Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (SCS-WG)

Eleventh Meeting

Guangzhou, China
25 and 26 September 2023

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UNESCO 2024

ICG/PTWS-WG-SCS-XI
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1. WELCOME AND OPENING

The Eleventh meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (WG-SCS-XI) was held on 25 and 26 September 2023 in Guangzhou, China.

Mr Dakui Wang, Chair of WG SCS, opened the meeting and welcomed participants from China, Indonesia, Malaysia, and Viet Nam. He remarked that it had been three years and a half since the previous in-person meeting and was also the first face-to-face meeting of the WG-SCS since the full operation of the South China Sea Advisory Center (SCSTAC) on 5 November 2019. He commented that the Group was in a transition period from providing end-to-end seismic tsunami warning and mitigation services to coordinating national systems and capacities, facilitating technical exchanges in risk assessment and reduction, detection, warning, and dissemination, as well as promoting awareness and response, with the aim of saving lives and reducing the impacts to communities in both near-field and distant-tsunami events in the South China Sea region. Emerging challenges include developing capacities and raising awareness, establishing monitoring networks and warning procedures for non-earthquake tsunamis in the South China Sea region, and implementing the Ocean Decade Tsunami Programme at national and regional levels.

Mr Öcal Necmioglu, Programme Specialist and the new Technical Secretary for the ICG/PTWS and ICG/CARIBE EWS, Tsunami Resilience Section, IOC-UNESCO remarked that he took up this new position in September 2023 and wished to solicit support from all members. He also thanked the government of China for organising the meeting of WG-SCS and rendering continued support to the activities of ICG/PTWS.

Mr Zhiguo Xu, head of the Local Organising Committee, expressed his warm welcome to all participants and encouraged all to continue to contribute to the better development of tsunami warning and mitigation system in the South China Sea region.

2. ORGANIZATION OF THE SESSION

2.1 ADOPTION OF AGENDA

The Technical Secretary, Mr Öcal Necmioglu thanked local organiser for facilitation of online participation, but there was no registration of online participation, and no participants were expected to attend online.

The Chair, Mr Wang, introduced the provisional agenda that was circulated prior to the meeting. The Vice-Chair, Ms Suci Anugrah checked and the Technical Secretary, Mr Öcal confirmed that there would only be four national reports respectively from China, Indonesia, Malaysia, and Viet Nam. The agenda was adopted without changes and is included under Annex I.

2.2 DESIGNATION OF RAPPORTEUR

The Delegation of China volunteered Ms Ching-chi Lam from the Hong Kong Observatory (HKO) to serve as rapporteur and Mr Zongchen Wang from the National Marine Environmental Forecasting Center (NMEFC) to support Ms Lam. These recommendations were accepted by the Group.

2.3 CONDUCT OF THE SESSION, TIMETABLE AND DOCUMENTATION

The Chair, Mr Wang, provided an overview of the schedule of all agenda items as indicated in the provisional timetable. The timetable was adopted as presented. The Chair indicated that all the documents pertinent to the meeting were available at the ICG/PTWS-WG SCS-XI meeting website.

3. REVIEW OF DECISIONS, RECOMMENDATIONS AND ACTIONS ARISING FROM ICG/PTWS-WG-SCS-X MEETING AND ICG/PTWS-XXX SESSION

The Chair, Mr Wang, recalled that ICG/PTWS-WG-SCS-X was held online on 28 and 30 September 2021 and was attended by Brunei Darussalam, China, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam as well as NWPTAC.

The Chair also recalled that the previous meeting of the WG-SCS (ICG/PTWS-WG-SCS-X) agreed to conduct an IOC Training Workshop on Tsunami Forecasting and Risk Assessment for Tsunami Warning Operators, which would include topics on new methods and technologies of seismic data processing and analysis, sea level data processing, tsunami numerical modelling, tsunami forecasting and tsunami risk assessment. The training for seismic and tsunami warning operators on strengthening the Standard Operating Procedures (SOPs) for seismic data and tsunami warning in the South China Sea region was organised online by the SCSTAC/NMEFC, China on 9-10 December 2021. It was attended by over 150 participants from Brunei Darussalam, China, Indonesia, Malaysia, and Viet Nam.

The Chair added that two more workshops were held during the intersessional period. The first NMEFC-BMKG Workshop on Non-seismic Tsunamis and Complex Tsunamis was also held online on 14 July 2022, and was attended by over 200 participants from Brunei Darussalam, China, Indonesia, the Philippines, and Singapore, as well as Japan, Tonga, and the United States. An International Symposium on Applied Technologies for Earthquake and Tsunami Monitoring, Early Warning and Disaster Mitigation in the South China Sea Region was also organised online by SCSTAC/NMEFC on 20 December 2022, and was joined by over 100 participants from Brunei Darussalam, China, Indonesia, Malaysia, the Philippines, Singapore, and Thailand.

The Chair recalled that the two recommendations from ICG/PTWS-WG SCS were adopted at the ICG/PTWS-XXIX Session, namely the dissolution of the Task Team of the Regional Working Group on Tsunami Warning and Mitigation in the South China Sea Region on Establishment of a South China Sea Tsunami Advisory Center and the establishment of a Task Team on Capacity Development and Services with the elected Chair Mr Zhiguo Xu (China) and the Terms of Reference as in Appendix 2 to Annex II.

The Chair further recalled that the ICG/PTWS-WG-SCS-X agreed the commencement of full operation of BSCSTAC (Hong Kong) upon satisfactory performance in the trial operation period, with specific date to be decided by SCSTAC and announced by the IOC Secretariat to WG-SCS Member States through IOC Circular Letter. An IOC Circular Letter announcing the launch of full operation of BSCSTAC (Hong Kong) by HKO on 29 March 2023 was issued on 9 March 2023. HKO would report on the trial and full operation of the BSCSTAC (Hong Kong) under Agenda item 6.

The Chair continued that the ICG/PTWS-WG-SCS-X supported China's nomination of Mr Dakui Wang to serve as Chair of WG-SCS in the next intersessional period of ICG/PTWS and requested WG-SCS Member States to send Vice-Chair nomination for WG-SCS to the

IOC Secretariat before ICG/PTWS-XXIX Session. The ICG/PTWS-XXIX agreed to continue the Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region with Chair Mr Dakui Wang (China) and Vice-Chair Ms Suci Anugrah (Indonesia) and the Terms of Reference remained unchanged.

The Chair further recalled that the ICG/PTWS-WG-SCS-X welcomed SCSTAC's proposal of continuing with the International Staff Programme to host two or three experts from the Member States of the WG-SCS in 2022 subject to the condition of the COVID-19 pandemic, with the travel and local expenses covered by SCSTAC, and requested the IOC to make the corresponding announcement to all Member States' TNCs and NTWCs of WG-SCS. IOC announced the opportunity of short-term secondment of international staff from NTWCs of WG-SCS Member States to the SCSTAC in its Circular Letter on 5 June 2023. The SCSTAC International Staff Programme commenced in 2018, continued in 2019, but was suspended for the following three years due to COVID-19 pandemic. In 2023, a total of four nominations, namely two from Indonesia, one from Malaysia and one from the Philippines, were accepted for undertaking the secondment. The Chair thanked for Member States' nominations. NMEFC would report on the SCSTAC International Staff Programme under Agenda item 10.

The Chair completed the review of the recommendations and decisions of the WG SCS-X with the remark that it accepted with appreciation the offer of China to keep the possibility of hosting an in-person meeting of ICG/PTWS-WG-SCS-XI in 2022 in Guangzhou, China with dates and venue to be discussed and determined in consultation with the Secretariat and the Chairperson. The Chair expressed gratefulness that the WG SCS-XI could finally be organised in Guangzhou in September 2023.

The Chair provided a summary of key issues discussed and decisions made at the ICG/PTWS-XXX Session in Nuku'alofa, Kingdom of Tonga on 11-15 September 2023. The decisions related to the WG-SCS include the continuation of Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region, and also the Task Team on Capacity Development and Services under the Regional Working Group on Tsunami Warning and Mitigation Systems in the South China Sea Region, with their Terms of Reference remained unchanged as given in Appendix 1 and Appendix 2 to Annex II respectively, noting that the Chair and Vice-Chair of the Regional Working Group and the Task Team would be elected at WG-SCS-XI meeting.

The Chair also reported that the ICG/PTWS decided to carry out the eleventh Exercise Pacific Wave in 2024 (PacWave 24) in the months of September through to November 2024 to support the International Disaster Risk Reduction Day (13 October) and the World Tsunami Awareness Day (5 November).

Finally, the Chair informed that ICG/PTWS-XXX Session has accepted with appreciation China's offer of hosting the ICG/PTWS-XXXI Session in April 2025 in Beijing, and the newly elected Chair Mr Yuji Nishimae (Japan), and Vice Chairs Mr Dakui Wang (China), Mr Ofa Fa'anunu (Tonga) and Mr Wilfried Strauch (Nicaragua).

The Technical Secretary, Mr Necmioglu commented that the number of participants of the online workshops and symposium mentioned by the Chair was remarkable. He recommended that the presenters in the future could submit a 1-pager abstract for compilation of proceedings for sharing their useful experiences and findings with a wider community, say the other ICGs, on the ICG/PTWS website and promoted to the next generation. The Chair remarked that the previous workshop reports were compiled in Chinese, but the future reports would be preferably in English and available on the website.

In response to Ms Anugrah's question about the communication test, Mr Zaidi Bin Zainal Abidin responded that a communication test of SCSTAC would be conducted in October 2023. Mr Wang remarked that the outcomes of communication test would be reported by SCSTAC under Agenda item 4.2.

4. REPORTS

4.1 NATIONAL PROGRESS REPORTS

4.1.1. China

Mr Zongchen Wang, National Marine Environmental Forecasting Centre (NMEFC), Ministry of Natural Resources of the People's Republic of China, presented the report of China. He reported that the global seismic network consists of real-time, broadband seismic waveform data acquired from nearly 800 broadband seismic stations. These stations consist of 27 coastal seismic stations installed by Ministry of Natural Resources (MNR), 54 national seismic stations maintained by China Earthquake Administration (CEA) and more than 700 IRIS, GEOFON and GEOSCOPE stations. More than 100 of these stations make up the network in the South China Sea region. The earthquakes are detected, and the data is analysed using SeisComP, and Antelope which can be verified against each other. Considering the relatively high maintenance cost of Antelope, a self-designed seismic analysis software to determine the source parameters was developed. A Global Earthquake Automatic Detecting and Location System has also been developed and operating to detect and analyse global moderate to strong earthquakes in near real time.

The global real-time sea-level monitoring system is comprised of nearly 600 functional tidal gauges and DART buoys via GTS as well as data from sea-level monitoring facility website. The NMEFC also makes access to the metadata file and Tide Tool updates and software packages from the Pacific Tsunami Warning Center (PTWC) upon receipt of notification emails. Specifically, there have been 21 buoys added to the tsunami observing system since 2022. In addition, the NMEFC receives real-time sea-level data from more than 130 tidal gauges along the coast of China. Data from five of these have also been shared via GTS for the tsunami warning and mitigation system in the SCS region, three from the mainland China and two from Hong Kong.

Two sets of tsunami database are in use for tsunami hazard analysis along the coast of China and over the SCS region, namely the NW Pacific Scenario Database (NWPSD) covering the Northwest Pacific and the Pacific Unit Source Database (PUSD) covering the Pacific Ocean. There were 1,671 sources with a total of 60,156 tsunami scenarios at a resolution of 0.5-deg in the NWPSD, while in the PUSD, there were 1,391 sources with a length of 100 km and a width of 50 km. On-the-fly tsunami forecast model run on GPU was capable of producing a Pacific tsunami forecast within 45 seconds. In the Northwest Pacific and SCS region, the respective model run can be completed in less than 5 seconds, comparable to the speed of using the database method. Being the national tsunami forecast service provider, tsunami forecasting has also been extended to the Indian Ocean, North Atlantic Ocean, Mediterranean Sea, and Caribbean for domestic users and stakeholders.

A Smart Tsunami Information Processing System (STIPS) has been developed to serve as a tsunami warning and decision support system in China and adopted in SCSTAC and BSCSTAC operation. It was developed by Mr Hongwei Li of NMEFC in Python language. STIPS was put into operation in 2022. Details of the design would be introduced by Mr Li under agenda item 7.

In 2022, China's National Tsunami Warning Centre (NTWC) responded to 46 major earthquakes and issued 92 tsunami information bulletins, with an average latency of 9.0 minutes for the first message, excluding the case triggered by Tonga volcanic eruption event which brought about a maximum tsunami amplitude of about 20 cm in Shipu, Zhejiang province of China. Mr Lining Sun had shared these observations at the PTWS Post-event Brief in January 2022. He would give more details in the response review of 2022 Tonga Volcanic Tsunami under agenda item 8. In September 2022, an earthquake event in Mexico with a magnitude of Mw7.6 necessitated tsunami model run following the SOPs of NMEFC. A maximum tsunami height forecast of 93 cm was produced in the first message within 10 minutes of the earthquake in Mexico.

