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

Eighth Meeting
Jakarta, Indonesia
4–6 March 2019
Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (SCS-WG)

Eighth Meeting
Jakarta, Indonesia
4–6 March 2019
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WELCOME AND OPENING</td>
<td>1</td>
</tr>
<tr>
<td>2. ORGANIZATION OF THE SESSION</td>
<td>1</td>
</tr>
<tr>
<td>2.1 ADOPTION OF AGENDA</td>
<td>1</td>
</tr>
<tr>
<td>2.2 DESIGNATION OF RAPPORTEUR</td>
<td>1</td>
</tr>
<tr>
<td>2.3 CONDUCT OF THE SESSION, TIMETABLE AND DOCUMENTATION</td>
<td>2</td>
</tr>
<tr>
<td>3. REVIEW OF DECISIONS, RECOMMENDATIONS AND ACTIONS ARISING FROM ICG/PTWS-WG-SCS-VII MEETING</td>
<td>2</td>
</tr>
<tr>
<td>4. REPORTS</td>
<td>4</td>
</tr>
<tr>
<td>4.1 NATIONAL PROGRESS REPORTS</td>
<td>4</td>
</tr>
<tr>
<td>4.1.1 China</td>
<td>4</td>
</tr>
<tr>
<td>4.1.2 Malaysia</td>
<td>7</td>
</tr>
<tr>
<td>4.1.3 Philippines</td>
<td>9</td>
</tr>
<tr>
<td>4.1.4 Singapore</td>
<td>10</td>
</tr>
<tr>
<td>4.1.5 Viet Nam</td>
<td>10</td>
</tr>
<tr>
<td>5. REPORT FROM NWPTAC</td>
<td>11</td>
</tr>
<tr>
<td>6. REPORT FROM SCSTAC TRIAL OPERATION</td>
<td>11</td>
</tr>
<tr>
<td>7. REPORT OF SCS REGIONAL TRAINING IN 2018</td>
<td>13</td>
</tr>
<tr>
<td>8. REPORT FROM SCSTAC INTERNATIONAL STAFF</td>
<td>14</td>
</tr>
<tr>
<td>9. REPORT FROM OTHER ORGANIZATIONS</td>
<td>14</td>
</tr>
<tr>
<td>10. SEISMIC AND SEA LEVEL CORE STATIONS IN THE SOUTH CHINA SEA REGION FOR FURTHER ENHANCING TSUNAMI WARNING CAPABILITY</td>
<td>15</td>
</tr>
<tr>
<td>11. PALU EARTHQUAKE AND TSUNAMI ON 28 SEPTEMBER 2018: POST-DISASTER SURVEY, LESSONS LEARNED AND IMPENDING TASKS</td>
<td>17</td>
</tr>
<tr>
<td>12. REPORT ON PACWAVE18 EXERCISE IN THE SOUTH CHINA SEA REGION</td>
<td>18</td>
</tr>
<tr>
<td>13. CAPACITY BUILDING ACTIVITIES IN THE SOUTH CHINA SEA REGIONS IN 2019–2020</td>
<td>19</td>
</tr>
<tr>
<td>14. NEXT MEETING</td>
<td>19</td>
</tr>
<tr>
<td>15. ANY OTHER BUSINESS</td>
<td>20</td>
</tr>
<tr>
<td>16. SUMMARY OF DECISIONS, RECOMMENDATIONS AND ACTIONS</td>
<td>20</td>
</tr>
<tr>
<td>17. CLOSE OF THE MEETING</td>
<td>20</td>
</tr>
</tbody>
</table>
ANNEXES

I. AGENDA
II. ADOPTED RECOMMENDATION
III. OPENING SPEECH
IV. LIST OF PARTICIPANTS
V. LIST OF ACRONYMS
1. WELCOME AND OPENING

The Eighth meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region was held from 4 to 6 March 2019 in Jakarta, Indonesia. The opening took place in presence of Dr Untung Merdijanto, Executive Secretary, and Dr Widada Sulistya, Deputy for Instrumentation, of the Agency for Meteorology Climatology and Geophysics (BMKG), Indonesia.

Dr Daryono Daryono, Head of the Earthquake Information and Tsunami Early Warning Center of BMKG, addressed the meeting on behalf of the Organising Committee. He noted that this meeting brings together experts of the international community that cooperates with the aim of saving lives of the people living in coastal communities. He remarked that the group would be invited to visit BMKG Earthquake Information and Tsunami Early Warning Center at the end of the meeting.

