 20th Anniversary of the Indian Ocean Tsunami of 2004.

**Recommends** the nomination of a Tsunami Symposium co-chair and members of the committee.

## **TASK TEAM ON TSUNAMI WATCH OPERATIONS (TT TWO) SEPARATE SESSION #1**

(Chaired by Mr Yuji Nishimae)

### **1. TT TWO SESSION ORGANISATION**

#### **Logistics, participants, agenda**

Mr Yuji Nishimae welcomed all participants to the separate session and meeting of the TOWS-WG Task Team on Tsunami Watch Operations (TT TWO). He requested the members of the Task Team to introduce themselves.

Mr Rick Bailey, IOC-UNESCO Technical Secretariat for TT TWO, reviewed the meeting logistics and agenda (refer to Annex 1). He proposed that *Agenda Item #2 Review of Action Items* be included under *Agenda Items #11 Discussion on the Workplan*, which was supported by the Chair. Mr Rick Bailey further spoke about the importance of data sharing and planning for the Ocean Decade. The group adopted the modified agenda.

Dr Mohammad Mokhtari asked about discussing mud volcanoes within the agenda. Mr Rick Bailey replied that this could be included in the Ocean Decade planning discussions.

### **2. REVIEW OF ACTION ITEMS**

Open recommendations and action items were reviewed by the Task Team prior to the meeting and during each relevant agenda item. New actions and recommendations arising from the current meeting were reviewed and included under *Agenda Item #11*. A summary of all recommendations and actions can be found in Annex 4.

### **3. TSUNAMI WATCH OPERATIONS: STATUS AND PLANS IN ALL ICGS**

The Chairperson introduced this agenda.

#### **3.1 CARIBE-EWS**

Dr Elizabeth Vanacore reported that many Member States are preferring to use low-technology communication methods (i.e., radio) that are reliable during tsunami events.

Dr McCreery reported on the CARIBE-EWS status and plans. Maps of the current seismic and sea level monitoring stations in the Caribbean region were shown. Upcoming changes to products include listing countries and territories in alphabetical order in the initial threat message and grouping estimated tsunami arrivals by country/territory. Types of water level measurement will be indicated on tsunami bulletins, descriptive text informing of the small possibility of a local tsunami may be added to information statements, and initial alerts may be based on travel time instead of distance. Future activities of CARIBE-EWS include the addition of South Pacific seismic data to forecasts, incorporation of GNSS data, faster RIFT server, and a seamless backup to US TWC. A longer-term focus is progressing the SMART cable project for more deep ocean sensors.

Dr Bill Fry asked if there is standardization for arrival times across TSPs to which Dr Chip McCreery replied there are not. Mr Rick Bailey noted the ICG/IOTWMS provides the time for four arrivals. Dr Francois Schindele noted that the Global Standard Tsunami Service Definition should be referenced for reporting guidelines.

Dr Elizabeth Vanacore noted that the group should revisit the tsunami arrival in the discussion on the glossary tomorrow as the first arrival may be a trough.

Mr Yuji Nishimae noted there are major problems about instrument reliability. And maintenance Dr Vanacore replied that funding, Covid relating travel restrictions, and the occurrences of other natural hazards have poised issues.

Mr Yuji Nishimae emphasized the importance of equipment maintenance to collect data for tsunami warnings. Dr Bill Fry noted that New Zealand has struggled to repair monitoring stations in other countries quickly (i.e., New Caledonia). This could be greatly assisted with a recommendation from TOWS-WG. Dr Vanacore conveyed the benefit of training local people to be the first responders for fixing equipment issues and noted this has been done in CARIBE-EWS.

### **3.2 IOTWMS**

Mr Pattabhi Rama Rao presented the status and plans of the ICG/IOTWMS. In the Indian Ocean region, there are three interoperable TSPs located in Australia, India and Indonesia providing harmonized threat information. Email is the most reliable dissemination mechanism for TSP notifications, which is shortly followed by fax. Highlights of the last year include the updated version of the IOTWMS Standard Service Definition Document (version 5) and the development of maritime bulletins by TSP Australia. A Key Performance Indicator (KPI) web application has been developed by TSP India and is under test. Member States have tested TSP Indonesia's new WRS notification tool during two IOTWMS communication tests. A strategic pathway has been identified in alignment with the UNDOS outcomes. The future plans are to implement the IOC-UNESCO Tsunami Ready Recognition Programme, conduct IOWave23, commemorate the 20th anniversary of the 2004 Indian Ocean tsunami, and complete the next phase of the UNESCAP-fund project in the Northwest Indian Ocean. Dr Mike Angove recalled the 2017 meteo tsunami in the Persian Gulf and asked if there are procedures within the IOTWMS and/or its Member States to address meteo-tsunami events. Mr Pattabhi replied that he is not aware of any developments in this area.

Dr McCreery asked about the KPI reporting web application for the TSPs and noted this would be useful for the reporting of all TSPs. Mr Pattabhi replied that after it is fully tested and implemented, the application will be made available for all TSPs.

### **3.3 NEAMTWS**

Dr Alessio Piatanesi presented the status and plans of NEAMTWS. A meeting of the Task Team will be held during the first quarter of 2023 in coordination with meetings of the Steering Committee and other Task Teams. Future activities include to coordinate the development of sea-level reading procedures with other TSPs; to coordination with TSPs on a common tsunami Common Alerting Protocol (CAP) template; to server both NEAMTWS

and national needs simultaneously; to develop the TSP Inter-Operability Tool (TSP-IOT) especially for overlapping regions; and to improve the Performance Monitoring Framework for NEAMTWS upstream components. Stromboli was provided as an example where the integration of the existing beacon system with national and NEAM tsunami warning systems has proven worthwhile.

Dr Vanacore noted that the Atlantic events can affect the Caribbean and asked if there are plans for coordination amongst these ICGs. Dr Piatanesi and Mr McCreery agreed that inter-basin collaboration and coordination is needed.

There was a discussion about the need to develop a CAP template for sharing tsunami information between TSPs (in addition to the format utilized by NTWCs). Mr Pattabhi shared that the ICG/IOTWMS has evaluated the use of CAP and decided that is not relevant at the TSP level but will be implemented at the national level. Dr Fry noted that New Zealand has had great success with CAP at the national level, especially at the administration level. Overall, the Task Team broadly agreed to investigate the usefulness of CAP messaging between TSPs in different basins

Dr Vanacore replied that we should gather the existing CAP messaging formats and look for commonalities. Mr Yuji Nishimae mentioned that he thinks sharing information among the TSPs is important, however, they do not stick to the CAP format specifically. Cdr Carlos Zuniga recalled the Turkey event in February 2023 and noted that coordination among the TSP for sharing their assessment would be worthwhile.

### 3.4 **PTWS**

Mr Yuji Nishimae presented the status and plans of ICG/PTWS. There are four PTWS-TSPs including PTWC, NWPTAC, SCSTAC, and CATAAC. The Steering Committee will next meet at IOC-UNESCO in Paris during 6-9 March 2023. The ICG/PTWS-XXX will be held in the Kingdom of Tonga during 10-16 September 2023. The TSPs continue to conduct regular communications tests and the last test was held by NWPTAC in February 2023. PacWave22 was successfully conducted during 2022 and preparations for Exercise Pacific Wave 2024 will commence following ICG/PTWS-XXX.