The NTWC organised a domestic tsunami desk-top exercise on 1 November 2022 for a hypothetical earthquake with magnitude Mw8.8 in Manila Trench. Catastrophic impact was expected in Hainan, Guangdong, Guangxi, and Fujian. Warning messages and forecast maps were sent and received effectively in 10 minutes via all communication channels.

Regarding mitigation and publicity, NMEFC developed a tsunami hazard assessment system and has completed tsunami hazard assessment for more than 60% of the coastline since 2011. To promote public education on tsunami hazards, lessons were conducted for elementary school students in Tianjin in April 2023, and a live webcast of publicity on tsunami hazard was conducted in Beijing together with the NMEFC's mascots on the National Disaster Prevention and Mitigation Day on 12 May 2023. Tsunami stories and introduction of the tsunami warning system were shared with the public at the Beijing Science Center in May 2023.

In 2022, two international activities were organised online, including the NMEFC-BMKG International Conference on Non-seismic Tsunamis and Complex Tsunamis on 14 July, and the International Symposium on Applied Technologies for Earthquake and Tsunami Monitoring, Early Warning and Disaster Mitigation in the South China Sea Region on 20 December. The China delegation attended the Thirtieth Session of the ICG/PTWS in Nuku'alofa, Kingdom of Tonga on 11-15 September 2023.

Malaysia inquired about the design of STIPS and questioned whether Antelope could be replaced with the use of STIPS. China clarified that STIPS uses database of seismic analysis software including SeisComP and Antelope, though China has also self-developed an earthquake detection system. STIPS was not designed to replace the function of Antelope. As for the dissemination of tsunami messages to local users, SMS will also be used. China welcomes sharing of more functions of the decision support system STIPS with the Member States.

Viet Nam asked about the method for generating more than 60,000 tsunami scenarios in compiling the tsunami database for the NW Pacific as compared with their case of around 19,000 scenarios. China explained that GPU model was used to simulate the scenarios based on different categories of earthquake magnitude, namely Mw6.5, 7.0 and 7.5, and with different focal depths (viz. 10, 20, 40, 60 and 100 km). Uniform source was used. In response to the question from the Technical Secretary, Mr Necmioglu regarding the setting of focal depths and dip angles, China further explained that the tectonic subduction at the region was not considered for the choice of focal depth. The choice of dip angle would depend on the shape of the coastline, otherwise the same dip angle was used for different focal depths. In the future, use of different dip angles for different focal depths could be considered.

Mr Necmioglu suggested China to consider using probabilistic approach (say Monte Carlo) to generate probabilistic tsunami forecast taking into consideration variations in the dip,

strike and rake angles of different source models given the availability of high GPU model performance. He also asked whether evacuation maps were produced in addition to inundation maps for all coastal areas of China. China responded that evacuation maps were available only for large-impact and high-risk areas.

Viet Nam asked China how to identify the appropriate one from more than 60,000 scenarios and whether the source code of the GPU tsunami forecast model could be shared with the Member States. China responded that the scenario was picked by an automatic algorithm in a couple of seconds. Views from the Task Team Chair need to be sought as to whether the code could be shared.

Malaysia enquired whether the tsunami model has been validated. China has published journal paper on model validation in the Pacific region for earthquakes of magnitude more than Mw8.0. This model only catered for tsunami generated by earthquakes, but not submarine landslides.

In response to Malaysia's question about the time consumed for running the tsunami model for the South China Sea, China explained that model simulation took 4 seconds, not including the time for input of parameters and preparation of the bulletin. The KPI for the first message issued or sent by SCSTAC is within 10 minutes from the occurrence of earthquake in the SCS. The time taken to for the user to receive the message could not be controlled.

4.1.2. Indonesia

Mr Indra Gunawan, Agency for Meteorology, Climatology and Geophysics (BMKG), presented the progress report for Indonesia. Mr Gunawan introduced the seismotectonic characteristics and seismicity of Indonesia. Being located at the junction of four active tectonic plates, namely the Eurasian Plate, Pacific Plate, Philippine Plate, and Indo-Australian Plate, and with 295 seismic faults identified in addition to six subduction zones with 13 megathrust segments, Indonesia is inevitably prone to tsunamis due to earthquakes. There are 5,000-6,000 earthquakes of various magnitudes in a year. Among which, there are 250-350 earthquakes with magnitude M>5.0 and 9-10 destructive earthquakes.

BMKG operates the Indonesia Tsunami Early Warning System (InaTEWS). The earthquake and tsunami processing system consists of SeisComP and Tsunami Observation and Simulation Terminal (TOAST). There is also a dissemination system. A backup system of InaTEWS was set up in Bali, similar to that in Jakarta. The system was supported by Presidential Decree No.93 - 2019 for strengthening and development of earthquake information and tsunami warning. Mr Gunawan introduced the components of the InaTEWS, which consist of an earthquake monitoring system, sea level monitoring system, with data collected respectively processed in the Earthquake Processing System and Tsunami Processing System. The main products include earthquake information and tsunami warning. Through multi-mode dissemination, the products are sent to stakeholders and subsequently to the coastal and affected communities.

Mr Gunawan briefed on the milestone of monitoring and processing of InaTEWS. Starting from utilising less than 21 seismic sensors and requiring a couple of days to process earthquake data manually before 1990, Indonesia gradually expanded its seismic network to 521 sensors, of which 21 are shared in real-time internationally, with a reduction of processing time to 3-5 minutes in 2023. With continued strengthening of InaTEWS, Indonesia targets to have its self-developed automatic earthquake processing and dissemination system similar to China and perform earthquake data processing in 1-3 minutes. In addition to the 521

seismic stations, Indonesia plans to build 31 additional seismic stations in 2023 and reach 600 stations in 2024 eventually. As for sea level monitoring, there are a total of 266 integrated sea level monitoring sensors, including tide gauges, automatic water level gauges, Inexpensive Device Sea Level (IDSL) water level gauges and tsunami buoys. In particular, IDSL are equipped with coastal cameras to visually confirm tsunami waves. Indonesia plans to build 100 additional sea level monitoring sensors in 2023 and 2024.

Mr Gunawan outlined InaTEWS's responsibilities globally, being the tsunami service provider for the Indian Ocean and the ASEAN.

Regarding the processing system of InaTEWS, SeisComP is used for seismic processing while the Toast application, for which Indonesia pays for the license, is employed for tsunami processing. Two methods are used for tsunami processing. They are the precalculated Tsunami Database built using the TsunAWI model utilising unstructured grids and nonlinear modelling with 22,000 scenarios in 2023, and on-the-fly linear tsunami simulation (Easywave). Toast is used to prepare tsunami bulletins for the National Tsunami Warning Centre (NTWC), the ASEAN and the Indian Ocean. Mr Gunawan also introduced the Indonesia Tsunami Non-Tectonic (InaTNT) application, which is an integrated system that detects sea level change anomalies potentially indicating a tsunami detected by sea level monitoring sensors. Mr Gunawan reported that the application recorded the tsunami induced by the Tonga volcanic eruption in 2022.

Mr Gunawan introduced the tsunami warning timeline of Indonesia. The first bulletin that contains earthquake parameters and tsunami potential is issued within 5 minutes from the occurrence of the earthquake regardless of the status of warning, and the second bulletin containing the updated earthquake parameters, estimated time of arrival of tsunami waves and the status of warning within 10 minutes from the occurrence. As the sea level observation becomes available, the third bulletin that includes sea level observation and the updated status of tsunami would be issued and updated if newer data arrives. A final tsunami bulletin would be issued as the tsunami event ends.

Mr Gunawan presented the development of dissemination system for InaTEWS. He noted that InaTEWS used several different communication channels including SMS, email, fax, upgraded Warning Receiver System (WRS), website, smartphone apps, and social media. He also briefed on the dissemination flow for WRS. Information prepared by BMKG is sent directly to stakeholders include local governments, BPBD, BNPB, the media, the police, the army, private and industry sectors, etc. and eventually reach all communities.

Regarding the mitigation of earthquake and tsunami, BMKG organised an Earthquake and Tsunami Field School – Tsunami Ready (SLG-TR) to build the capacity of local governments and communities. They also assessed the tsunami readiness of the communities with their own tsunami response systems. Besides, BMKG prepared tsunami evacuation routes and inundation maps for some areas of Indonesia and conducted on-site inspection. Through the scheme "BMKG Goes to School", BMKG educated students on earthquakes, tsunamis, and tsunami warnings. BMKG is piloting the UNESCO IOC Tsunami Ready Recognition of 9 communities by implementing 12 Tsunami Ready indicators.

Viet Nam asked about the reporting frequency of the IDSL sensor. Mr Gunawan responded that the data latency from the source to their system was around 5 minutes while the sampling period was 5 seconds.

The Technical Secretary, Mr Necmioglu inquired whether the 5-minute latency was a standard latency for the whole sea level monitoring network and the number of sea level

monitoring observations Indonesia would consider before issuing its alert messages for non-tectonic sources. Indonesia responded that BMKG works with another institution that operates a seismic network near volcanoes to monitor volcanogenic tsunamis and observes the data from monitoring instruments over the coastal areas close to the volcanoes. BMKG will continue to enhance the observation network for non-tectonic sources. Regarding the transmission rate of sensor data, Indonesia reported that some sea monitoring stations have real-time transmission at a rate of 5 seconds. BMKG will continue to improve its sea level monitoring network.

China asked how Indonesia determined the tsunami source for non-tectonic tsunami events. Indonesia responded that they relied on tide gauges close to volcanoes and coastal cameras for detection. They would treat the volcano as the tsunami source and issue bulletins in case anomalies are observed close to it. China also asked how Indonesia operates the backup center in Bali. Indonesia responded that they stop the operation in Jakarta every Friday for 3 hours so that the backup center can take over the main center during the period for upkeep of readiness.

In response to Malaysia's question on the business continuity plan for the unavailability of the main center in Jakarta, Indonesia confirmed that the backup center in Bali would then take over the main center. The switch-over arrangements have not been in SOPs yet. Indonesia also briefed on the data communication in Bali via satellite.

The Chair, Mr Wang enquired about the staff arrangement at the backup center in Bali. Indonesia responded that the center operates round-the-clock with 6 staff and a 12-hour shift schedule.

The Technical Secretary, Mr Necmioglu asked if Indonesia would consider arranging ad-hoc switch-over between main and backup centers of InaTEWS without pre-notification in addition to the regular Friday switch-over to check the readiness of the backup center. Indonesia clarified that the Bali center occasionally takes over the Jakarta center, for example when the Jakarta center undergoes urgent maintenance, and permission is required for such switch-over. Mr Necmioglu also asked if Indonesia has simulated M9.1 earthquake like the 2004 Sumatra earthquake with the broadband data and other seismological data problems for testing the response of BMKG. Indonesia explained that starting from 2022 BKMG has been operating with broadband and working on the use of ground acceleration for its own replicate calculation.

Viet Nam enquired about the difficulties with disseminating local tsunami bulletins to affected areas such as that for the 2018 Palu case. Indonesia shared that the tsunami waves hit the coast in 2 minutes while BKMG took 5 minutes to issue tsunami warning advising Indonesians over coastal areas to go to higher ground. Indonesia also noted that they would be able to alert the community directly using the WRS alarm set for the automatic earthquake information before they receive the tsunami warning. In response to the question from Mr Necmioglu regarding the implementation of an earthquake early alert system based on P-wave arrival, Indonesia responded that it was being set up.

Viet Nam asked whether there is an application that detects earthquake and tsunami events and alerts the watchstanders. Indonesia responded that an algorithm serving the function has already been implemented in the InaTEWS application. Mr Zaidi mentioned that SeisComP also possesses similar function.

4.1.3. Malaysia

Mr Zaidi Bin Zainal Abidin of the Malaysian Meteorological Department (MMD), presented the progress report for Malaysia.

He introduced that the National Weather and Geophysics Operation Centre (POCGN) is responsible for earthquake and tsunami operations in Malaysia. Malaysia has a dissemination system called Advanced decision Dissemination Malaysian earthquake and tsunami Information System (ADMIS) similar to that in China.

Malaysia operates 80 seismic stations in total, 42 over the Peninsula, 28 over Sabah and 10 over Sarawak. In addition, data are collected from 25 tide gauges and 18 coastal camera systems. 53 tsunami sirens were set up over the territory.

Mr Zainal Abidin also introduced the Area of Responsibility (AOR) of Malaysia. POCGN disseminates information on local earthquakes of M3.0 or above, earthquakes of M5.0 or above in neighboring regions within AOR and M6.0 or above outside AOR.

Malaysia simulated the tsunami worst-case scenarios due to earthquakes at sea that occur in neighboring countries including Indonesia and the Philippines using the Tohoku University's Numerical Analysis Model for Investigation of Far-field Tsunamis (TSNAMI-F1). Malaysia has switched to use Tsunami Observation and Simulation Terminal (Toast) for tsunami simulation.

Earthquake information and tsunami warnings are disseminated through tsunami sirens, the myCuaca application, social media, mass media and television, website and mygempa, SMS and messaging platform, email, and fax.