Mr Sai-Tick Chan, Chairperson of the Pacific Tsunami Warning and Mitigation System Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region (SCS-WG) and Senior Scientific Officer of the Hong Kong Observatory (HKO), welcomed all participants to the meeting and thanked BMKG for hosting the Eighth Session of the group. He specially thanked the local organizing committee for the arrangements. He recalled that it was the second time Indonesia kindly hosted a session of the Working Group. He indicated his privilege of continuing leading this group that had been able to deliver increased seismic and sea level data exchange among Member States, to create opportunities for training and exchange and to establish a dedicated regional tsunami advisory centre. He noted that the Palu earthquake and tsunami was a reminder that the tsunami threat was not yet fully understood and expressed the expectation that lessons learnt from this event would enlighten the work of the group.

Dr Ir. Muhamad Sadly, Deputy Director of Geophysics of BMKG, delivered the welcome speech on behalf of the Government of Indonesia. He noted that the SCS-WG is very important for Indonesia and thanked the Intergovernmental Oceanographic Commission (IOC) of UNESCO and the Member States of the SCS-WG for giving Indonesia the opportunity to host a new session of the Working Group. He noted that three tsunami events had struck the South China Sea region according to the NCEI/WDS Global Historical Tsunami Database between 1960 and 2000, highlighting the importance of setting up a regional warning system to be able to deliver timely threat information, based on reinforced regional cooperation. He expressed that the spirit of cooperation shown in the development process of the South China Sea Tsunami Advisory Centre (SCSTAC) would become the best practice and a model for marine cooperation in the South China Sea region. He closed by wishing the participants fruitful discussions and a good meeting. He thanked the Organising Committee for its hard work and declared the meeting officially open. The full text of his speech is available in Annex III.

2. ORGANIZATION OF THE SESSION

2.1 ADOPTION OF AGENDA

Chair Sai-Tick Chan recalled that the meeting was attended by representatives from China, Indonesia, Malaysia, the Philippines, Singapore and Viet Nam, as well as invited representative from the Japan Meteorological Agency (JMA). He introduced the provisional agenda that was circulated prior to the meeting. The agenda was adopted without changes, and is included under Annex I.

2.2 DESIGNATION OF RAPPORTEUR

The Delegation of Indonesia volunteered Ms Suci Dewi Anugrah from BMKG to serve as rapporteur. China volunteered Dr Dakui Wang from the National Marine Environmental
Forecasting Centre (NMEFC) to support Ms Suci. These recommendations were accepted by the Group.

2.3 CONDUCT OF THE SESSION, TIMETABLE AND DOCUMENTATION

The Chair, Mr Chan, provided an overview of the schedule of all agenda items as indicated in the provisional timetable. The Chair suggested that subgroup meetings might not be needed in light of the issues to be discussed, all of which could be addressed in plenary. 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/VIII meeting website, and some of them were printed in advance for the delegates.

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

Requests IOC Secretariat to send an email to TNCs of Member States with a copy to SCS-WG-VII participants for updating Inventory of the SCS Seismic and Sea Level Core Stations after the meeting.

Encourages again Member States to sustain and enhance SCS Tsunami Warning and Mitigation System by contributing more seismic and sea level data internationally, or to SCS Seismic and Sea Level Data Exchange Server for operation of SCSTAC, also available to NTWCs in the SCS region.

Action taken: Two new core sea level stations from Hong Kong, China (Shek Pik), and Philippines (Davao PH) added to the inventory. No new additions for core seismic station list and the number remained 151.

Requests SCSTAC to provide quarterly reports on data availability, including percentage of availability of core stations, percentage of availability of real-time data and data latency for each station, and detection performance based on up-to-date seismic and sea level Networks contributed by Member States.

Action taken: SCSTAC had summarized the performance statistics for the four quarterly of 2018. A report would be presented to the meeting under Agenda item 5 on “Seismic and Sea Level Core Stations in the SCS Region for further Enhancing Tsunami Warning Capability”.

Encourages Member States to contribute to increase the number of accessible seismic and sea level stations in Sulu Sea, Celebes Sea and North Borneo, according to Annex III of report of ICG/PTWS-WG-SCS-VI, with the purpose of enabling timely alert and warning services for vulnerable populations.

Action taken: Not much progress was yet made with reference to preceding item on SCS Seismic and Sea Level Core Stations.

Requests the Member States to further review the technical document “Tsunami Advisory Products for the South China Sea Tsunami Warning and Mitigation System” and provide comments by the end of May 2018 via email correspondence.
Action taken: No further comments were received prior to or after PacWave18. The draft IOC technical document would be ready for proposed adoption as official publication by IOC Assembly.