#### **Actions for TT TWO and ICGs**

1. In addition to providing guidance to NTWCs, develop a global CAP template for all TSPs, not for public exchange, but to facilitate exchange of bulletins between basin TSPs and their NTWCs, and between TSPs of different basins.
2. All ICGs routinely monitor and report on status of sea level and seismic networks (like CARIBE-EWS currently does) to better understand data availability and work with operators to resolve instrument issues, in order to help improve present tsunami forecasts and help identify needs and monitor implementation of enhanced data systems to meet UN Ocean Decade goals

#### **Recommendation to IOC Sea Level Monitoring Facility:**

IOC-UNESCO Sea Level Monitoring Facility increase the tabled sea level data at one second

intervals (where available) and display sea level time series as a continuous line.

#### **4. PLANNING FOR THE OCEAN DECADE**

There was a discussion about the role of the UNESCO-IOC in tsunami and if this extends to meteo-tsunami and other sea level hazards. Mr Rick Bailey reminded the group that UNESCO-IOC was given the UN mandate for tsunamis, following the devastating Indian Ocean Tsunami of 2004. As 'other sea level hazards' are included within the TOWS-WG acronym, the inclusion of meteo-tsunami would be valid.

The group also discussed the tsunami generated by the shock waves following the HTHH eruption and if this is classified as a meteo-tsunami. Mr Mike Angove asked what organisation(s) would be responsible for similar future events. Dr Mohammad Mokhtari noted that the source of the tsunami is currently debatable and suggested an alternative point of view where the focus is placed on tsunami propagation and inundation [not the source mechanism]. Mr Yuji Nishimae recalled the tsunami following the HTHH eruption traveled at the speed of sound and therefore presents unique warning challenges.

Mr Yutaro Taira explained that JMA monitors for both storm surge and tsunami, enabling easy cooperation within the one organisation. However, in many Member States the hazards are overseen by separate agencies. Thus, the challenge is inter-agency collaboration.

There was a discussion about the best way to monitor for such even more infrequent anomalous events. Mr Mike Angrove presented the concept of an outer and inner grid of nested instrumentation providing coverage for both typical earthquake subduction and non-seismic and complex source [even less frequent] events. Dr Francois Schindele emphasized that the near-field cannot be forgotten and should be a focus area of Member States. Ms Elizabeth Vanacore recalled that a cost-benefit analysis is important for decisions related to instrumentation. Mr Rick Bailey further noted the importance of risk assessments as the first fundamental inputs to instrument network design. Cmdr Carlos Zuniga supported the greater network density, while noting the importance in providing guidance to the met services on how to handle meteo-tsunami.

The group discussed the near-field events and if there is a need to provide a definition that includes timeframe, which currently varies between countries. Member States including New Zealand and the United States implemented densified instrumentation in the near-field to enable more precise tsunami monitoring and forecasting.

#### **Action for TT TWO**

TT TWO on US and NZ efforts to explore specific design of risk-based grid integrated monitoring network in support of UN Decade Objectives and provide , recognizing the role of the TT TWO in helping to enhance the monitoring and warning aspects of the Global Tsunami Warning and Mitigation System



**TASK TEAM ON TSUNAMI WATCH OPERATIONS (TT TWO) AND TASK TEAM ON DISASTER MANAGEMENT AND PREPAREDNESS (TT DMP) JOINT SESSION #2**  
(Chaired by Prof Harkunti Pertiwi Rahayu and Mr Yuji Nishimae)

**J6 LOCAL SOURCE SOPs**

- ***Visual Communication of Tsunami Warnings***

Mr Yuji Nishimae reported on visual communication of tsunami warnings and advisories in Japan. A study group found that flags were an effective method to communicate tsunami warnings/advisories, and that red and 'U' flags are most visible at a distance. A questionnaire of people with hearing and color impairments confirmed the aforementioned flags were most identifiable. The study group then proposed specifications for the flags. In response to the report, JMA amended the regulation on 24 June 2020 and published a brochure showcasing the adopted flag.

Ms Christa von Hillebrandt-Andrade reported that she observed flags being used in Odisha, India for tsunami alerting while observing IOWave18 exercise. She further asked if other flags are used for beach warnings in Japan. Mr Yuji Nishimae responded that JMA modified the regulation for dissemination flags for tsunami warnings and no other flags are currently used along beaches.

Dr Chip McCreery asked about the practicality of implementation. Mr Yuji Nishimae replied that the local government is responsible for tsunami evacuations and should prepare enough flags to cover the beaches.

Mr Ardito Kodijat asked about the timing of using the flag. Mr Yuji Nishimae explained that the U-flag is used for the first warning to evacuate and is not used even when the tsunami warning is updated after the tsunami strikes.

Dr Harkunti Rahayu noted the merit in flag use for people who have a hearing impairment. She further recalled that this practice is being employed in Oman. Mr Yuji Nishimae also recalled that Oman uses something like fireworks.

Mr Rick Bailey agreed that communities should agree and consult with other groups, such as surf life-saving who also used flags for communicating hazards at the beach.

Ms Christa von Hillebrandt-Andrade suggested a recommendation on disability inclusiveness with regards to tsunami warnings, noting the example from Japan.

Dr Mohammad Mokhtari suggested including a tsunami symbol on the flag. Mr Yuji Nishimae responded that this has been tested and is not as visible as a U-flag.

Dr Elizabeth Vanacore noted the benefit of global harmonization of tsunami warning flags.

**Recommendations to TOWS-WG**

**Noted** that Japan has defined a flag called “Tsunami Flag” as a visual communication method of tsunami warning in order to disseminate tsunami warning to people with hearing difficulties and people at the beach. The flag has been used since June 2020.

**Recommends** global harmonisation of the tsunami beach flag in consultation with other groups using flags to warn for other coastal hazards, and the broader consideration of people with disabilities in tsunami warnings.

#### **Recommendations to TOWS-WG TT DMP:**

1. TT DMP to further investigate requirements and methods to warn people with disabilities and underserved communities, especially given WTAD objective 2023 “fighting inequality for a resilient future”.
2. TT DMP take action now to upgrade NTWC competency training framework from a Pacific to global approach and include competency training for Tsunami Warning Focal Points (TWFPs) in the framework given their key role in tsunami warnings.

#### **J7 GLOBAL NTWC COMPETENCY FRAMEWORK**

Dr Laura Kong reported on the Global Competency Framework for National Tsunami Warning Centres. The ICG/PTWS Task Team on Minimum Competency Levels for NTWC Operational Staff was formed based on the request from the Pacific Small Island Developing States (SIDs) for a competency framework for NTWC personnel. The task team has proposed a first draft of the framework, which was approved in 2019 (ICG/PTWS-XXIX). The document outlines two tiers of competencies (i.e., expert and basic).