A tsunami drill for Mersing was conducted by the Mersing Disaster Management Committee (JBPD) in collaboration with MET Malaysia and other disaster management agencies from 4 to 5 September 2023. The drill was conducted with the tsunami scenario set as a M9.2 earthquake along the Manila Trench. The estimated time of arrival was shortened to about half an hour for the purpose of drill whereas the Toast simulation indicated that the estimated time of arrival would be 10 hours. Mr Zainal Abidin also demonstrated the alarm of the tsunami siren over the area.

The Technical Secretary, Mr Necmioglu asked if there is a standard colour coding for the tsunami simulation and if Malaysia is in position to modify the colour coding. Malaysia responded that the colour coding Malaysia used is embedded and editable in the Toast application and the graphics are produced based on tsunami height. Mr Necmioglu suggested the standardization of colour coding among member states.

Mr Necmioglu also enquired if the siren is a tsunami-specific siren. Malaysia shared that the siren is a very specific tsunami siren which is a speaker system that disseminates tsunami information after the wail. While there is another siren that warns any threat in certain areas not operated by MMD, local people can identify the sound of different sirens. In response to the question from the Chair, Mr Wang, on the number of tsunami sirens, Malaysia responded that there are currently 53 sirens and an increase to 83 is being planned.

China enquired how Malaysia determines earthquake parameters. Malaysia currently uses SeisComP mostly but found that Antelope is more receptive and specialised in tackling local earthquakes.

Regarding the suggestion of standardization of colour coding in tsunami simulation output among member states, Mr Wang opined that the difference in colour coding between member states is likely caused by utilization of different software and systems, and the different risks faced by different member states. Viet Nam shared that they used the colours provided by PTWC at the beginning, then they divided it into 5 categories with different backgrounds. Viet Nam recently attended the ITIC training in Hawaii and saw that most of the countries in the Pacific region have different colour coding.

4.1.4. Viet Nam

Mr Truyen Pham, of the Institute of Geophysics (IGP) within the Viet Nam Academy of Science and Technology (VAST), presented the report of Viet Nam.

He recalled that the Viet Nam Earthquake Information and Tsunami Warning Centre (EITW) was established under the Institute of Geophysics in 2007. He introduced the warning system and explained that the data sources of the seismic data processing centre are from national, regional, and local seismic networks. The national network consists of 31 broadband seismometers. The regional seismic network consists of the internationally shared seismic data. Meanwhile, the local seismic network contains about 50 broadband seismic stations which were deployed in a specific study area to monitor earthquake activities induced by hydro power plants in central Viet Nam. The seismic data, along with tsunami scenarios, sea level stations and tsunami buoys provide information to the EITW, which then disseminates earthquake information for events above Mw 3.5 and tsunami information for events above Mw 6.5. Earthquake and tsunami information is disseminated by phone, fax, TV, radio to local government offices and related agencies. Tsunami information is also disseminated through the alert system.

Viet Nam uses SeisComP as the main data processing system, while Earthworm is another data processing system that is used by Viet Nam in recent years as a backup of SeisComP. Viet Nam also uses a software called SEISAN to automatically analyse induced seismic activities.

Mr Pham then briefed about the seismicity in Viet Nam. Although Viet Nam is not located at the circum-Pacific seismic belt, large earthquakes could still occur in Viet Nam, mainly over the north-western part of the country. The strongest historical earthquakes were two M6.7 earthquakes that happened in 1935 and 1983 respectively. Besides, a M6.1 volcanic earthquake occurred in 1923 over southern Viet Nam, which did not cause tsunami.

The Hydrometeorological Service of Viet Nam operates 23 stations in the national sea level network. The data are shared with EITW and observations at two stations are shared internationally with National Meteorological and Hydrological Services (NMHSs) and IOC.

Mr Pham showed the 9 potential tsunami source zones that are capable of affecting the Vietnamese coast according to previous studies. Among those, Viet Nam identified that Manila Trench and the 109° meridian fault pose the greatest threat to the Vietnamese coast as the residents would not have enough time to evacuate. Viet Nam built 666 and 335 tsunami scenarios in the Manila Trench source and the 109° meridian source respectively.

Mr Pham then presented the tsunami SOPs of Viet Nam for local and distant tsunamis. The threshold of criteria for declaring a potential tsunami emergency depends on the location of the source and the magnitude of the tsunamigenic earthquake. Regarding tsunami warning dissemination, the information is sent to governmental disaster response organisations, and

the highest priorities are the Disaster Management Office (DMO), the National Committee for Search and Rescue, and People Committee of the coastal provinces of Viet Nam, and the media.

Mr Pham reported that drills on tsunami response were conducted in Da Nang and Quang Nam provinces in central Viet Nam. The area is equipped with 51 sirens with speakers and lighting. The ongoing project aims at building 1,500 sirens in the high-risk areas of Viet Nam.

Finally, Mr Pham reported on plans, including upgrading the national seismic networks with more broadband seismic sensors, upgrading the tsunami scenario database for warning purpose, and assessing the tsunami hazard for harbours and high-risk areas along the Vietnamese coast.

Malaysia asked about the details of the induced earthquake area in central Viet Nam. Mr Pham explained that there are a lot of dams in that area and the EITW recorded about 600 events in 2 years, with the largest one recorded as M4.7.

The Technical Secretary, Mr Necmioglu enquired if Viet Nam has investigated into the correlation between the induced activities and the change in water volume of the dam. Viet Nam responded that they found some correlation between the water level and the seismicity. When the dam underwent water storage activities, stress developed in the crust under the ground and caused seismic events. In fact, no seismic activity had been recorded before the dams went into operation.

China inquired about the department responsible for the local seismic network in Viet Nam and the purpose of building the network. Mr Pham responded that IGP is responsible, and the seismic network was set up for faster detection of smaller earthquakes in central Viet Nam to supplement the national seismic network, which was designed to detect earthquakes of M3.5 or above.

Indonesia asked about the division of duties between DMO and EITW. Mr Pham explained that the messages regarding other natural disasters such as tropical cyclones are issued by DMO while that for earthquakes and tsunamis are issued directly by EITW. In response to Malaysia's follow-up question on the legal issue, Mr Pham further explained that an agreement between the DMO and EITW was signed, granting EITW the authority to issue bulletins on earthquakes and tsunamis directly.

Ms Anugrah encouraged Viet Nam to implement the IOC-UNESCO Tsunami Ready Recognition Programme. Viet Nam responded that they would arrange more trainings and would possibly be ready in 2024.

4.2 REPORT FROM SCSTAC

Mr Zhiguo Xu, the Deputy Head of Tsunami Warning Centre of NMEFC, presented the report of the SCSTAC.

Mr Xu introduced the existing services of the global Tsunami Early Warning System (TEWS) under IOC/UNESCO. He also recalled the area of service of the SCSTAC, which has been in full operation since 5 November 2019. According to the ICG/PTWS, it encompasses all coasts of the South China Sea and the adjacent Sulu Sea and Celebes Sea, separated by

Palawan and the Sulu Archipelago from north to south respectively. Nine countries are included in this area: Brunei Darussalam, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Viet Nam. The SCSTAC provides tsunami advisory products including text messages and graphical products. Based on the SOPs for SCSTAC, tsunami bulletins will be issued for all earthquakes of Mw 6.0 or above in the South China Sea region with the bulletin type depending on the magnitude of the earthquake.

Mr Xu indicated that SCSTAC issued tsunami bulletins for 15 events between October 2021 and August 2023, noting that most earthquakes were located in the northwestern part of the Philippines, eastern Taiwan region and southeastern Indonesia. He also noted that a M7.0 shallow earthquake that occurred in Luzon, the Philippines on 27 July 2022 generated small local tsunami. The tsunami waves were observed about 35 minutes after the earthquake and the maximum wave height was 8 cm. Regarding the timeline of this event, SeisComP gave the preliminary parameters of the events 2 minutes after the earthquake occurred while SCSTAC issued the first tsunami message with Mwp6.8 in 4 minutes. The W-phase solution was available 12 minutes after the event. SCSTAC monitored all tide gauges nearby and the tsunami waves arrived at Currimao tide gauge 35 minutes after the earthquake. The maximum tsunami height was recorded later. Two hours and 4 minutes after the earthquake, SCSTAC issued the second and final tsunami message with revised magnitude 7.0. He also presented the graphical products showing the results from the tsunami simulation.

Mr Xu stated that SCSTAC key performance indicators (KPIs) were evaluated during the full operation and all targets were met. The average elapsed time from earthquake to issuance of initial tsunami products was 7.1 minutes, and the average differences between the epicentre location, magnitude and depth of the earthquakes as compared with those issued by USGS were 0.2°, 0.13 and 14 km respectively. The only KPIs that could not be evaluated were the accuracy of the Estimated Time of Arrival (ETA) and the tsunami amplitudes. This is because no earthquake of Mw 7.1 or higher occurred in SCSTAC's area of service during the evaluation period.

Mr Xu briefed that SCSTAC had conducted 6 communication tests since September 2021 thanks to the coordination of the IOC secretariat and cooperation of the Member States. He suggested to regularly update the contact list of focal points and fix the SCSTAC communication test on the first working day of each quarter in order to simplify the workflow. He then reported that the South China Sea Tsunami Warning and Communications Exercise for PacWave 22 was successfully conducted on 13 October 2022.

SCSTAC also conducted regional trainings and workshops, including online training for seismic and tsunami warning operators on strengthening SOPs for seismic data and tsunami warning in the South China Sea region from 9 to 10 December 2021, NMEFC-BMKG Online Workshop on Non-seismic Tsunamis and Complex Tsunamis on 14 July 2022, 2022 International Symposium on Applied Technologies for Earthquake and Tsunami Monitoring, Early Warning and Disaster Mitigation in the South China Sea Region on 20 December 2022, and face-to-face communications between SCSTAC and HKO in February 2023 on operation workflow and experience sharing.

In addition, SCSTAC continues to conduct the International Secondment Programme with full funding by hosting four experts from Member States from October to December 2023 for a two-month period. The major activities during the secondment include training on analysis of earthquake location and focal mechanism inversion, tsunami scenario database, forecast model and decision support system of the SCSTAC. The experts from Member States would also serve as a watchstander once a week and conduct communication with Member States regarding the activities related to the operation of SCSTAC.

SCSTAC also participated in several international meetings and sessions, including PTWC Post-event Brief on Hunga-Tonga-Hunga-Ha'apai Volcanic Eruption and Tsunami, the Thirty-second Session of the IOC Assembly, the TSP working group online meeting and the ITIC Training Program in Hawaii, USA.

Finally, Mr Xu talked about plans of the SCSTAC. The SCSTAC would ensure the continuous and stable operation of South China Sea tsunami warning and mitigation system, continue to perform communication tests and tsunami warning drills, provide opportunities for in-person education, outreach, and training activities in the region, and conduct online training workshop on tsunami warning technology and platforms in the South China Sea region.

Malaysia inquired why SCSTAC took 47 minutes but not a shorter time, say 15 minutes, to issue the final tsunami message after the Currimao tide gauge recorded the maximum tsunami height for the M7.0 Luzon event. Mr Xu responded that SCSTAC checked all the tide gauge observations in the region before issuing the final tsunami message.

Malaysia also asked why SCSTAC compared its preliminary earthquake parameters with the USGS parameters. Mr Xu responded that USGS final Preliminary Determination of Epicenters (PDE) bulletins were used in the comparison as the preliminary results could be inaccurate. The Technical Secretary, Mr Necmioglu further supplemented the background for the KPI. There is a global service definition document published in 2016 which proposed the KPIs to measure performance of the TSPs. It was stated in that document that the accuracy of earthquake parameters should be assessed making use of the final estimate from USGS. Malaysia added that they compared their parameters with those from Indonesia and the Philippines. Mr Necmioglu responded that it is better to set a benchmark that is globally accessible to everyone when it comes to a global standard. Indonesia shared that they do not compare with USGS for the first tsunami message and set their own standards in their SOPs because the comparison is not apple-to-apple with different seismic stations used. Mr Necmioglu concluded that TSPs or NTWCs can set their own KPIs to evaluate their performance and the idea of the global service definition document is to introduce a baseline to compare performance in an objective way, but there is no limitation for TSPs or NTWCs to put additional KPIs that are tailored for their own purposes. Viet Nam suggested that focal mechanism could also be compared against USGS.

Ms Anugrah asked about the “Failed to response” flags shown in the communication test result. Mr Xu responded that SCSTAC did not receive the feedback forms from some Member States. Ms Anugrah suggested SCSTAC to seek updated information from the Member States who conducted the communication test in order to improve their engagement. Mr Necmioglu asked whether IOC circular letters are required for each regular communication test. Mr Wang responded that circular letters are issued for each communication test enclosed with the feedback form to be returned to the TSP.

Mr Necmioglu asked whether setting the first working day of each quarter for the communication test could be done without a circular letter. The TSP could also use an online document to collect and store feedback results of the communication test automatically. Mr Wang recalled that the three TSPs in the Pacific Ocean, PTWC also follow this approach. Meanwhile, circular letters are issued for the two communication tests conducted by NTWCs each year. Mr Necmioglu noted that one of the advantages of hosting a survey platform is the automatic production of the statistical results of the feedback collected. Ms Anugrah suggested that a summary of feedback could be sent to Member States after a communication test. Mr Wang suggested SCSTAC to consider the suggestions made.