Asks the PTWC, NWPTAC and SCSTAC to further discuss about the arrangement on the consistency of earthquake parameters, and finalize the arrangement before the next ICG/PTWS SC meeting, to be held at Honolulu on 4–8 June 2018.

Action taken: Arrangement finalized without further changes.

Decides to make a proposal to the 28th ICG/PTWS session, on the full operation of SCSTAC in the second half of 2019 as in Annex to this recommendation.

Draft Recommendation to be submitted to ICG/PTWS-XXVIII on Trial and Full Operation of SCSTAC.

Action to follow: Steering Committee of ICG/PTWS, at its meeting held in June 2018 in Honolulu, US, was informed of the decision of WG/SCS to make a proposal about full operation of SCSTAC to ICG/PTWS-XXVIII. Proposal to be made at ICG/PTWS-XXVIII during 2–5 April 2019 in Nicaragua subject to further changes / updates made to the draft recommendation by this meeting.

Encourages Member States to nominate trainees to participate in the Regional Training Workshop on Tsunami SOPs and ICG/PTWS SCS Tsunami Advisory Products, to be held by NMEFC/SOA in Beijing on 8–11 May 2018.

Action taken: Training successfully conducted with participants from the Philippines, Viet Nam, Thailand, Brunei, Indonesia, Malaysia and China.

Encourages all Member States to participate at PacWave 18 exercise, taking Manila Trench Mw 8.8 event as exercise scenario, to further test SCSTAC operations and products, and conduct the exercise preferably within one-week and if possible on the same day between 1 September and 30 November 2018 to maximize the role of exercise in tsunami awareness.


Welcomes SCSTAC’s proposal to host one short-term international staff per year from the Member States with travel and local expenses covered by SCSTAC, and requests the SCSTAC to officially make the announcement to all Member States TNCs and NTWCs regarding the matter.

Action taken: Two international staff, one each from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and BMKG were accepted by SCSTAC and attached to the Center from 22 October–21 December 2018.
Agrees to develop an inventory on tsunami educational materials in the SCS region, with written language not limited to the English, and designates Mr Lianda ZHAO (China) to serve as inter-sessional contact point to collect the educational materials contributed by Member States and post them on the SCSTAC website.

Encourages Member States to make available English version of their contributed educational materials for convenient use by other Member States.

Action taken: Mr Zhao gathered relevant educational materials on tsunami warning and posted them on SCSTAC website at http://www.scstac.org/education/tsunamiEducationList?scienceType=3.

Requests the Member States to provide further comments to Mr Lianda ZHAO of China on the booklet Public Education on Tsunami Hazard for the South China Sea by end of March 2018 for onward submission to IOTIC to finalize and publish the booklet.

Action taken: Comments consolidated by Mr Zhao and forwarded to Mr Kodijat (Indian Ocean Tsunami Information Center, IOTIC) for follow up.

Action arising from WG/SCS-V (Manila, Philippines, 2–3 March 2016)

Instructs the Secretariat to continue the process of refining and finalising the report for the Scientific meeting of experts for coordinated scenario analysis of future tsunami events and hazard mitigation schemes for the South China sea region, Meeting of Experts, Xiamen, China, 16–18 November 2015 before it is distributed to all Member States and for discussion on the way forward by the Working Group.

Action taken: Report recently finalized and published as IOC Workshop Report No. 275 (IOC/2018/WR/275). WG/SCS Members were informed via email from Mr Bernardo Aliaga (IOC Secretariat) dated the 31 December 2018.

Mr Bun Liong Saw, Malaysian Meteorological Department, inquired about the integration of regional earthquake sources at Negros, Cotabato, Sulawesi, Sulu and Molucca into ComMIT/MOST. Mr Dakui Wang (NMEFC) answered that they would check and respond.

4. REPORTS

4.1 NATIONAL PROGRESS REPORTS

4.1.1 China

Dr Dakui 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 NMEFC was responsible in China for operating the Tsunami Warning and Mitigation System. NMEFC received real-time waveform data from 25 coastal seismic stations installed by Ministry of Natural Resources, 54 national seismic stations maintained by China Earthquake Administration and around 580 IRIS and GEOFON and GEOSCOPE stations. The focal mechanism inversion system based on the W-phase method was operationally running at the NMEFC. NMEFC received real-time sea level data from GTS sea level stations and more than 120 tidal gauges along the Chinese coasts via dedicated cable and VSAT.
Two sets of tsunami database were developed respectively covering the Northwest Pacific region and around the Pacific Ocean. On-the-fly tsunami forecast model run on GPU was capable of accomplishing a Pacific tsunami forecast within 45 seconds, 135 times faster than the serial version. The model was validated by 9 major historical tsunamis induced by submarine earthquakes with Mw more than 8.0 in the Pacific region since 2006 with abundant observations. Forecasting accuracy of threat levels was acceptable in terms of tsunami warning purpose, with 80% of results falling into the corresponding levels. The Decision Supporting System (DSS) at NTWC operated stably and smoothly. Furthermore, NMEFC was developing an English version for international colleagues. Another DSS based on Web-GIS was developed for local tsunami emergency response agencies.