As an example of the value for capacity building, Dr Laura Kong gave the example of Tonga. Since 2009, capacity building initiatives have been conducted through five in-Tonga trainings and abroad, where Tonga participated in international training on tsunami warning operations. They built their warning response capacity over time, and their built capacity to respond well was demonstrated for the 2022 HTHH event. Further, the Solomon Islands Meteorological Service underwent impact based forecast training and identified that DRR aspects should be included within the competency framework. A capacity training workshop in the South-West Pacific (SWP) in 2022 highlighted the need for training of the trainers and for support to map and develop a framework among the Pacific Island Countries (PICTs). The PICT Task Team on Capacity Development met on 2 February 2023.

Dr Laura Kong further outlined the task team’s plans to finish the PTWS Competency Framework for approval in September 2023 at the next ICG/PTWS-XXX. The ITIC plans to work with expert and advanced NTWC partners to develop a Concept Note for Implementation, which is planned as a funded pilot in 2024 and beyond. In August 2023, the ITIC plans to partner with New Zealand to conduct its 2-week ITP-Hawaii in New Zealand, where warning centre operations will be a focus. Additionally, the 2024 ITIC Training Programme (ITP-Hawaii) is planned to be in Chile (2018 was first time), which operates advanced seismic monitoring and tsunami warning centres.

Dr Chang-Seng asked how this can be utilized in other regions. Dr Laura Kong noted the documents outline the requirements for staff at warning centres everywhere. The PTWC NTWC competency framework contains global content, which could be implemented in other

areas.

Dr Elizabeth Vanacore noted that warning centres may need competency in understanding the products they are receiving from TSPs. Dr Laura Kong responded that the task team Framework document provides a basis for developing a global competency framework.

### Recommendations to TOWS-WG

**Noted** the work of the PTWS to develop a National Tsunami Warning Centre (NTWC) Competency Framework (2017), and the ITIC's leadership to pilot training courses based on the Framework;

**Recommends** ITIC to pilot the PTWS NTWC Competency Framework with the goal to develop a global framework for all ICGs to use.

### J8 IUGG UPDATE

Dr Laura Kong provided an update on the International Union of Geodesy and Geophysics (IUGG) Joint Tsunami Commission (JTC). IUGG/JTC promotes the exchange of scientific and technical information about tsunamis among nations concerned with the tsunami hazard. There are six Working Groups: Tsunami Terminology, Science-based Tsunami Warning, Tsunami Magnitude, GNSS Data for Tsunami Warning, Meteo-tsunami, and Tsunami Data. Future meetings being organized include the EGU 2023 on tsunamis from source processes to coastal hazard and warning. Proposed meetings include the IUGG JTC - PTWS Tsunami Symposium (ICG/PTWS-XXX) in September 2023 in Tonga and the proposed IOC – IUGG/JTC 2nd International Tsunami Symposium in December 2024. Recent publication series edited by the IUGG/JTC include special journal issues on the Sulawesi/Palu (2018) and Anak/Krakatau (2018) Tsunami as a Topical collection in Pure and Applied Geophysics (19 papers), and the Tonga Volcanic Explosion 2022 as a topical collection in Pure and Applied Geophysics (6 papers and ongoing). Support provided to the IOC includes the Tsunami Glossary 2019 update, and Tsunami Generated by Volcanoes and Meteotsunami *ad hoc* team reports.

Ms Christa von Hillebrandt informed the meeting that the 28th IUGG General Assembly will be held 11-20 July 2023 at the Messe Berlin – City Cube, Berlin, Germany. It is a special opportunity for participants from around the world to come together and share their science and culture. She noted that there will be a tsunami symposium consisting of 70 abstracts and it would be interesting to see the outcome.

### Recommendations to TOWS-WG

**Notes** the recent EGU 2022 meetings on tsunamis from source processes to coastal hazard and warning;

**Notes** the publication of IUGG concerning the Sulawesi/Palu (2018) and Anak/Krakatau (2018) Tsunamis;

**Further notes** the support provided by IUGG to IOC on the tsunami glossary update in 2019 and reports on meteo-tsunamis and tsunamis generated by volcanoes;

**Welcomes** the engagement of the members of the TOWS-WG task teams at the 28th IUGG General Assembly, 11-20 July 2023 at the Messe Berlin – City Cube, Berlin, Germany;

**Further welcomes** the proposed joint IUGG and IOC Tsunami Symposium prior to ICG/PTWS meeting in September 2023 in Tonga.

## **J9 EMERGENCY WARNING SERVICE IN GALILEO**

Mr Eric Guyader, an engineer at the European Commission - Galileo Programme delivered an online presentation on the new emergency warning service in Galileo. Galileo has been in operation for 20 years, and it is now introducing its services in a wider public context. It is a new service to help alert the population. The initiative is in line with global trends and contributes to the UN DRR targets. It offers a satellite dissemination means of alerts to the population. Messages can be broadcasted to any place on earth. Galileo can alert population through smart phones. Anyone with a smart phone can receive alerts, however it is the sovereign responsibility of nations to issue alerts and choose best means of alert dissemination. Galileo must first consult with each nation it proposed sending alerts to. Galileo programme takes care of the formatting and dissemination of the alert message. There is no need for any specific network connection. Only relevant people can receive the message, and it can target populations as large as a continent to a building block. It uses an eclipse approach to target the population. Galileo takes care of 130 hazards. The target date to start full implementation is 2024. Several bilateral contacts have been established mainly with CPAs. There are ongoing discussions with countries including Australia to use Galileo services in ocean /maritime area. Field demonstration is expected to be carried out in four locations in France, Germany, Cyprus, and Belgium. They are developing the capacity and scenarios to carry out the demonstration examples. There is a workshop planned in February 2024. Galileo Programme is happy to receive relevant materials, story lines, protocols, guidelines to help design the demonstration examples in those mentioned countries. It was clarified that instructions can be sent to people inside or outside the threat zone. There are no cost implications, it is free of charge aside the operational cost. There are only 32 authorized entities able to contact Galileo, and these are pre-agreed authorized entities. It was clarified that the ellipse corresponds to people threatened. Cancellation of alerts works in the same way as issuing alerts. Mrs. Caroline Morisot-Pagnon attended the meeting in person and was available to provide further information on the Galileo services.

## **Recommendations to TOWS-WG**

**Noted** the expanded services to be offered by Galileo European Global Navigation System in 2024 for satellite-based dissemination of targeted alerts to the population and the Galileo demonstration examples to be carried out in France, Germany, Cyprus, and Belgium, the workshop planned in February 2024, and **welcomed** the offer of the Galileo Programme to provide relevant documents, storylines, protocols, guidelines and manuals to support the design of the demonstration examples.