Indonesia reflected the difficulties to respond to communication tests because of

personnel issues. Mr Necmioglu responded that communications are made through official channels to the designated Tsunami Warning Focal Points (TWFPs) and a solution to the personnel issues is to identify an institutional email account that would route emails received to a list of users that can be controlled by the institution. For facsimile and telephone, they should be always ready to be accessed by the officers in the operations room.

4.3 REPORT FROM SCS WG TASK TEAM ON CAPACITY DEVELOPMENT AND SERVICES

Mr Zhiguo Xu, the Chair of SCS WG Task Team on Capacity Development and Services (TT-CDS), presented the report of TT-CDS. He began by recalling the establishment of a Task Team on Capacity Development and Services with the elected Chair Mr Zhiguo Xu (China) as recommended at the tenth meeting of ICG/PTWS-WG SCS. The general objectives of the task team include developing methods and tools for tsunami warning and mitigation, enhancing the SOPs for issuing warnings and response to tsunamis, reviewing experiences and lessons learnt from major tsunami events, providing guidance and assistance to the training and capacity building on tsunami services, and identifying potential requirements for the full operation of the SCSTAC.

Mr Xu next introduced methods and tools developed by SCSTAC to enhance tsunami warning capacity. Smart Tsunami Information Processing System (STIPS) developed by Mr Hongwei Li, SCSTAC, a tsunami early warning and decision-making product dissemination system, has been put into full operation at the end of 2022. The system is an integrated decision support system for tsunami warning, enabling real-time monitoring of seismic and sea level data, tsunami scenario database, GPU-accelerated parallel tsunami numerical simulation, and automatic generation and dissemination of tsunami warning products. According to the routine operation assessment made during the full operation of SCSTAC, the average delay in dissemination is less than 10 minutes after the earthquake. The average delay of earthquake alarm and the average response time of the tsunami watchstanders is 4.6 minutes and 5.4 minutes respectively.

Another tool developed to enhance global earthquake monitoring is the Global Earthquake Automatic Detecting and Location System. It comprises a near real-time waveform reading and format conversion module, an earthquake phase picking module, an automatic location and magnitude calculation module, and a parameter storage and release module. The system is able to locate global moderate to strong earthquakes near real-time automatically. It can also perform real-time seismic data decoding, pre-processing, analysis and display real-time seismic waveforms.

NMEFC self-developed GTS sea level data decoding and processing module, which expands the channels for acquiring sea level data and enhance the capability to monitor tsunamis automatically. The tool enables users to decode and process shared sea level observation data selectively. In response to possible global tsunamis triggered by volcanic eruptions, a Volcanic Eruption Display and Sea Level Alarm System were developed and put into trial operation to obtain near real-time volcanic eruption information from volcanic ash alerts online, analyse the type and location of volcanic eruption and monitor water level fluctuations. Mr Xu suggested that it is better to provide an early warning of atypical tsunami events by observing the tsunami wave field and using the earliest arrival of tsunami wave as an indication of the potential impact level of the tsunami.

Mr Xu then briefed the setup of the backup tsunami warning system in Huairou district, Beijing, China. The backup system has independent functionality through synchronization of

data with the primary system and backing up its function. Backup SCSTAC (Hong Kong) operated by HKO officially launched its full operation on 29 March 2023. A backup website was optimised and deployed, and synchronous operation with SCSTAC was achieved. Data and products are also shared with HKO for the operation of backup SCSTAC.

GPU is utilised to boost the performance of tsunami modelling for the SCS region. Models were also refined to simulate the maximum tsunami amplitude. NMEFC also conducts studies on the mechanisms of landslide tsunamis and volcanic tsunamis. Mr Xu also introduced tsunami disaster mitigation and promotion conducted locally by NMEFC, including the publication of technical guidelines for tsunami risk assessment and zoning, introduction to SCSTAC, a book titled “Modern Earthquake Tsunami Warning Technology” and another book titled “Frequently Asked Questions of Tsunami”. Internationally, regional trainings and workshops as well as short-term visits of international staff were also organised.

Indonesia enquired why NMEFC monitors basins other than SCS and expressed concern about possible confusing information from different TSPs. Mr Xu responded that NMEFC has a mission to enhance the community tsunami services and global tsunami warning services in China. Mr Wang added that NMEFC provides tsunami warning services at national and regional levels for different purposes.

Malaysia inquired how the backup tsunami warning system in Huairou district works. Mr Xu explained that the backup system can get seismic data itself and is a fully operational and parallel backup. If the main centre is not operational, SCSTAC staff can remote control the backup system. Mr Xu also clarified that the backup system in Huairou is the backup for national tsunami services while the backup SCSTAC in Hong Kong is the backup for regional tsunami services.

5. SEISMIC AND SEA LEVEL CORE STATIONS IN THE SOUTH CHINA SEA REGION FOR FURTHER ENHANCING TSUNAMI WARNING CAPABILITY

Mr Zongchen Wang, NMEFC, presented the report on seismic and sea level core stations in the SCS region for tsunami warning.

Mr Wang began by reporting on the purpose of data sharing. He shared that seismic and sea level measurements are critical for tsunami warning operations because they support tsunami detection in real time, evaluation of tsunami threat, earthquake and tsunami analysis, tsunami forecast correction, and tsunami source inversion. He next presented the discussions in previous SCS-WG meetings on the strengthening of tsunami warning capacity. An inventory of seismic and sea level stations in the SCS region was requested to be compiled at the SCS WG-IV meeting in 2015. At the 2017 meeting, the lists of seismic and sea level stations were prepared. The SCS WG-VII meeting in 2018 requested SCSTAC to provide the reports on data availability of core stations, which were presented the following year at SCS WG-VIII.

Mr Wang then recalled that a training workshop for enhancing the capacity of tsunami observation and data sharing in the SCS region was organised and hosted jointly by IOC and NMEFC in Hangzhou, China from 21 to 26 October 2019. It was attended by operational staff responsible for tsunami warning and data management. The aim of the workshop was to improve the understanding of data acquisition, treatment and management and data management, as well as to promote data sharing.

With regards to the methods for sharing seismic data in the SCS, a data-sharing server was built for seismic core stations in 2018 for sharing seismic data stream among WG-SCS

Member states using SeedLink client. For sharing of sea level data, a data-sharing server was also set up for sea level stations for Member States to share their sea level data via ftp protocol. Mr Wang reported that almost no Member State currently shares their data via the servers.

There are 115 seismic core stations in the SCS region with 49 of them, equating to 32% of the total, being publicly accessible in 2023. Mr Wang stated that the current accessibility of seismic data is not ideal for monitoring earthquakes near or at the Manila Trench with few available stations nearby. He also noted the scarcity of accessible seismic stations around the Sulu Sea and Celebes Sea for fast detection of seismic activities. He then presented a summary of the arrival rates of accessible seismic stations in the first two quarters of 2023, pointing out that there were two seismic stations, one in Malaysia and one in Thailand, with arrival rate of less than 40%.

For sea level stations, there are a total of 71 sea level stations in the SCS region for sharing and only 17 of them, accounting for 24% of the total, being accessible via GTS in 2022. However, it was noticed that the number of accessible stations dropped to 13 up to 20 September 2023, with data from 4 stations maintained by Malaysia and Viet Nam interrupted since December 2022. Mr Wang called for attention to the lack of sea level stations for monitoring tsunamis around Sulu Sea and Celebes Sea, as well as along the northern coast of Borneo, Malaysia. He then presented the arrival rates of the 17 accessible sea level stations in 2022, opining that the quality was ordinary with arrival rates of less than 40% in at least one quarter observed at 8 of these stations. He also praised Hong Kong, China and the Philippines for the good quality of their sea level data. In 2023, data from 4 stations accessible in 2022 was lost while the stability of data from China and the Philippines has improved compared with that in 2022. He concluded that there is a need to further improve the arrival rates.

Mr Wang emphasised the problems of the current availability of seismic and sea level data. The available seismic stations in SCS are scarce, especially at the Manila Trench, the most dangerous tsunami source, as well as around Sulu Sea and Celebes Sea, and in north Borneo. The available sea level stations in SCS are also sparse, especially over east of Sulu Sea and Celebes Sea, north of Borneo and Negros trench. Seismic and sea level monitoring gaps are obvious in the SCS region, and there is much room for improvement based on the core station inventory. Lastly, there is no tsunami buoy in service within the area.

SCSTAC recommended Member States of the WG-SCS to make an effort to maintain the data acquisition, quality and effective transmission of the stations they are sharing. SCSTAC also encouraged Member States of the WG-SCS to share more seismic and sea level station data to further enhance the tsunami warning capability in the SCS region, especially in the Sulu Sea, Celebes Sea, and north Borneo.

The Technical Secretary, Mr Necmioglu asked if China shares its tide gauge data with IOC Sea Level Monitoring Facilities and the others via ftp as proposed in 2019. Mr Wang responded that China shares the data collected by 3 tide gauges with IOC Sea Level Monitoring Facilities.

Malaysia expressed that they should be sharing seismic data recorded at 7 stations via IRIS instead of 5 as given in the report. Mr Zaidi would confirm with his colleagues concerning the issue.

Mr Necmioglu recommended the WG to make reference to the IOC Oceanographic Data Exchange Policy and Terms of Use as the background for data sharing.

6. TRIAL AND FULL OPERATION OF THE BACKUP SOUTH CHINA SEA TSUNAMI ADVISORY CENTER (HONG KONG)

Ms Ching-chi Lam, Hong Kong Observatory (HKO), presented the report on the trial and full operation of the Backup South China Sea Tsunami Advisory Center (Hong Kong) (BSCSTAC).

She recalled the setup history of the BSCSTAC. NMEFC of the Ministry of Natural Resources, China invited HKO to set up and operate the BSCSTAC. Preparations including system setup, data sharing and capacity building were made from April 2020 to March 2022. The trial operation of the BSCSTAC and backup website of SCSTAC commenced on 29 March 2022. After a year of trial operation, BSCSTAC was officially launched on 29 March 2023.

Ms Lam then introduced the preparation of the setup of the BSCSTAC from the perspectives of personnel and operating system. Experts from SCSTAC provided trainings on earthquake analysis, tsunami prediction and operating procedures. Regular refresher course for watchstanders on SOPs, operating system and earthquake analysis skills are also conducted. With regards to practice and drills, watchstanders are required to conduct 3 tsunami simulation exercises every day to familiarize themselves with the procedures and advisory products. The outputs are recorded for internal evaluation. Ms Lam also mentioned that these watchstanders are working at the Central Forecasting Office (CFO) at the HKO Headquarters that is manned round the clock to provide public weather services. In addition, case reviews are conducted regularly to provide comments and feedback to watchstanders.

For the operating system, the Decision Support System (DSS) of BSCSTAC was adapted from the DSS of SCSTAC, and the earthquake processing software used by the BSCSTAC includes SeisComP and Antelope. Two workstations, with one in hot standby mode, were made available for watchstanders with operating software installed. 2 GPU servers were also set up for real-time tsunami simulation. Besides, a web server hosting BSCSTAC website, which is a redundant website for SCSTAC, was set up.

During the trial operation, the watchstander at the CFO of the HKO round-the-clock responded to earthquakes within the Area of Service (AoS) and followed SOPs to prepare advisory products. The products were recorded for internal evaluation. The watchstanders also conducted system check twice a day to ensure system availability.

HKO participated in PacWave 22 and organised a government-wide table-top exercise of tsunami based on a Mw 8.8 earthquake at Manila Trench under the framework of PacWave 22 on 11 November 2022, assuming a multi-hazard scenario in which the earthquake occurred on a rainstorm day. Around 100 staff from 35 government departments participated in the exercise. During the exercise, 5 bulletins in the capacity of the BSCSTAC were issued to an internal website for performance monitoring. Local tsunami warning and situation reports were also issued to intranet email addresses. Briefing and debriefing were organised respectively before and after the exercise.

Ms Lam stated that the criteria for the issuance of tsunami bulletins adopted by BSCSTAC are the same as that by SCSTAC. She then presented the key performance of the BSCSTAC in hot standby mode during the trial and full operation. Fifteen cases since the commencement of trial and full operation (29 March 2022 to 22 September 2023) were reviewed. The average time required to issue the first tsunami product from earthquake occurrence was 10.6 minutes. Ms Lam noted that the BSCSTAC determined one of the 15 cases as a M7.1 while SCSTAC rated it as a M7.0 case. BSCSTAC performed tsunami model

run at the time and consumed additional time for this case. There was also another case for which BSCSTAC did not issue a tsunami bulletin as the magnitude was determined to be 5.9, while SCSTAC rated the magnitude as 6.1 and issued a tsunami information bulletin and USGS rated it as M6.0. Regarding the accuracy of epicenter location, magnitude, and focal depth, the BSCSTAC compared its results with those issued by SCSTAC and USGS. BSCSTAC also compared the focal mechanism solutions of the 15 review cases derived by SeisComP used by BSCSTAC with those published by USGS several months later and found the two sets of results very similar.