## J10 UN SEC GENERAL “EARLY WARNING FOR ALL”

Dr Denis Chang Seng reported that the World Meteorological Organization (WMO) will provide an official report on the progress concerning implementing “Early Warning for All” during the TOWS-WG session on 2 March 2023. However, he remarked that it is important to briefly report and discuss the matter during the task teams meetings. “Early Warning for All” aims to ensure that every person on earth is covered by an early warning system by the year 2027. WMO is leading the initiative with UNDRR and partners. “Early Warnings for All” Action Plan was unveiled at COP27, Sharm el-Sheikh, Egypt, 7 November 2022. There are currently four “Early Warning for All” pillars:

Pillar 1: Risk Knowledge and Management

Pillar 2: Observations, Monitoring and Forecasting

Pillar 3: Dissemination and Communication

Pillar 4: Preparedness to Respond

“Early Warnings for All” (EW4ALL) will address the following:

- Enhancing capacity to detect hazard ,
- Close the observing gaps,
- meet the data needs for monitoring hazards (Estimated for 70 priority countries
- Enhance the existing framework and the capabilities of global data processing, forecasting, and analysis systems.
- Sustainable data and Information exchange infrastructure to support EWS
- Optimize international efforts on observation, monitoring, and forecasting
- Upscale successful regional initiatives on sharing data and forecasting products

WMO and partners are working on the action plan. Following recent discussions, it is understood that UNESCO is tasked to contribute to Pillar 2 on Observation, monitoring and forecasting together with WMO, UNEP and UNDP. UNESCO's (All Sector approach) position is to contribute to multi-hazards (flood, drought, tsunami, and earthquake). UNESCO can contribute to Innovation EWS (AI, Citizen Science) in Pilot Projects. Several steps are being undertaken to advance the initiative. For instance, WMO is developing a shared workspace for EW4All Pillar 2 group to collect inputs and share information and initial country mapping. IOC has already provided a list of countries where we have project interventions.

### Recommendations to TOWS-WG

**Acknowledges** the gaps in the global coverage of the tsunami early warning system and **recommends** full global coverage be pursued to ensure that all at risk coastal areas are assured of access to tsunami early warnings by 2027. This is a commitment to the UN “Early Warnings for All” initiative.

## J11 PLANNING FOR WTAD 2023

Ms Regina Khanbekova (UNDRR), reported that World Tsunami Awareness Day (WTAD)

2022 advocated on reducing tsunami risk globally through increasing access to early warning systems. Through political engagement to drive change, the UN Secretary-General, Antonio Guterres launched the “Early Warnings For All” Action Plan to achieve early warning for all in five years. This will save lives and protect livelihoods. In addition, the UNDRR event in New York on “Early Warning and Early Action Before Every Tsunami” served to build partnerships and leverage data to ensure no one is left behind, and aims to minimize the risks posed by tsunamis and other hazards.

Citizen engagement to build a culture of tsunami and other coastal hazards awareness for all the people at risk took place with the conduction of the *#gettohighground* public-facing campaign, where citizens participated in fun walks of tsunami evacuation routes at local level. The campaign was supported by Member States such as Indonesia, Samoa, Ecuador, Cook Islands, Portugal, and Mauritius. Approximately 4000 people participated in the *#gettohighground* campaign.

For the 2023 campaign, the theme will focus on fighting inequality for a resilient future. It will look to engage with more Member States, Making Cities Resilient (MCR) 2030, advocate decision makers on the importance of EWS coverage using strategic communications, and to continue the strong synergy between partners such as UNESCO-IOC, WMO and the UN System.

TICs, TT-DMP representatives reported on the key activities and achievements of WTAD 2022

Ms. Christa von Hillebrandt-Andrade requested that UNDRR also use the hashtag *#TsunamiReady* as part of its WTAD in support of the Ocean Decade goal of 100% of at-risk communities are ready for and resilient to tsunamis by 2030 through programmes like UNESCO/IOC Tsunami Ready Recognition Programme.

### Recommendations to TOWS-WG

**Notes** the activities undertaken by the respective regions for WTAD 2022, and as part of this, the strong engagement in the *#GetToHighGround* initiative, and the success achieved through the United Nations Office for Disaster Risk Reduction (UNDRR), and IOC collaboration;

**Further notes** to build connections with EW4ALL multi-hazard approach to coastal risk and Making Cities Resilient (MCR2030);

**Further notes** the 2023 WTAD theme will highlight the importance of fighting inequality for a resilient future;

**Further notes** activities will include continuing the *#GetToHighGround* initiative and the *#TsunamiReady* to engage citizens on tsunami awareness. The theme aligns closely with the current focus of the TOWS-WG in the context of the UN Ocean Decade, The Mid-Term Review of the Sendai Framework, and action to accelerate the implementation of the Early Warnings for All (EW4All) initiative to ensure everyone on earth is covered by MHEWS in the next four years, prioritizing the most at-risk communities;

**Recommends** continued collaboration between the UNESCO-IOC and the UNDRR;

**Requests** the UNDRR to strengthen collaboration with respective ICGs and corresponding TICs.

## J12 TSUNAMI GLOSSARY UPDATE

Dr Laura Kong provided an update on the status of the 2019 Tsunami Glossary. In the last session of the TOWS-WG-XV meeting in 2022, Dr Laura Kong recommended delaying the next update until 2023, due to delays caused by unforeseen events and to enable accommodation of the new Tsunami Ready terminology when it becomes an IOC Programme, as well as terminology related to tsunamis generated by non-seismic and complex sources under development. TOWS-WG agreed to postpone the next update of the Tsunami Glossary to 2023 to facilitate the incorporation of important changes.

In addition, the group again noted the importance of translating the Tsunami Glossary into languages additional to the UN languages, so many more people and authorities at the local level can understand and use the terminology consistently, and the importance of having abbreviated definitions for key terms for use in social media and other abbreviated language communication tools.

The 2023 version of the Tsunami Glossary will contain updates to tsunami maps and tables, information on meteo-tsunami, tsunami generation theory, and tsunami numerical modeling. New material will be included on lamb waves, the IOC-UNESCO Tsunami Ready Recognition Programme, and tsunamis generated by volcanoes.

There was a discussion about the definition of meteo-tsunami, and it was decided the *Ad Hoc* Team on Meteo-tsunamis will provide this for the glossary.

Dr Elizabeth Vanacore raised the issue that the definition of arrival time is currently the arrival of the maximum tsunami wave amplitude and suggested it be revised to be the time of the first maximum or minimum tsunami wave amplitude. It was decided to adopt the definition given in the Tsunami Watch Operations Global Service Definition Document (IOC TS 130, 2016).

Dr Mohhamad Mokhtari asked if tsunami sources such as splay-faulting and landslides could be defined within the glossary. He also mentioned that translation of the glossary into the local language will be important for implementation of the IOC-UNESCO TRRP.

Dr Bill Fry suggested the addition of another term to define the time that the tsunami reaches a threshold value. Mr Bernardo Aliaga replied that the update could be included in a future addition.

### Recommendations to TOWS-WG

**Express appreciation** to the IUGG-JTC Terminology Working Group and ITIC for leading the effort to review the Tsunami Glossary 2019.

**Approves** the glossary updates and requested the IOC to implement the updates to create the Tsunami Glossary 2023, with support from ITIC.

**Requests** the IUGG JTC Terminology Working Group and ITIC to undertake a review to advise the next meeting of the TOWS Inter-agency Task Teams on whether the 2023 Tsunami Glossary is sufficient to meet the needs of the scientific community, tsunami stakeholders, and other practitioners, or if separate target audience specific versions are required.



## TASK TEAM ON TSUNAMI WATCH OPERATIONS (TT TWO) SEPARATE SESSION #2

(Chaired by Mr Yuji Nishimae)

### 5. DISCUSSION ON SOPS FOR TSUNAMIS GENERATED BY VOLCANOES AND METEO-TSUNAMIS

Mr Mike Angove facilitated the discussion on Standard Operating Procedures (SOPs) for tsunami generated by volcanoes and meteo-tsunami. He drew reference to a chart that has been compiled on the tsunami lifecycle stages (see below).