As for the operational arrangement, the BSCSTAC will take over from SCSTAC for not more than 2.4 months per year for scheduled operation in winter as agreed with SCSTAC, and the actual duration is subject to availability of resources and will be liaised with SCSTAC at least 3 months before the scheduled operation. The first-year scheduled operation is scheduled for 02 UTC from 11 to 22 December 2023. The BSCSTAC will follow the same SOPs as SCSTAC, i.e. advisory bulletins will be issued for M ≥ 6.0 over the AoS within 10 minutes, and bulletins with quantitative forecast of tsunami height will be provided at M ≥ 7.1 within 15 minutes. The BSCSTAC will use GTS, fax, email and website to disseminate the advisory products. The BSCSTAC also operates the backup website of SCSTAC (https://bscstac.hko.gov.hk).

The BSCSTAC conducted a communication test in April 2023 and shared the collected statistics with SCSTAC. Ms Lam reported that the observations were similar to those presented by SCSTAC. The upcoming communication test was proposed to be conducted at 02 UTC on 20 November 2023. The BSCSTAC will arrange communication test with TWFPs within the AoS once a year. Ms Lam reiterated the need for update of contact list.

Indonesia enquired whether there was any real-time communication between SCSTAC and BSCSTAC to choose the set of parameters for the M5.9 case. Ms Lam responded that there is time constraint even though BSCSTAC is under hot standby operation. In this case, the time limit was 10 minutes for the issuance of tsunami information bulletin. There has always been close coordination between SCSTAC and BSCSTAC and the two parties discussed about the case afterwards. The seismic data analysed by SeisComP in SCSTAC and BSCSTAC are not exactly the same, and the results given by SeisComP installed on different machines within HKO can also be slightly different. It is unavoidable to have a magnitude difference of 0.1. Ms Lam assured that BSCSTAC would communicate with SCSTAC in cases that would possibly pose tsunami threats. Mr Xu commented that despite the difference in the analysed magnitude of this earthquake, BSCSTAC was able to detect all earthquakes of Mw ≥ 6.0 as analysed by SCSTAC and met the corresponding KPI target.

Malaysia asked why the magnitude of this earthquake was determined to be 5.9 while the magnitudes analysed by SCSTAC and USGS were 6.1 and 6.0 respectively. Ms Lam responded that the magnitude was automatically computed by SeisComP and it is not uncommon to have a difference of 0.1 in the magnitude analysis. In addition to SeisComP, the BSCSTAC also refers to other sources such as Antelope and other centres.

Indonesia asked how BSCSTAC obtains seismic data from other stations and whether the BSCSTAC relies on internet to obtain them. Ms Lam responded that the BSCSTAC obtains data from IRIS as well as data recorded at several stations in mainland China. There is also system backup for data transmission.

Viet Nam enquired about the focal mechanism solutions derived by SeisComP. Ms Lam responded that the solution is generated by a paid module of SeisComP and the results are found to be comparable to USGS. The focal mechanisms are derived generally more than 10 minutes after the occurrence of an earthquake, say around 12 to 15 minutes. The speed

depends on the number of stations near the epicenter. The moment magnitude is also computed by the module. In response to Indonesia's question, Ms Lam confirmed that the final focal mechanisms from the USGS website should have been used for comparison in the performance evaluation of BSCSTAC. She also responded that SeisComP would update its solution as data from additional stations become available, and the results would become more stable and reliable if there are 30 or more picked phases.

Mr Xu commented that the computation of source parameters of an earthquake depends on factors such as the velocity model, the stations used, phase picks and the experience of the watchstander, etc.

The Technical Secretary, Mr Necmioglu asked about the arrangement for issuing IOC circular letters for communication tests conducted by the BSCSTAC in the future. Ms Lam expressed that BSCSTAC could be responsible for one of the regular communication tests to be conducted by SCSTAC in the future. Mr Necmioglu restated the idea of optimising the use of IOC circular letters to avoid regular routines.

7. PROGRESS OF THE TSUNAMI DECISION SUPPORTING SYSTEM AT SCSTAC

Mr Hongwei Li, SCSTAC, presented the report on the progress of the tsunami decision supporting system at SCSTAC.

He began by outlining the responsibilities of SCSTAC. The SCSTAC acquires seismic data from multiple sources, locates and characterizes the earthquake source, analyses sea level monitoring data in real time from multiple sources to confirm the generation of a tsunami and its severity, computes the Estimated Time of Arrival (ETA) and amplitudes of tsunamis, and disseminates tsunami messages and bulletins to NTWCs and TWFPs. To support these responsibilities, SCSTAC developed an open-source DSS to integrate all these functions and make it flexible to accommodate possible changes in SOPs and easy to maintain.

Mr Li introduced the integrated DSS for tsunami warning called Smart Tsunami Processing System (STIPS). It monitors, receives and processes seismic and sea level data in real time. Tsunami scenario database and GPU parallel tsunami numerical simulation are used for computing tsunami travel time and maximum amplitude. The DSS was developed using Python, one of the most popular and fastest growing programming languages. A free software GMT is used for plotting most of the graphical tsunami products while MySQL serves as the core database of the system.

A research team was set up in 2018 to develop STIPS. STIPS (V1.0) was completed in January 2022 and the trial operation commenced at the same time. A DSS for BSCSTAC was developed in March 2021 and the trial operation of the BSCSTAC DSS started in March 2022. Full operation of both STIPS and BSCSTAC DSS began in 2023.

Mr Li explained the structure of the DSS by introducing the modules of the STIPS and their functions starting from earthquake observations to bulletin generation as illustrated in Figure 1.

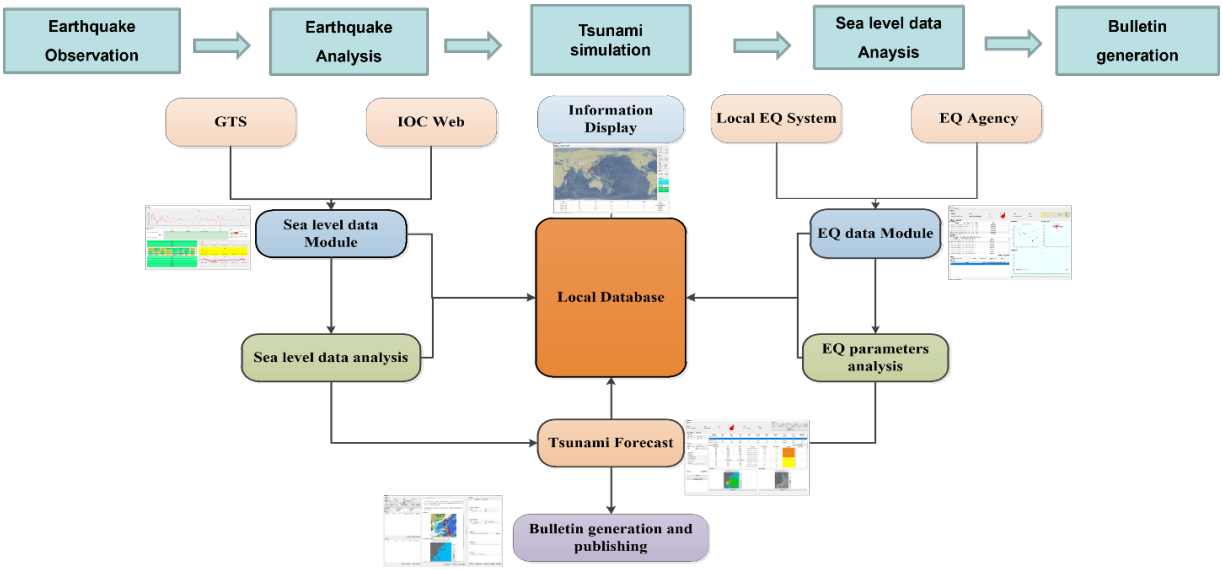

Figure 1. The structure of the DSS of SCSTAC

Mr Li briefed that earthquake bulletins of STIPS are collected from local monitoring systems like SeisComP and Antelope as well as earthquake agencies such as USGS, Japan Meteorological Agency and China Earthquake Administration. Centroid Moment Tensors (CMTs) are collected from both local systems including W-phase method, the SeisComP MT module and USGS. All earthquake events are displayed on an interactive map. For the next version of STIPS, SCSTAC plans to update the earthquake information module so that the new module would be based on a message queue mechanism. The module would be deployed on a server, which would send the earthquake information collected from various sources to each STIPS. It would save network resources, improve the performance of local seismic monitoring systems, and eliminate the differences between the earthquake bulletins received by STIPS installed on different workstations.

Mr Li then introduced the function of the earthquake analysis module. After collecting the bulletins from multiple sources, they will be listed in this module and the system can automatically select the preferred set of parameters based on historical events and observation. Magnitude against time plot displays the trend of magnitude while the depths of historical earthquakes near the estimated epicenter displaying the vertical profile of the subduction zone indicates the possible focal depth. As the first CMT solution is usually only available beyond 10 minutes after the earthquake, a new method for estimating the CMT based on historical events and tectonic setting was introduced.

After defining the earthquake parameters, the tsunami forecasting module can be used to forecast tsunami height if the magnitude of the earthquake reaches the threshold. Users can use the scenario database and the GPU version of the linear model to conduct on-the-fly simulation. The products showing the maximum tsunami wave height will be automatically plotted after the calculation is completed.

Sea level data collected by the system is mainly from the GTS and websites. There are about 600 functional tidal gauges and DART buoys. An algorithm for filtering discontinuous sea level data is available in the new version of the system. Besides, the module can automatically select the maximum height in a given time range.

The users can at last generate the product in the bulletin generation module. There are nearly 200 templates designed based on the SOPs. Users are able to generate products for multiple regions and disseminate the products through multiple ways such as email, SMS and website at the same time. The function of disseminating communication tests is also included in this module.

STIPS has been installed in Macao Meteorological and Geophysical Bureau, Macao, China to facilitate earthquake and tsunami operation. Meanwhile, the STIPS for BSCSTAC installed in Hong Kong has a similar structure but some differences in functions.

Mr Li then shared the performance of STIPS since its full operation in 2023. Six bulletins were issued using STIPS and the average elapsed time from the earthquake occurrence was 8.6 minutes for the SCSTAC operation, slightly longer than the average elapsed time of 7.1 minutes using the old DSS, possibly due to the unfamiliarity of duty officers with the new system. Some bugs were also found and fixed.

Mr Li finished by identifying future work relating to STIPS. Additional work will be done including update of the earthquake information module and the interactive map. An algorithm for filtering sea level data based on machine learning method will also be investigated. SCSTAC will also enhance the stability of the system.

The Technical Secretary, Mr Necmioglu commented that STIPS was remarkable and asked whether it could be made available to Member States. Mr Li responded positively. Indonesia suggested using historical tsunamis to validate and test the system. China suggested Indonesia might consider arranging a staff for a 2-month attachment to conduct the validation.

8. RESPONSE REVIEW OF 2022 TONGA VOLCANIC TSUNAMI

Mr Lining Sun from NMEFC presented the report on the response review of 2022 volcanic tsunami regarding the lessons learnt and the follow-up actions.

The volcano in Tonga erupted on 15 January 2022, and the tsunami hit Tabu Island about 20 minutes after the eruption, and eventually reached faraway areas in the Pacific region such as Chile, China, and Japan. The volcanic eruption caused changes in atmospheric pressure, with weather stations along the coast of China picking up changes of 1-2 hPa in general.

Mr Sun presented a timeline showing the response of PTWC and SCSTAC to the Tonga Tsunami. SCSTAC, also the national tsunami warning center of China, issued 2 tsunami messages about the Tonga tsunami. The volcano erupted at 4:27 UTC on 15 January 2022, and SCSTAC manually issued the first tsunami message at 11:30 UTC on that day. Regarding the PTWC tsunami messages, Mr Sun reported that the first tsunami message received from PTWC was indeed the ^{7t}h message issued by PTWC. It was explained in PTWC's email that PTWC manually issued 6 messages through the backup Listserv as the operational dedicated messaging software did not have the flexibility to manually issue basin-wide messages for non-seismic sources. PTWC issued the final tsunami message at 02:46 UTC on 16 January 2022 and SCSTAC issued the second and final tsunami message about an hour later.

SCSTAC advised that the volcanic eruption caused a local tsunami and quoted the tsunami wave observations around Tonga Island in the first tsunami message. It also

concluded that there was no tsunami threat to China. In the second message issued, SCSTAC updated the status of the tsunami, mentioning the volcanic eruption had caused a trans-oceanic tsunami and tsunami waves had been observed all around the Pacific region including China with no catastrophic impact. Mr Sun reported that tsunami waves were recorded by tide gauges along the south-eastern coast of China, especially in Zhejiang and Guangdong provinces around 12 hours after the volcanic eruption. The maximum tsunami wave height was about 22 cm at Shipu, Zhejiang.

Mr Sun next presented the post-event tsunami analysis using the tide gauges near the coast of south-eastern China. The largest wave amplitude recorded in Taiwan was 44 cm at the Wushi tide gauge station in Yilan. This was the maximum amplitude observed over the region. According to the research studies, leading waves were found in Taiwan (see Figure 2 below). The blue waveforms in Figure 2 are typical tsunami signals with period between 2 and 90 minutes while the red waveforms are signals with period between 30 and 90 minutes. The pink vertical bars indicate the air-pressure pulse recorded at around 12 UTC, while the green vertical bars show the theoretical arrival time calculated by Tsunami Travel Time (TTT) software. The long-period sea waves arrived at tide gauges in Taiwan, except Wushi and Keelung, at the same time as the air-pressure pulse. For Wushi and Keelung, the latencies were around 20 and 40 minutes respectively. The reason for such an observation as proposed by the research study is that the two tide gauges are located on the continental shelf with shallower water depth as compared with other gauges in Taiwan. For gauges along the coast of China, the arrival latencies between the tsunami signal and the pressure pulse were much more noticeable than those in Taiwan and Japan. The 5 tide gauges located at Guangdong and Zhejiang provinces recorded a maximum amplitude of more than 10 cm. The shortest arrival latency was more than 2 hours. Mr Sun also shared that the tsunami waves lasted for more than 20 hours at some tide gauges and some even exceeded 48 hours.

Mr Sun then gave a synopsis of the lessons learnt. Firstly, traditional tsunami monitoring methods and software cannot be used to detect tsunamis caused by volcanoes, landslides, and other factors effectively. A denser water level monitoring network on a global scale is needed. The generation mechanism and propagation dynamics of tsunami caused by these non-seismic factors also require further studies. The tsunami dissemination system needs to be further optimised for operational use. Finally, public awareness of tsunami disaster prevention should be enhanced, and tsunami evacuation drills should be carried out regularly to minimise casualties.

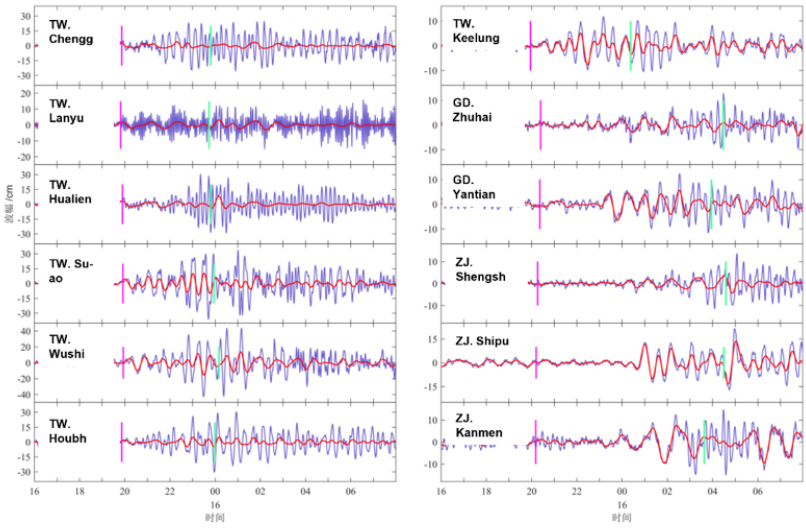

Figure 2. Waveforms recorded at tide gauges near the coast of south-eastern China.

Mr Sun next introduced SCSTAC's research on volcanic and landslide tsunamis. SCSTAC collected the information of historical volcanic tsunamis in the Pacific region and their source mechanisms. The frequency of volcanic tsunamis is low, but the impact could be severe. The process is very complex especially for large-scale volcanic eruptions which may be continuous and accompanied by various movement mechanisms such as pyroclastic flow, landslide, and collapse. For the research on potential mechanism of Palu tsunami, Okada uniform slip model and finite fault model were used to calculate the initial sea surface deformation caused by the earthquake, and Geowave was utilized to calculate the initial sea surface caused by landslide. Funwave was then run to simulate the tsunami propagation. According to the simulation results, the earthquake was not likely to generate a destructive tsunami in Palu. On the other hand, field survey after the tsunami indicated landslides in Palu. Considering both the earthquake and the landslides, numerical simulation results fitted well with TTT and tsunami waves at the Pantoloan gauge. The earthquake might have caused more than one landslide in Palu and the landslides possibly caused the tsunami.

Landslide tsunami risk assessments in SCS was also conducted using the potential submarine landslide parameters evaluated based on the data collected. The generation and propagation of the tsunami was simulated with numerical model. Under the worst-case scenario, the tsunami might take four hours to reach China with a maximum amplitude of 3 m along the coast near Shantou and Shanwei, and a maximum amplitude of 6 m in deep ocean.

Mr Sun next introduced the volcanic eruption monitoring and tsunami wave alarm software developed in light of volcanic tsunamis. A tool has been developed for searching historical volcanic events based on user's input time range and area, and the selected volcanic events is shown on a map. The software can also get volcanic information available online and display it on a map. For the purpose of monitoring, sea level data are obtained from the GTS and decoded by the software. Once there is a volcanic eruption or detected earthquake, the software will calculate the tsunami travel time based on the input location and monitor the sea level data in the specified area. If a tsunami wave over the threshold value is recorded at a sea level station in the specified area and the arrival time of the observed tsunami wave matches the calculated arrival time to a certain extent, the software will trigger an alarm. Users can check the tsunami waves recorded at the sea level stations within the tsunami event window and generate time series plots on-the-fly. The sea level data and the filtered tsunami wave, arrival time of the tsunami wave, its maximum amplitude and period can all be automatically calculated. After confirming the characteristic values of the tsunami, the software can automatically generate a report for the tsunami event. The software is currently under trial operation.

Mr Sun finished by identifying future work relating to the software. Additional work will be conducted to improve its stability and design an English interface.

Viet Nam asked about the input parameters for the simulations of volcanic tsunamis. Mr Sun explained that SCSTAC does not have a generic model for simulating volcanic eruptions because the mechanism of the volcanic eruption to induce a tsunami can be very complex. Nevertheless, there is a model for simulating landslides and pyroclastic flow that may induce tsunamis. Therefore, the first step is to identify the type of the volcanic eruption and choose a suitable model for simulation.

The Technical Secretary, Mr Necmioglu suggested that the long duration of sea level fluctuations of at least 36 hours induced by the Tonga volcanic tsunami might be caused by the trapped pressure waves in the troposphere as the initial pulse of tsunami should not have such a long duration. Mr Sun responded that it might be an explanation, another reason for such a long duration could be resonance near-shore, and that requires further studies.

Mr Necmioglu asked whether the tsunami wave alarm in the software must be manually launched. Mr Sun replied that the software can automatically get the details of the volcanic eruption and the possible volcanic tsunami, but the user is still required to manually input the start time and the location. Automatic launch based on the analysis of arriving tsunami waves is possible, but the uneven density and quality of global sea level stations may cause an issue.

Mr Necmioglu further suggested that SCSTAC can take into account possible landslides triggered by volcanic unrest. Volcanoes can get unstable without an actual explosion, and in theory earthquakes of lower magnitudes nearby have the potential to trigger a landslide. Mr Necmioglu suggested automation of this tool for monitoring of earthquakes generating tsunamigenic landslides. Mr Necmioglu appreciated SCSTAC's effort to develop this tool.

Ms Anugrah enquired how the software distinguishes short waves and tsunami waves. Mr Sun responded that the software contains a filtering program to apply band-pass filter to obtain waves with a period between 10 and 120 minutes.

Indonesia asked about the method used in the software to observe the tsunami waves in a spectrum of sea level data and whether the signal and noise are split to compare the tsunami waves with the background spectrum. Mr Sun explained that the tsunami waves induced by earthquakes may have longer period than those induced by volcanoes and landslides, so the spectrum and the main period of the tsunami can be used to evaluate the mechanism of the tsunami. Some of the noise in the spectrum is filtered by the software but the signal and noise spectrum are not split in the software as it was designed to be reliable and fast.

The Technical Secretary, Mr Necmioglu asked if the software allows adjustment of the length of the tsunami window for atypical tsunamis. China responded that they would consider adding this feature.

Indonesia enquired about how the potential submarine landslide was identified. Mr Sun responded that there are some potential sites at which submarine landslides might occur according to SCSTAC's research, and the slope angle would have been considered when the landslide parameters were decided. The scenario will be set based on data including the slope of the landslide, the bathymetry, and the topography. Indonesia then asked if SCSTAC considered landslides caused by distant earthquakes. Mr Zongchen Wang and Mr Sun clarified that the landslide tsunami risk assessments presented was performed based on historical data. The software was not an operational analysis system.

Ms Anugrah asked whether SCSTAC considers also the seismicity to determine the potential submarine landslides. Mr Sun explained that the research on landslide tsunami risk was conducted based on bathymetry and topography data and focused on the biggest potential landslide in SCS while the mechanisms triggering a landslide could be earthquakes, changes in air pressure and storm surge. The Technical Secretary, Mr Necmioglu added that it is a classical approach, which is to assess the landslide stability regardless of the external forces that can trigger the landslide and is a feasible approach.

Viet Nam asked if SCSTAC considered the speed of the landslide and its steepness. Mr Sun responded that the model takes the slope angle and the density of the landslide into consideration to automatically compute the speed and the acceleration of the landslide.

Malaysia enquired about the time taken for the tsunami generated by the submarine landslide in SCS to reach the coast and the distance between the location of the landslide and

the coast. Mr Sun and Mr Wang responded that the tsunami would reach the coast of mainland China in about 4 hours and the distance to mainland China is about 200 to 300 km. Mr Sun also clarified that the speed of tsunami waves generated by landslides is similar to that generated by earthquakes as it is determined by the water depth. Given the large-scale continental shelf near the coast of China, the water depth decreases gradually from deep ocean to coastal area and the waves will propagate slower near the coast.

9. UN DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT

Mr Jianyu Shi, NMEFC, presented the report on UN Ocean Decade Tsunami Programme (UNODTP).

The Chair, Mr Wang, stated that the reason for including UNODTP in the SCS-WG meeting was to draw attention of the Member States to the programme and to think about how the working group and the Member States can contribute to the programme.

Ms Anugrah suggested that the working group and the Member States could focus more on the risk assessment and the provision of tsunami hazard maps. Ms Anugrah also proposed the participation in the Tsunami Ready Recognition Programme (TRRP). China supported the proposal and would assist in the promotion of TRRP.

The Chair, Mr Wang, asked about the status of the implementation of TRRP in Malaysia and Viet Nam. Viet Nam expressed that they would divide the many items of the TRRP into several steps. They could first focus on the upstream like monitoring and warning, then conduct tsunami hazard and risk assessment, identify high-risk areas, and at last mitigation. For Malaysia, they would need to enhance techniques to support tsunami warning. After taking this step, they would consider community readiness. MMD is responsible for tsunami readiness in terms of application, software, and facilities, and for community readiness, they would need to collaborate with the DMO.

The Technical Secretary, Mr Necmioglu reiterated the purpose of TRRP is to raise awareness and increase readiness of the governments of Member States with commitment and intention to go through all the requirements. Any effort to pursue this programme is welcomed.

Ms Anugrah then presented a report introducing TRRP and the implementation in Indonesia.

Ms Anugrah recalled that the UN declared in 2017 that the Decade of Ocean Science would be held from 2021 to 2030. One of the aims of the global framework is ‘A Safe Ocean’, meaning coastal communities should be equipped well and with sufficient awareness of ocean-related hazards. The Tsunami Programme was established in 2021, with the aim of making 100% of communities at risk of tsunami prepared for and resilient to tsunamis by 2030 through the implementation of the IOC-UNESCO TRRP or equivalent activities.

Regarding the importance of TRRP, Ms Anugrah stated that Member states should not only rely on tsunami warning supported by advanced technology, but also involve the communities at risk to increase their capacity to respond to early warnings. There were also loss of lives and properties at many high-risk coastal communities in the past due to weak preparedness. For example, Indonesia has 5,744 villages that are prone to tsunami and other areas at which tsunamis can arrive 2 minutes after the earthquake. Tsunami preparedness is important as these communities cannot wait for the tsunami warning and should have the

ability to do self-evacuation. Indonesia is currently focusing on tsunami preparedness even though many activities on community preparedness have been organised.

There are now 43 communities that have been recognised as Tsunami Ready communities from different basins, including 11 from Caribbean, 21 from the Pacific, and 11 from Indian Ocean. Ms Anugrah elaborated that communities cannot perform the tsunami preparedness exercise themselves and other stakeholders should be involved. Hence, it requires more engagement from the NTWC, national and local DMO, academia and even private sector. The initiative of the Programme should come from the community itself and the approach is systemic preparedness and sustainable improvement.

Ms Anugrah next presented the indicators of the Tsunami Ready community, covering assessment, preparedness, and response. For assessment, the community should have tsunami hazard maps, identify the people at risk and identify economic, infrastructural, political, and social resources owned by the community. In terms of preparedness, the communities should have tsunami evacuation maps. They should display tsunami information including signage publicly and make available outreach, public awareness, and educational resources. In addition, outreach or educational activities should be held at least 3 times a year and a community tsunami exercise should be conducted at least once every two years. For the response indicators, the community should have a tsunami response plan and the capacity to manage emergency response operations during a tsunami. The community should also have redundant and reliable means to disseminate and receive 24-hour official tsunami warnings.