Tsunami Lifecycle Stage	Time to Impact: < 15 min	Time to Impact: > 15 min < 30 min	Time to impact: >30 min < 60 min	Time to Impact: > 60 min < 180 min	Time to Impact: > 180 min	Primary Tools
Initial indicators	TAO - 5 min	TAO - 5 min	TAO - 5 min	TAO - 5 min	TAO - 5 min	Seismic/geodetic; Natural Warning
Tsunami (detection) confirmation	NA -	TAO - 10 min	TAO - NLT 15 min	TBI NLT - 30 min	TBI NLT - 60 min	Tsumeters, GNSS where avail
Tsunami Characterization and Forecast	NA -	NA	TBI - NLT 20 min	TBI - NLT 45 min	TBI - NLT 90 min	Seismic (CMT) Tsumeter (SL)
Tsunami Validation	TAO - 30mins	TAO - 45mins	TAO - 60mins	TAO - 75mins	TAO - 120mins	Coastal Gauges
Tsunami Cancellation	TAO - 60mins	TAO - 75mins	TAO-90mins	TAO - 120mins	TAO - 180mins	Coastal gauges; Tsumeters

**Table 1:** Tsunami lifecycle for seismic events.

This includes thresholds for the initial indicators (earthquake parameters), tsunami (detection) confirmation, tsunami characterization and forecast, tsunami validation, and tsunami cancellation. Mr Mike Angove further noted that instrument deployment must be balanced against cost and need. Dr Bill Fry commented that to provide greater impact, the table could also be linked to exposure and risk.

Dr Elizabeth Vanacore emphasized the importance of low probability, high impacts events. She expressed the merit in engaging with network operators as a useful initial step to also identify the challenges faced in instrument maintenance and deployment. Mr Mike Angove replied that in the ICG context, we can look at regions and then reach out to the providers noting that Member State buy-in is essential.

Mr Mike Angove presented a similar life cycle table for non-seismic events (see below) noting that much of the information will not be made available until later in the cycle. Mr Mike Angove noted that for non-seismic events, the instrumentation of SMART cables is of great value.

Tsunami Lifecycle Stage	Time to Impact: < 15 min	Time to Impact: > 15 min < 30 min	Time to impact: >30 min <60 min	Time to Impact: > 60 min < 180 min	Time to Impact: > 180 min	Primary Tool
Initial alert	n/a	n/a	n/a	Watch	Watch	n/a
Tsunami confirmation	NA -	N/A	N/A	TAO NLT - 60 min	TAOI NLT - 60 min	Tsunameter
Tsunami Forecast	NA	N/A	N/A	TBI - NLT 90min	TBI - NLT 120 min	Tsunameter
Tsunami Validation	TAO - 60mins	TAO - 60mins	TAO - 60mins	TAO - 90mins	TAO - 180mins	Coastal gage Tsunameter
Tsunami Cancellation	TAO - 180mins	TAO - 180mins	TAO-180mins	TAO - 180mins	TAO - 180mins	Tsunameter

**Table 1:** Tsunami lifecycle for non-seismic events.

Dr Mohhamad Mokhtari recalled the ongoing discussion on the life cycle of tsunami and the merit in relating this to different scenarios (as illustrated in the two charts).

Dr Francois Schindele noted the value of high-resolution bathymetry data in accurate tsunami forecasts.

There was a discussion about the forecast accuracy required by emergency managers. Dr Elizabeth Vanacore noted that for many emergency managers a first-order approximation may be good enough. Dr Bill Fry commented that the accuracy needs will differ between end users and their applications of the forecast.

Mr Yuji Nishimae noted that for non-seismic events identification of the location, wave amplitude and travel time forecasts may prove difficult. Dr Bill Fry noted that disperse ocean observations of the wavefield can be used for forecasting.

The Task Team agreed to establish a subgroup to provide guidance on the feasibility of developing a risk informed grid.

Mr Yuji Nishimae reported on SOPs for tsunamis developed by JMA. JMA's SOPs for tsunamis generated by volcanoes have historically been on a case-by-case basis. However, following the HTHH event JMA developed more systemised procedures and formed two expert study groups.

Mr Yuji Nishimae provided an example of a barometric pressure time-series and corresponding sea level fluctuation in Japan, noting the barometric pressure waves were also observed by the Himawari meteorological satellite. Sea level changes of more than 1 m were observed along the Pacific coast of Japan. Quantitative forecasting of the heigh of sea level change along the Japanese coast is currently difficult, so JMA has used the tsunami warning/advisory system based on sea levels and barometric pressure to call for caution. Mr Yuji Nishimae also shared the procedures for observations of a tsunami inferred from barometric pressure change caused by large-scale volcanic eruptions with both short and a long lead time. JMA has decided to carefully disseminate information and provide explanations for large-scale volcanic eruptions occurring overseas to prepare for tsunamis generated by them. They will issue tsunami warnings related to tsunamis generated by volcanoes based on sea level observations. JMA will conduct public awareness activities, including for rare

phenomena that occur infrequently, during normal [quiet] times to connect to disaster mitigation measures.

Dr Francois Schindele summarized the suggestions of the *ad hoc* team, as reported in the joint morning session, including the identification of several methods to forecast for tsunamis generated by volcanoes. Dr Bill Fry suggested forecasts could be issued based on Centroid Moment Tensor (CMT) solutions, indicative of inflation or deflation, scaled by sea level measurements. Dr Elizabeth Vanacore suggested that the volcanic observatories could be the first point of information followed by sea level observations.

Mr Mike Angove recalled the three recommendations from the *ad hoc* team on meteo-tsunamis. He questioned if meteo-tsunami are best forecast by meteorology organisations, Tsunami Service Providers, or through a collaboration between the organisations.

The Task Team discussed how advanced forecasting could benefit from the inputs of multiple organisations. Mr Yutaro Taira expressed that in Japan meteo-tsunami are being handle by JMA in the storm surge warning format. Mr Mike Angove noted that this is the case in most countries. However, such forecasts could be improved through calibration using sea-level data in collaboration with the tsunami warning community.

## **6. DISCUSS OUTCOMES OF THE JOINT MEETING WITH TT DMP**

The group reviewed the outcomes of the joint meeting with the Task Team on Disaster Management Preparedness (TT DMP). Emphasis was placed on refining the recommendations from the *ad hoc* teams on tsunami generated by volcanoes and meteo-tsunami

## **7. OTHER BUSINESS**

No other business was tabled for discussion.

## **8. UPDATE PRODUCTS FOR MARITIME COMMUNITY**

Mr Pattabhi Rama Rao Eluri briefed the group on updates to products for the maritime community. Such products have been developed in consultation with IHO and IOC. The subgroup comprised Dr Yuelong Miao, Rear-Adm Patricio Carrasco, Cmdr Carlos Zuniga and Dr Chip McCreery. TSP Australia has developed a TSP bulletin for NAVAREA coordinators that is ready for implementation by the Indian Ocean TSPs. The bulletins have been added to the IOTWMS SSD. The next step is to inform the NAVAREA coordinators of the commencement of the service through the UNESCO-IOC Secretariat. The contact details for distribution need to be obtained.

Dr Chip McCreery enquired about threshold reporting parameters and the communication mode(s) for providing notification to NAVAREA coordinators. Mr Pattabhi Eluri noted that in the Indian Ocean region, the messages would be distributed when the tsunami is predicted to be at least 0.3 m somewhere on a coast in the region. The notifications will be distributed through email and WWS dissemination modes.

Mr Rick Bailey asked when other basins will be able to implement these products. PTWC TSP in the Pacific replied that they could implement within the next year. Dr Elizabeth Vanacore

suggested the products could be tested during upcoming exercises such as CARIBEWave. JMA is currently providing tsunami information to NAVAREA XI coordinator. There was a discussion as to whether the distribution of these NAVAREA maritime community products should be the responsibility of each NTWC and not the TSPs. Mr Rick Bailey reminded the group that these bulletins are for alerting shipping before they enter an impacted area, so they can safely change direction at sea, sometimes at the start of their journey on the other side of the ocean basin. Accordingly, they are for TSPs to distribute to the broader region via NAVAREA coordinators.

### **Actions for ICGs**

TSPs from each basin to issue test the tsunami maritime safety products within next 12 months and implement in 24 months.

## **9. UPDATES TO AREA OF COVERAGE AND ESZ MAPS OF THE ICGS**

Mr Yuji Nishimae reported there have been no changes to the Areas of Coverage and Earthquake Source Zone maps since the 2022 TOWS-WG meeting. In the ICG/PTWS XXIX session, the ICG/PTWS decided to expand the Earthquake Source Zone to include the southernmost Atlantic due to the associated tsunami hazard to the Pacific. The proposal was discussed at TOWS-WG XV and a recommendation taken to the 55<sup>th</sup> UNESCO-IOC Executive Council in June 2022. However, Argentina expressed it didn't receive the proposal at the required submission time before the Executive Council meeting to fully assess the proposal and requested specified coordinates for the area be provided before a decision could be made at a later meeting of the UNESCO-IOC Assembly.

## **10. UPDATE TO THE GLOBAL SERVICES DEFINITION DOCUMENT**

Dr Chip McCreery introduced this topic and noted that the Global Services Definition Document (GSDD) was last published in 2016. In 2022, Dr Francois Schindele provided the currently reviewed and updated document and summarized the changes requested by TOWS\_WG XV. Dr Chip McCreery was nominated to take over the task of updating the document.

During the 2022 TT TWO meeting, Mr Yuji Nishimae recalled that HTHH eruption was 1-month prior. Consequently, the Task Team decided that outcomes from this event should be included in the GSDD. Dr Wilfried Strauch (CARIBE-EWS) noted that the IOC timeseries sea-level data had to be down-sampled to one-minute and further the time-series data should be displayed as a continuous line.

The following GSDD recommendations from the 2022 TT TWO meeting were discussed:

- Recommends the GSDD be updated with suggested changes by TTTWO, including warning for non-seismic generated tsunamis.
- Recommends ICGs monitor sea level data exchanges and encourage one (1) sample/second data transmission

- Requests IOC Sea Level Facility display data as continuous line representing the waveform (i.e., not as dots representing each data point) and include data transmitted at 1 sample/second data (currently not included).

The Task Team then considered new actions and recommendations related to the GSDD:

### Recommendations to TOWS-WG

1. Interim procedures for a repeat tsunamigenic eruption of HTHH Volcano have now been finalized by the ICG/PTWS and can be described and referenced in the GSDD as an example for handling this type of event.
2. The *Ad Hoc* Team on Tsunamis Generated by Volcanos (TGV) report once completed can be described and referenced in the GSDD.
3. Dr Chip McCreery and Dr Francois Schindele finalize the updated GSDD within the next month and send it to the IOC for publication, noting the last published version was in 2016.

### Actions TT TWO and ICGs

1. Implement threat levels described in Global Services Definition Document in NEAMTWS to help harmonise global tsunami warning products
2. Develop a recommended basic tsunami warning product/template for use in eg radio
3. The definition of near-field needs to be reviewed
4. Update the GSDD within month for current services
5. TSPs to not list countries with threat less than minimum threshold, subject to review and approval by each ICG as relevant

## 11. DEVELOP TT TWO WORK PLAN

The Task Team reviewed the new recommendations and actions, especially with regards to those to be presented to the TOWS-WG XV meeting. These and a status of all recommendations and actions related to the TT TWO can be found in Annex 4.

## 12. MEETING CLOSE

Mr Yuji Nishimae thanked the online and in-person members, invited experts, and observers for their participation and thanked the UNESCO-IOC Secretariat for their support. Mr Yuji Nishimae expressed appreciation for the active discussion throughout the meeting. He commented he was happy to see everyone again and for the in-person participation, following the previous two online meetings of the Task Team [2021, 2022] due to the Covid pandemic. The group requested the Task Team meet more often through online meetings and asked the Secretariat to help organise this.

### Action UNESCO-IOC secretariat

TT TWO to meet more often online (during the intersessional period)

Mr Yuji Nishimae declared the meeting closed at 5:30pm Paris time on 28 February 2023.

## Annex 1: Agenda

**Day 1: Monday, February 27, 2023, 0915 - 1800 Paris time (UTC+1)**

Item	Paris time (UTC+1)	Topic	Lead
<b>JOINT TT TWO and TT DMP SESSION #1</b>			
J1	0915 - 0930	<b>Welcome &amp; Introductions</b>	Head TSU TT Chairs
J2	0930 - 1030	<b>Wave exercises and significant tsunami events in each ICG (share outcomes, lessons learned, and coordination on exercise surveys)</b>	Joint presentations by TT reps each ICG Special update from Prof Yalciner (Türkiye EW/Tsu event)
J3	1030 - 1100	<b>Report from Ad Hoc Team Tsunamis Generated by Volcanoes</b>	Francois Schindele, Raphael Paris, and Laura Kong
	1100 - 1130	<b>Break</b>	
J4	1130 - 1200	<b>Report from Ad Hoc Team Meteo-tsunamis</b>	Mike Angove
J5	1200 - 1300	<b>Planning for Ocean Decade</b> <ul style="list-style-type: none"> <li>• Ocean Decade Tsunami Programme Endorsement</li> <li>• Draft of the 10—year research, development and implementation plan for the ODTP</li> <li>• Progress report on the Tsunami Ready Coalition</li> <li>• Plans for the 2nd IOC UNESCO Science Symposium on advances in tsunami warning to enhance community responses</li> </ul>	Secretariat Chairs Srinivas Kumar
	1300 - 1400	<b>Lunch</b>	
<b>SEPARATE TT TWO SESSION #1</b>			
1	1400 - 1410	<b>Session organization</b> Logistics, participants, agenda	Yuji Nishimae Secretariat
2	1410 - 1430	<b>Review Action Items</b>	Secretariat
3	1430 - 1530	<b>Tsunami Watch Operations status and plans in all ICGs, (15 mins ea ICG max)</b>	All
	1530 - 1600	<b>Break</b>	
4	1600 - 1700	<b>Planning for the Ocean Decade:</b> Meeting objective of more timely and accurate tsunami warnings	Yuji Nishimae Secretariat
5	1700 -1800	<b>Discussion on SOPs for Tsunamis Generated by Volcanoes and Meteo-tsunamis</b>	Yuji Nishimae Secretariat Francois Schindele Raphael Paris Mike Angove
	1800	<i>End of Day 1</i>	