Ms Anugrah then introduced the recognition process for a Tsunami Ready community. First, the community should apply through the National Tsunami Ready Board (NTRB). After that, NTRB will send advocates to this community to verify whether they can be recognized as a Tsunami Ready community for IOC-UNESCO. The functions of the NTRB include:

- Coordinating the implementation of the Tsunami Ready community through advocation, promotion and socialization;
- Ensuring consistency in the implementation of the guidelines and indicators;
- Checking and providing direction on assessing Tsunami Ready Community at the national level for the proposed coastal communities prone to tsunami;
- Reviewing, evaluating, and approving requests for Tsunami Ready Community Recognition at the national level;
- Monitoring, collecting reports and evaluating Tsunami Ready Community which has received recognition annually;
- Recommending the Tsunami Ready Community to IOC for recognition.

The NTRB of Indonesia consists of many institutions including DMO, universities and the National Agency for Research and Innovation.

Ms Anugrah next presented the merits of implementing ‘Tsunami Ready’. By implementing ‘Tsunami Ready’, a community can enhance its tsunami preparedness, improve tsunami hazard assessment, improve the early warning system and warning chains, raise public awareness, and ensure exercise. There are in total 9 Tsunami Ready Communities in Indonesia and some more communities are in plan.The ‘Tsunami Ready’ are also implemented in critical infrastructures such as airports.

The Chair, Mr Wang thanked Ms Anugrah for the informative presentation. Regarding the proposal to establish a task team within WG-SCS for the Ocean Decade Tsunami Programme, he recalled that a new Task Team was established under the Working Group 3 (WG3) of ICG on Tsunami Ready during ICG/PTWS-XXX in Tonga with the Chair and the Vice-

Chair elected. In the light of this, Mr Wang encouraged Member States to actively involve in the new Task Team under WG3 of ICG instead of establishing a task team within WG-SCS.

Viet Nam enquired the time taken for a Tsunami Ready Community to get recognised. Ms Anugrah responded that it took one year for Indonesia to get the Tsunami Ready recognition and BMKG worked with local advocates, organisations, universities, and sometimes private sector as the processing of application by IOC-UNESCO takes time. She also emphasised that the community should improve its readiness and report to NTRB every year. Viet Nam also enquired about the budget involved for implementing the TRRP. Ms Anugrah responded that Indonesia allocated the budget depending on whether own resources of the community could be identified. BMKG assisted communities with tight budget by providing them with sign boards, hazard maps and tsunami information.

10. REVIEW AND PLAN OF THE SCSTAC INTERNATIONAL STAFF PROGRAMME

Mr Jianyu Shi, NMEFC, presented the report on the SCSTAC International Staff Programme.

Mr Shi recalled that the SCSTAC International started in 2018 and the major activities performed by international staff during the programme are:

- Receiving training on earthquake analysis, focal mechanism inversion, tsunami scenario database, forecast model and decision support system of the SCSTAC;
- Serving as a back-up watchstander once a week with a shift time of 12 hours in the daytime;
- Participating in communication test and coordination among WG-SCS Member States regarding activities related to the operation of SCSTAC;
- Attending academic and technical seminars about earthquake and tsunami warning.

Two international staff, one from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) of the Philippines and one from BMKG of Indonesia, attached to SCSTAC from 22 October to 21 December 2018. The programme continued in 2019, and 3 short-term international staff from MMD of Malaysia, PHIVOLCS and IGP of Viet Nam were seconded to SCSTAC from 16 September to 15 November. The programme was postponed due to COVID-19 pandemic.

Mr Shi next summarised the programme in 2018 and 2019. The 2 international staff that visited in 2018 learnt the operation SOPs and end-to-end tsunami warning system of SCSTAC and discussed with SCSTAC watchstanders the SOPs of tsunami warning of their countries. They also discussed the M7.5 Palu earthquake and tsunami from the perspective of detection, warning, and focal mechanism. A field visit was also arranged for understanding the operation of seismic and sea-level stations at a marine station. The seconded staff also had the opportunity to conduct research on the focal mechanism of the M7.5 Palu earthquake.

For the 3 staff that seconded to SCSTAC in 2019, they learnt the SOPs and end-to-end tsunami warning system of SCSTAC and discussed with SCSTAC watchstanders the SOPs of tsunami warning of their countries. They also discussed the W-phase method and its application for earthquake mechanism inversion. Arrangements were made for them to attend 5-day seismic and sea level training in Hangzhou. In addition, they visited China Earthquake Networks Center, Institute of Oceanography and Marine Monitoring and Forecasting Center of Zhejiang.

For the programme in 2023, a total of 4 nominations from MMD, PHIVOLCS and BMKG were received in response to the invitation made via IOC Circular Letter No. 2949. All the nominees were accepted, and the secondment would be from 10 October to 10 December 2023. Accommodation, office and funding were arranged for these participants.

Mr Shi finished by stating the advantages of the programme. The programme establishes a good channel of direct communication for tsunami operation staff of WG-SCS Member States. It also contributes to the acceleration of tsunami detection by sharing local sea level observations, messages from NTWCs and social media. Lastly, it strengthens bilateral and multilateral cooperation on earthquake and tsunami operation and scientific research.

Malaysia inquired if the Programme would continue in 2024 and 2025. China responded that the Programme would continue.

The Technical Secretary, Mr Necmioglu expressed sincere gratitude to China for organising the programme which is important for capacity development, bringing together Member States and transferring information and knowledge.

Indonesia thanked China for organising the programme and expressed wish to learn more about the new software developed by SCSTAC in future secondments.

The Chair, Mr Wang, recalled that Viet Nam expressed interest in the new DDS STIPS developed by SCSTAC. Mr Wang recommended Viet Nam to nominate candidates for the next round of the International Staff Programme in 2024 to discuss and learn more about the software. Viet Nam responded that their participation would be subject to availability of staff.

Ms Anugrah opined that the programme is good for promoting activities by WG-SCS. The Chair, Mr Wang, asked the IOC Secretariat to contact the Member States to promote the International Staff Programme and draw their attention and interest to join the programme in the future. The Technical Secretary, Mr Necmioglu, responded that IOC Circular Letters would be used for promoting the programme.

The Technical Secretary, Mr Necmioglu suggested that members of other ICGs could join the International Staff Programme without financial support from China to exchange and learn the best practices of the Pacific. This could possibly be developed in the ICG Exchange Programme so that all can benefit from global knowledge. The Chair, Mr Wang, appreciated the suggestion and will seek assistance from IOC Secretariat to move it forward.

11. NEXT MEETING

The Chair, Mr Wang, recalled that the WG SCS-VIII accepted the offer of China to host WG SCS-IX in Guangzhou, China in March 2020. At that time, Malaysia (Mr Bun Liong Saw) also volunteered to host WG SCS-X in 2021. However, in-person meetings of the SCS WG were cancelled due to the COVID-19 pandemic. As such, WG SCS-IX was held online on 27-28 August 2020 and WG-SCS-X was also held online on 28 and 30 September 2021.

The Group decided to accept the offer of Indonesia to host ICG/PTWS WG SCS-XII in 2024 back-to-back with the International Tsunami Symposium in Banda Aceh, Indonesia, with dates and venue to be discussed and determined in consultation with the Secretariat and the Chair.

The Group welcomes the possibility of Malaysia for hosting WG SCS-XIII in 2025. Indonesia also suggested Hong Kong, China to host WG SCS-XIV in 2026 for a visit to the backup South China Sea Tsunami Advisory Center. Ms Lam of China showed positive response.

12. ELECTION OF OFFICERS

The Chair Mr Wang noted the need to elect office bearers.Following the rules of procedure which apply to IOC subsidiary bodies, the Chair and at least one Vice-Chair must be elected either by the ICG/PTWS or members of WG for two years with possible re-election of one term in the same position. The current Chair, Mr Wang, has already elected as Vice-Chair of ICG/PTWS at ICT/PTWS XXX and nominated Ms Anugrah to take up the role of Chair of WG SCS.

The Group **accepted the nominations of Ms Suci Anugrah of Indonesia as Chair of WG-SCS and Ms Ching-Chi Lam of China to serve as Vice Chair of WG-SCS** in the next intersessional period of ICG/PTWS. The Terms of Reference of the WG SCS remained unchanged.

13. ANY OTHER BUSINESS

China noted that the Working group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG) was established to co-ordinate and provide the co-operation framework for multi-hazard early warning for hazards such as tsunamis, storm surge and ocean waves. China proposed to warning service providers of hazards related to sea-level under IOC framework in South China Sea region the collective establishment of a Multi-Hazard Early Warning System in the region.

The Chair, Mr Wang recalled that the Third International Conference on Multi-hazard Early Warning Systems (MHEWS-III) was held in Bali, Indonesia in 2022, and Multi-Hazard Early Warning System was one of goals of the Sendai Framework. He proposed that SCSTAC could share experience and expertise in other ocean-related hazards among the Member States.

Viet Nam supported the proposal for the establishment of Multi-Hazard Early Warning System in view of the threat posed by tropical cyclones and storm surge to the country.

Malaysia appreciated the proposal and suggested China to create a pilot program that serves as a platform for communications between Member States and sharing warning messages within South China Sea region to establish the multi-hazard early warning system.

Indonesia supported the proposal and suggested the initial work could be on the utilisation of instrumental data, but also expressed concern about the sharing of data between warning centers such as satellite and synoptic data. Mr Wang responded that the coordination could be arranged after the establishment of the Early Warning System.

The Technical Secretary, Mr Necmioglu recalled that the global target G of Sendai Framework focused on Multi-Hazard Early Warning Systems for the initiative of Early Warnings for All (EW4ALL). He also noted that the essence of the Multi-Hazard Early Warning Systems is in practice to integrate the capabilities and functionalities of hazard-specific (tsunami, earthquake, volcano and other meteorological-related hazards including tropical cyclones and storm surge) monitoring and warning systems. It is also related to sustainability of the

observational systems, including the maintenance and integration of various observations from different agencies in the system. Any effort towards increasing capabilities of the existing systems and the multi-hazard early warning approach is therefore welcome.

Mr Wang then noted the need to elect office bearers for TT-CDS established in 2021. He recalled that Mr Zhiquo Xu from China was elected Chair of TT-CDS, and he also recalled the Terms of Reference of TT-CDS.

The Group **elected Mr Zhiguo Xu (China) to continue serving as Chair of TT-CDS, and Mr Indra GUNAWAN (Indonesia) as the Vice Chair of TT-CDS in the next intersessional period of ICG/PTWS**.

14. SUMMARY OF DECISIONS, RECOMMENDATIONS AND ACTIONS

Based on the reports and discussions, **the WG-SCS adopted** Recommendation ICG/PTWS-WG-SCS-XI.1 and drafted recommendations to be submitted to ICG/PTWS-XXXI in Annex II.

15. CLOSE OF THE MEETING

The Chair, Mr Wang closed the meeting on 26 September 2023 at 0500 UTC, wishing all successes to Ms Suci Anugrah as the next Chair of the WG.

The Technical Secretary, Mr Öcal Necmioglu, expressed deep gratitude to China for hosting the meeting and the leadership of Mr Wang as the Chair of the WG. He also thanked Member States for contribution to the WG-SCS. Mr Necmioglu also wished all successes to the newly elected office bearers of the WG.

ANNEX I

AGENDA

1. WELCOME AND OPENING

2. ORGANIZATION OF THE SESSION

2.1. ADOPTION OF AGENDA

2.2. DESIGNATION OF RAPPORTEUR

2.3. CONDUCT OF THE SESSION, TIMETABLE AND DOCUMENTATION

3. REVIEW OF DECISIONS, RECOMMENDATIONS AND ACTIONS ARISING FROM ICG/PTWS WG-SCS-X MEETING AND ICG/PTWS XXX SESSION

4. REPORTS

4.1. NATIONAL PROGRESS REPORTS
- 4.1.1. CHINA
- 4.1.2. INDONESIA
- 4.1.3. MALAYSIA
- 4.1.4. VIET NAM

4.2. REPORT FROM SCSTAC

4.3. REPORT FROM SCS WG TASK TEAM ON CAPACITY DEVELOPMENT AND SERVICES

5. SEISMIC AND SEA LEVEL CORE STATIONS IN THE SOUTH CHINA SEA REGION FOR FURTHER ENHANCING TSUNAMI WARNING CAPABILITY

6. TRIAL AND FULL OPERATION OF THE BACKUP SOUTH CHINA SEA TSUNAMI ADVISORY CENTER (HONG KONG)

7. PROGRESS OF THE TSUNAMI DECISION SUPPORTING SYSTEM AT SCSTAC

8. RESPONSE REVIEW OF 2022 TONGA VOLCANIC TSUNAMI

9. UN DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT

10. REVIEW AND PLAN OF THE SCSTAC INTERNATIONAL STAFF PROGRAMME

11. NEXT MEETING

12. ELECTION OF OFFICERS

13. ANY OTHER BUSINESS

14. SUMMARY OF DECISIONS, RECOMMENDATIONS AND ACTIONS

15. CLOSE OF MEETING

ANNEX II

ADOPTED RECOMMENDATIONS

Recommendation ICG/PTWS-WG-SCS-XI.1

Tsunami Warning and Mitigation System for the South China Sea Region: Sharing of Seismic and Sea Level Stations, Multi-Hazard Early Warning Systems, Communication Tests, Capacity Building, International Staff Programme, Working Group Governance and Next Meeting

The Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region,

Recalling that the Thirtieth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS-XXVIII) decided to continue the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (ICG/PTWS-WG-SCS) with Terms-of-Reference as attached in Appendix 1 to Recommendation ICG/PTWS-WG-SCS-X.1, and the Chair and vice-chair to be elected at its eleventh meeting.