**Day 2: Tuesday, February 28, 2023, 0900 – 1700 Paris time (UTC+1)**

Item	Paris Time (UTC+1)	Topic	Lead
<b>JOINT TT TWO and TT DMP SESSION #2</b>			
J6	0900 - 1000	<b>Local source SOPs</b> - Best practice for warning & response - Training - Visual notifications for tsunami in Coastal areas	Chairs All Yuji Nishimae
J7	1000 - 1015	<b>Global NTWC Competency Framework</b>	Laura Kong
J8	1015 – 1030	<b>IUGG update</b>	Maria Ana/ Laura Kong
J9	1030 - 1100	<b>Emergency Warning Service in Galileo</b>	DG ECHO
	1100 - 1130	<i>Break</i>	
J10	1130 - 1200	<b>UN Sec General “Early warning for all”</b>	WMO/UNDRR Bernardo Aliaga Denis Chang Seng
J11	1200 - 1230	<b>Planning for WTAD 2023</b>	TICs, Secretariat UNDRR
J12	1230 - 1300	<b>Tsunami Glossary update</b>	Laura Kong
	1300 - 1400	<i>Lunch</i>	
<b>SEPARATE TT TWO SESSION #2</b>			
6	1400 - 1430	<b>Discuss outcomes of the joint meeting with TT DMP</b>	All
7	1430 - 1500	<b>Other Business</b>	Yuji Nishimae Secretariat
8	1500 - 1515	<b>Update Products for Maritime Community</b>	Pattabhi
9	1515 - 1530	<b>Updates to Area of Coverage and ESZ Maps of the ICGs</b>	Yuji Nishimae Secretariat
	1530 - 1600	<i>Break</i>	
10	1600 - 1615	<b>Update to the Global Services Definition Document</b>	Chip McCreery Secretariat
11	1615 - 1700	<b>Develop TT TWO Work Plan</b>	Yuji Nishimae Secretariat, All
	1700	<i>Meeting Close</i>	Secretariat, Yuji Nishimae

## **Annex 2: List of Participants**

### **Chair**

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### **Annex 3: List of acronyms**

<b>ASEAN</b>	Association of Southeast Asian Nations
<b>BMKG</b>	Indonesian Meteorology, Climatology and Geophysical Agency
<b>CDEMA</b>	Caribbean Disaster Emergency Management Agency
<b>CEPREDENAC</b>	Coordination Centre for the Prevention of Natural Disasters in Central America
<b>CPPS</b>	Permanent Commission of the South-East Pacific
<b>CATAC</b>	Central America Tsunami Advisory Centre
<b>CTBTO</b>	Comprehensive Nuclear-Test-Ban Treaty Organization
<b>CTIC</b>	Caribbean Tsunami Information Centre
<b>EMIZA</b>	État-major Interministériel de la Zone Antilles
<b>GOOS</b>	UNESCO/IOC Global Ocean Observing System
<b>ICG</b>	Intergovernmental Coordination Group
<b>ICG/CARIBE-EWS</b>	Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions
<b>ICG/IOTWMS</b>	Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System
<b>ICG/NEAMTWS</b>	Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and connected seas
<b>ICG/PTWS</b>	Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System
<b>ICSU</b>	International Council of Science
<b>IGCP</b>	UNESCO International Geoscience Programme
<b>IHO</b>	International Hydrographic Organization
<b>IMO</b>	International Maritime Organisation
<b>INCOIS</b>	Indian National Centre for Ocean Information Services
<b>IOC</b>	Intergovernmental Oceanographic Commission
<b>IOCAFRICA</b>	Intergovernmental Oceanographic Sub-Commission for Africa and Adjacent Island States
<b>IOCARIBE</b>	IOC Sub-Commission for the Caribbean and Adjacent Regions
<b>IOTIC</b>	Indian Ocean Tsunami Information Centre
<b>ITIC</b>	International Tsunami Information Center

<b>ITU</b>	International Telecommunication Union
<b>IUGG</b>	International Union of Geodesy and Geophysics
<b>JATWC</b>	Joint Australian Tsunami Warning Centre
<b>JMA</b>	Japan Meteorological Agency
<b>NEAMTIC</b>	Tsunami Information Centre for the North-eastern Atlantic, the Mediterranean and Connected Seas
<b>NGO</b>	non-governmental organisation
<b>NOAA</b>	US National Oceanic and atmospheric Administration
<b>NTWC</b>	National Tsunami Warning Centre
<b>NTRB</b>	National Tsunami Ready Board
<b>NWPTAC</b>	North-West Pacific Tsunami Advisory Centre
<b>OTGA</b>	Ocean Teacher Global Academy
<b>PTWC</b>	Pacific Tsunami Warning Centre
<b>RTRB</b>	Regional Tsunami Ready Board
<b>SCSTAC</b>	South China Sea Tsunami Advisory Centre
<b>SFDRR</b>	Sendai Framework for Disaster Risk Reduction
<b>SPC</b>	Secretariat of the Pacific Community
<b>SPREP</b>	Secretariat of the Pacific Regional Environment Programme
<b>TIC</b>	Tsunami Information Centres
<b>TNC</b>	Tsunami National Contact
<b>TOWS-WG</b>	Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems
<b>TRLC</b>	Tsunami Ready Local Committee
<b>TSP</b>	Tsunami Service Provider
<b>TT DMP</b>	Task Team on Disaster Management and Preparedness
<b>TT TWO</b>	Task Team on Tsunami Watch Operations
<b>TWFP</b>	Tsunami Warning Focal Point
<b>UN</b>	United Nations
<b>UNDP</b>	United Nations Development Programme
<b>UNDRR</b>	United Nations Office for Disaster Risk Reduction
<b>UNESCAP</b>	UN Economic and Social Commission for Asia and the Pacific
<b>UNESCO</b>	United Nations Educational, Scientific and Cultural Organization
<b>WESTPAC</b>	IOC Sub-Commission for the Western Pacific
<b>WMO</b>	World Meteorological Organization

## **Annex 4: Summary of TT TWO Recommendations and Actions**

### **Actions for TT TWO Members and Invited Experts:**

1. Implement threat levels described in Global Services Definition Document in NEAMTWS to help harmonise global tsunami warning products (Alessio and Helene)
2. Develop a global CAP template for all TSPs, not for public exchange, but to facilitate exchange of bulletins between basin TSPs and their NTWCs, and between TSPs of different basins (TBC by Secretariat)
3. Routinely monitor and report on status of sea level and seismic networks (like CARIBE-EWS currently does) to better understand data availability and work with operators to resolve instrument issues, in order to help improve present tsunami forecasts and help identify needs and monitor implementation of enhanced data systems to meet UN Ocean Decade goals (Secretariat lead)
4. Develop a recommended basic tsunami warning product/template for use in eg radio (Liz, Derya)
5. Monitor and update TT TWO on US and NZ efforts to explore specific design of risk-based grid integrated monitoring network in support of UN Decade Objectives and provide , recognizing the role of the TT TWO in helping to enhance the monitoring and warning aspects of the Global Tsunami Warning and Mitigation System (Mike Angove and Bill Fry)
6. TSPs from each basin to issue test the tsunami maritime safety products within next 12 months and implement in 24 months. (Pattabhi, Chip, Hebert, Nishimae)
7. The definition of near-field needs to be reviewed (Liz, Alessio, Dakui, Mokhtari)
8. Update the GSDD within month for current services (eg HTHH) (Chip and Francois)
9. TSPs to not list countries with threat less than minimum threshold, subject to review and approval by each ICG as relevant (Pattabhi, Chip, Hebert, Nishimae)
10. TT TWO to meet more often online) (during the intersessional period (Secretariat, Chair).

### **Recommendations to TOWS-WG:**

1. TOWS-WG, given the critical need to resolve and understand the near-field threat to high at-risk communities where a tsunami may arrive in 5-30 minutes, reiterate the urgent need for all Member States to sample sea level data at one second intervals and transmit this in real-time.
2. TOWS-WG request IOC Assembly at its next session to reconsider the request to extend the Pacific Earthquake Observing Zone to include the South Atlantic, given the ongoing threat in this region to generate tsunamis that also impact the Pacific and Indian Oceans (eg South Sandwich Islands event, 12 August 2021)

### **Recommendations to TOWS-WG TT DMP:**

1. TT DMP to further investigate requirements and methods to warn people with disabilities and underserved communities, especially given WTAD objective 2023 “fighting inequality for a resilient future”.
2. TT DMP take action now to upgrade NTWC competency training framework from a Pacific to global approach and include competency training for Tsunami Warning Focal Points (TWFPs) in the framework given their key role in tsunami warnings.

## Recommendation to IOC Sea Level Monitoring Facility:

IOC-UNESCO Sea Level Monitoring Facility increase the tabled sea level data at one second intervals (where available) and display sea level time series as a continuous line.

## Specific Ad Hoc Team TGV Recommendations

### Recommendations to Member States:

#### *Monitoring and Warning:*

1. As a first step, organisation(s) should be designated for monitoring and warning of Tsunamis Generated by Volcanoes (TGV) . The second and third steps are to install monitoring instrumentation and develop Standard Operating Procedures (SOPs) to handle volcanic tsunamis.
2. The TGV monitoring and warning system should be implemented by, or in cooperation with the National Tsunami Warning Centre (NTWC) and regional Tsunami Service Provider and national and regional Volcano Service Providers , where such exist.
3. All volcanoes mentioned in the TGV report should be monitored and have processes in place to warn for tsunamis. Should other, potentially tsunamigenic volcanoes begin erupting, these should also be monitored and included within the tsunami warning process.
4. Detect/warn geophysical (seismology, GNSS, tiltmeter, barometric and sea level data streams need to be available to designated the tsunami monitoring/warning agency (and possibly also to the volcano monitoring agency)
5. As well as monitoring systems for volcano activity and potential far-field propagation of sea level signal, a sea level gauges network with real-time continuous data transmission should be deployed close to each identified volcano to verify risk and then ongoing monitoring and warning. One second sampling with 1 cm accuracy (< 1 mm sampling) is recommended sampling is recommended for recording and automatic detection. Data transmission through radio or microwave links, fiber optic, or dedicated telephone lines, or other modes should be implemented to ensure the data is transmitted and received and widely shared with international community in a timely manner.
6. Methods to also specifically alert persons in remote areas (such as scientific teams in the field, or recreational hikers) should be considered.
7. TGV SOPs for tsunami warning should be linked with existing Volcano Alert Activity scales.

#### *Risk Assessment and Preparedness:*

8. TGV hazard and risk assessment should be undertaken to determine vulnerable areas.
9. For TGV, multi-stakeholder meetings should be convened that included science agencies, volcano and tsunami warning operations centres, and disaster management agencies. For each identified potential source, worst-case and credible scenario planning discussions should start as soon as possible.
10. During a period of heightened TGV hazard, consider closing access to vulnerable areas. When eruption is imminent and then tsunami hazard is high, consider evacuating populations from vulnerable locations.

11. Specific TGV signage and evacuation routes should be implemented in all areas that may be impacted by tsunamis generated by volcanoes.
12. TGV public awareness campaigns should be conducted regularly – the type and frequency of awareness activities may be different for the local population compared to transient populations such as tourists.

#### **Recommendations to IOC-UNESCO Secretariat:**

IOC Secretariat to help inform Member States widely on the potential tsunami hazard from volcanoes:

1. Publish the TGV report as an IOC-UNESCO publication in 2023
2. Provide the TGV Report, including the List of Tsunamigenic Volcanoes to Volcano Observatories
3. Provide the TGV Report, including the List of Tsunamigenic Volcanoes to IOC-UNESCO Member States

#### **Recommendation to TOWS-WG:**

1. TGV warning notification systems should be considered and coordinated as part of the IOC-UNESCO Global Tsunami Warning and Mitigation System, and also when possible be part of a Multi-Hazard Early Warning System (MHEWS).
2. TOWS-WGs recommend ICGs examine TGVs in region of responsibility and review TGV hazard monitoring and warning requirements, including costs of deploying and maintaining such systems.
3. TOWS-WG recommend, where identified TGVs may impact multiple Member States, Tsunami Service Providers (TSPs) for the relevant ocean basin tsunami warning and mitigation systems consider if they need to be involved in monitoring and provision of threat advice.
4. IOC-UNESCO Ad hoc Team on TGV should continue and finalize the TGV Report by mid-2023.

#### **Specific Ad Hoc Team Meteotsunami Recommendations to TOWS-WG:**

##### **Recommendation to TOWS-WG:**

1. TOWS-WG initiate a comprehensive dialogue between the IOC and WMO is necessary to ensure full exchange of information in support of a robust international alerting system for meteo-tsunamis is achieved. It is the ad-hoc Meteotsunami team's recommendation that this report be used as a starting point of those discussions.
2. TOWS-WG to establish a mechanism for input from national and regional met services offices on data needs for meteotsunami monitoring and alerting as the GTWS considers a new generation of tsunami detection and measurement networks
3. TOWS-WG establish Framework for a Unified Meteotsunami Global System. Combining the direct tsunami detection capability of the GTWS with the NWP-based algorithms tuned to meteotsunami prediction could deliver significant advances in global capability at minimal cost.

4. TOWS-WG establish a task team made up of experts from both GTWS and NWP systems be formed with the expressed intent of outlining the potential construction of an integrated meteo-tsunami prediction system.
5. *Ad-hoc* Team on Meteotsunami continue through 2023, including WMO representatives for the purpose of recommending a global altering strategy to include specific roles of met services and TSP/NTWCs.
6. TOWS-WG establish an *ad-hoc* team to conduct a global meteo-tsunami hazard assessment to provide all MS advice on the meteotsunami hazard and risks on their coasts.