Further Recalling that the Thirtieth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS-XXVIII) decided to continue the Task Team on Capacity Development and Services (TT-CDS) under the Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region with Terms of Reference as attached in Appendix 2 to Recommendation ICG/PTWS-WG-SCS-X.1, and the Chair and vice-chair to be elected at its eleventh meeting.

Acknowledging with appreciation the satisfactory performance of the South China Sea Tsunami Advisory Center (SCSTAC) since its full operation starting on 5 November 2019, and the Backup South China Sea Tsunami Advisory Center (Hong Kong) [BSCSTAC (Hong Kong)] since its full operation on 29 March 2023.

Noting:

- Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted by UN Member States on 18 March 2015 at the World Conference for Disaster Risk Reduction (WCDRR) with one of the seven global targets to substantially increase the availability of and access to Multi-Hazard Early Warning Systems (MHEWS) and disaster risk information and assessments to people by 2030 to contribute to the initiative of Early Warnings for All (EW4All).

- IOC Decision A-31/3.4.1 on Warning Mitigation Systems for Ocean Hazards approved the establishment of the Ocean Decade Tsunami Programme (PROGRAMME) and a Scientific Committee (SC) to prepare the draft 10-Year Research, Development and Implementation Plan for this PROGRAMME,

- IOC Decision A-32/3.4.1 on Warning Mitigation Systems for Ocean Hazards decided to endorse the 10-Year Research, Development and Implementation Plan of the Ocean Decade Tsunami Programme as presented in document IOC/A-32/3.4.1.2.Doc(1), and also decided that warning systems for tsunamis generated by volcanoes should be considered and coordinated as part of the UNESCO/IOC Global tsunami and other Ocean-related Hazards Warning and Mitigation System (GOHWMS), and also when possible be part of a MHEWS;

Encourages the Member States of the WG-SCS to implement the IOC-UNESCO Tsunami Ready Recognition Programme (TRRP) or similar activities for vulnerable communities, to meet the UN Ocean Decade Tsunami Programme goal of 100% at-risk communities resilient and prepared for tsunamis by 2030, and to actively contribute to the activities of the ICG/PTWS WG3 Task Team on Tsunami Ready established at the thirtieth Session of the ICG/PTWS in Tonga, 2023;

Acknowledges and supports the proposal of China to establish a MHEWS for the South China Sea region in coordination with the IOC, and to share early warning products and information of other ocean-related hazards within the Member States.

Recognizes the paucity of seismic and sea level stations close to the major tsunami sources within the SCS region available to the South China Sea Tsunami Warning and Mitigation System;

Encourages the Member States of the WG-SCS to share more seismic and sea level stations for tsunami warning purposes in accordance with the IOC Oceanographic Data Exchange Policy to further enhance the tsunami warning capability in the South China Sea region, especially for the Sulu Sea, Celebes Sea and North Borneo;

Agrees and supports the quarterly communication tests (CTs) by SCSTAC, tentatively on the first day of each quarter with the last test of the year to be conducted by BSCSTAC (Hong Kong) before its commencement of scheduled operation, with an announcement by the IOC Secretariat to WG-SCS Member States through a circular letter before the effective and efficient use of online survey tools (links) embedded/included in the CT message itself to collect feedback for the CTs.

Requests the Member States of the WG-SCS to regularly update information on National Tsunami Warning Center (NTWC), Tsunami National Contacts (TNC) and Tsunami Warning Focal Points (TWFP) with IOC Secretariat following the established procedures, and **further encourages** the Member States to make use of centralized/institutional e-mail addresses as an internal e-mail list to efficiently accommodate changes to the responsible persons for receiving tsunami messages.

Welcomes SCSTAC's proposal to continue with the International Staff Programme to host seconded experts from the Member States of the WG-SCS in 2024, with the travel and local expenses covered by SCSTAC, and requests the IOC secretariat to make an announcement to all Member States' TNCs, TWFPs and NTWCs of WG-SCS on this matter;

Agrees to conduct an online Training Workshop on Tsunami Warning Technology and Platforms in late 2023 or early 2024 at the kind invitation of SCSTAC and NMEFC, China;

Recalling that Mr Dakui Wang (China) was elected Chair of WG-SCS at the 29th Session of ICG/PTWS (online), 2021, and elected Vice Chair of ICG-PTWS at its 30th Session, Tonga, 2023;

Elects Ms Suci ANUGRAH (Indonesia) to serve as Chair of WG-SCS, and Ms Ching-chi LAM (China) to serve as Vice Chair of WG-SCS in the next intersessional period of ICG/PTWS;

Recalling that Mr Zhiguo Xu (China) was elected Chair of TT-CDS at the 29th Session of ICG/PTWS (online), 2021;

Elects Mr Zhiguo Xu (China) to continue serving as Chair of TT-CDS in the next intersessional period of ICG/PTWS, and Mr Indra GUNAWAN (Indonesia) as the Vice Chair of TT-CDS in the next intersessional period of ICG/PTWS;

Accepts with appreciation the offer of Indonesia to host the Twelfth Meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region in 2024 back-to-back with the International Tsunami Symposium 2024 in Banda Aceh to commemorate the 20th Indian Ocean Tsunami. The Group welcomes the possibility of Malaysia for hosting the Thirteenth Meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region in 2025. The Group also welcomes the possibility of China to host the Fourteenth Meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region in 2026 in Hong Kong.

Appendix 1

Terms of Reference

Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (WG-SCS)

1. To evaluate capabilities of countries in the South China Sea Region for providing end-to-end tsunami warning and mitigation services.

2. To ascertain requirements from countries in the South China Sea Region for the tsunami warning and mitigation services.

3. To promote and facilitate tsunami hazard and risk studies in the region.

4. To facilitate cooperation in the establishment and upgrading of seismic and sea level stations and networks and communication systems in the region.

5. To facilitate improvement of the education programmes on tsunami mitigation in the region.

6. To facilitate capacity building and the sharing of tsunami information in the region, including the free and open exchange of data.

7. To serve as a coordination point within the region for member states proposals related to UNODTP objectives, and advising the PTWS SC on details of such proposals for consideration.

The Group will be composed of members nominated by Member States Brunei, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam and invited experts with a Chair and Vice-Chair to be elected by the members of the Working Group and endorsed by the ICG/PTWS.

Appendix 2

Terms of Reference

Regional Working Group on Tsunami Warning and Mitigation in the South China Sea Region Task Team on Capacity Development and Services

1. To coordinate training workshops and other technical exchanges on topics related to earthquake and tsunami for enhancing the tsunami warning capabilities of the WG-SCS Member States.

2. To facilitate implementation of the International Staff Programme for short-term secondment of staff from WG-SCS Member States to SCSTAC on an annual basis.

3. To explore ways for furthering the sharing and exchange of relevant data and information in the South China Sea region.

4. To ascertain the latest requirements of WG-SCS Member States for tsunami advisory service provided by SCSTAC.

Membership: Representatives of Member States of the ICG/PTWS WG-SCS (Brunei Darussalam, Cambodia, China, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam) and invited experts; representatives of PTWC and NWPTAC (JMA); with Chair and Vice-Chair to be elected either by the WG-SCS or the ICG/PTWS.

Draft Recommendations to be submitted to ICG/PTWS-XXXI

ICG/PTWS Governance

Decides to continue the Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region with Terms of Reference as attached in Appendix 1. Elected Chair is Ms Suci ANUGRAH (Indonesia), and elected Vice Chair is Ms Ching-chi LAM (China). The Terms of Reference for this group remains unchanged;

Decides to continue the Task Team on Capacity Development and Services (TT-CDS) under the Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region with Terms of Reference as attached in Appendix 2. Elected Chair is Mr Zhiguo Xu (China), and elected Vice Chair is Mr Indra GUNAWAN (Indonesia). The Terms of Reference for this group remains unchanged.

ANNEX III

LIST OF PARTICIPANTS

Chair

Dr Dakui WANG
Associate Research Professor National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 10 62105671
Email: dakui.nmefc@gmail.com

Vice-Chair

Ms Suci ANUGRAH
Agency for Meteorology Climatology and Geophysics (BMKG)
P.O. Box 3540 Jkt.
Jl. Angkasa I No.2 Kemayoran Jakarta Pusat
DKI Jakarta 10720
Indonesia
Email: sucirahman@yahoo.com

Working Group members
(listed under their country for ease of reference)

CHINA

Ms Ching-chi LAM
Senior Scientific Officer
Geophysics, Time and Marine Meteorological Services Division Hong Kong Observatory
134A Nathan Road, Kowloon
Hong Kong SAR China
Tel: +852 2926 8451
Email: cclam@hko.gov.hk

Mr Hongwei LI
National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 010 62104151
Email: lihw@nmefc.cn

Mr Jianyu SHI
National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 1520 1607372
Email: shijy@nmefc.cn

Mr Zongchen WANG
Tsunami Warning Division National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 10 62104151
Email: wangzc@nmefc.cn

Mr Lining SUN
National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 010 62104151
Email: sunln@nmefc.cn

Mr Zhiguo XU
National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 10 62104561
Email: xuzg@nmefc.cn

Ms Huaiwei YANG
National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuisi Road, Haidian District Beijing 100081
China
Tel: +86 1520 4709898
Email: zld@nmefc.cn

INDONESIA

Mr Indra GUNAWAN
Agency for Meteorology Climatology and Geophysics (BMKG)
P.O. Box 3540 Jkt.
Jl. Angkasa I No.2 Kemayoran
Jakarta Pusat
DKI Jakarta
Indonesia
Tel: +62 021 4246703 10720
Email: indra.gunawan@bmkg.go.id

MALAYSIA

Mr Zaidi Bin ZAINAL BIDIN
Meteorologist
Technical Weather and Geophysics
Malaysian Meteorological Department
Jalan Sultan
46667 Petaling Jaya Selangor
Malaysia
Email: zaidi@met.gov.my

VIET NAM

Mr Minh Tuan TRINH
National Bounary Commission
Ministry of Foreign Affairs of Viet Nam
58 Nguyen Du Street,
Hai BaTrung District
Hanoi Viet Nam
Email: ttminh.mofa@gmail.com

Mr Truyen PHAM
Researcher
Viet Nam Earthquake Information and Tsunami Warning Center, Institute of Geophysics, Viet Nam Academy of Science and Technology
18 Hoang Quoc Viet street
Cau Giay District
Hanoi
Viet Nam
Tel: +84 439940320
Email: ptt502@gmail.com

Secretariat

Mr Öcal NECMIOGLU
Programme Specialist
Tsunami Resilience Section
Intergovernmental Oceanographic Commission of UNESCO
7 Place de Fontenoy
75732 Paris Cedex 07
France
Tel: +33 1 45 68 21 88
Email: o.necmioglu@unesco.org

Group photo of the Eleventh meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (WG-SCS-X) held on 25 and 26 September 2023 in Guangzhou, China.

ANNEX IV

LIST OF ACRONYMS

BSCSTAC	Backup South China Sea Tsunami Advisory Center (Hong Kong)
BIG	Agency of Geospatial Information
BMKG	Agency for Meteorology Climatology and Geophysics
CEA	China Earthquake Administration
DSS	Decision Supporting System
EITW	Viet Nam Earthquake Information and Tsunami Warning Centre
EQFS	Earthquake Field School
HKO	Hong Kong Observatory
ICG	Intergovernmental Coordination Group
IGP	Institute of Geophysics
InaTEWS	Indonesia Tsunami Early Warning System
IOC	Intergovernmental Oceanographic Commission
IOTIC	Indian Ocean Tsunami Information Center
ITIC	International Tsunami Information Center
ITST	International Tsunami Survey Team
JMA	Japan Meteorological Agency
LDMO	Local Disaster Management Office
MMD	Malaysian Meteorological Department
MSS	Meteorological Service Singapore
NDMO	National Disaster Management Office
NMEFC	National Marine Environmental Forecasting Centre
NTWC	National Tsunami Warning Centre
NTWS	National Tsunami Warning System
NWPTAC	Northwest Pacific Tsunami Advisory Center
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PSN	Philippine Seismic Network
PTWC	Pacific Tsunami Warning Center
QEM	Quick Earthquake Message

SCS	South China Sea
SCSTAC	South China Sea Tsunami Advisory Center
SCS-WG	Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region
SMS	Short Message System
SOP	Standard Operating Procedure
TEMPP	Tsunami Evacuation Map, Plans and Procedures
TIC	Tsunami Information Centre
TSP	Tsunami Service Provider
TT-SCSTAC	South China Sea Tsunami Advisory Center Task Team
UNESCO	United Nations Educational, Scientific and Cultural Organization
VAST	Viet Nam Academy of Science and Technology
WFH	Work From Home
WRS	Warning Receiver System