In 2018, NMEFC responded to 47 major earthquakes with magnitude greater than 6.5, and issued 83 tsunami information bulletins to relevant agencies and stakeholders with average latency of 9 minutes, 2 minutes faster than that in 2017. Two watch standers were on duty all the time in 24 hours with a shift time of 12 hours since the trial operation of SCSTAC.

NMEFC participated at the Seventh meeting of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Region (ICG/PTWS-WG-SCS-VII/3) held in Hanoi, Viet Nam, from 6 to 8 March 2018. NMEFC hosted the opening ceremony of the IOC/UNESCO South China Sea Tsunami Advisory Centre (SCSTAC) in Beijing, China, the 8 May 2018 followed with a Regional Training during 8–11 May 2018. Mr Zhiguo XU went to Sidney (Canada) to exchange experiences with other users about the Antelope software on 29–31 August 2018. Dr Hongwei LI and Dr Zhiyuan REN attended the 10th South China Sea Tsunami Workshop on 10–11 October in Singapore.

Mr Bun Liong Saw inquired whether the sea level stations available for SCSTAC were available to other Member States in real time. Dr Wang responded that the stations available at SCSTAC are available to other Member States on a dedicated password protected website through NMEFC.

Mr Sai-Tick Chan, Senior Scientific Officer, Hong Kong Observatory (HKO), supplemented the report of China and presented a report on the Tsunami Warning System and Contingency Plan in Hong Kong, China.

Mr Chan indicated that Hong Kong, China, participated in the regional training on “Strengthening SOPs for Tsunami Warning and the use of the ICG/PTWS SCSTAC Tsunami Advisory Products” conducted by NMEFC in Beijing, China, during 8–11 May 2018.

The PacWave18 Exercise was conducted on 5 November 2018 with the participation of 27 government agencies and other organizations including NGOs like Red Cross. Taking into account complex topography of Hong Kong, China, and densely populated community, participating organizations were reminded of the importance of vertical evacuation to deal with disastrous tsunami events in Hong Kong, China.

A total of 168 Strong Earthquake Reports (M 6.0 or above) around the world were issued in 2018, with the median time lapse from the occurrence of earthquake to the Quick Earthquake Message (QEM) posted on Twitter and to the Strong Earthquake Reports manually issued on HKO website being 8 minutes and 12 minutes, respectively.

A network of sea level monitoring stations had been established in Hong Kong, China, for effective monitoring of tsunamis as well as storm surges caused by approaching typhoons. Frequented by typhoons, Hong Kong, China, was experienced and well prepared for storm surges such as the record-breaking event brought by Super Typhoon Mangkhut in September 2018, which was akin to a significant tsunami event hitting Hong Kong, China,
4.1.1 Indonesia

Ms Suci Dewi Anugrah, Government Officer, Earthquake and Tsunami Mitigation Subdivision, Agency for Meteorology, Climatology and Geophysics (BMKG), on behalf of Mr Rahmat Triyono, Director of Earthquake and Tsunami Centre of Indonesia, which hosts the Indonesia Tsunami Early Warning System (InaTEWS), reported on the status of InaTEWS. She explained that since 2007 and until 2018, there were 22 tsunami warnings issued by InaTEWS, 17 of the warnings were followed by tsunami. The latest warning followed by tsunami was the Tsunami Palu on 28 September 2018. On 22 December 2018, “a silent tsunami” caused by a collapse of volcano flank due to the Krakatau Volcano activities happened in Sunda Strait. There were no tsunami warnings due to this event, since the InaTEWS was solely aimed for a tsunami generated by an earthquake.

To strengthen the seismic monitoring network, there were 176 seismic broadband stations, 238 accelerograph stations and 137 tidal gauges in operation. 105 gauges were operated by the Agency of Geospatial Information (BIG), 7 gauges by BMKG, and 21 gauges were part of the IOC’s network. The InaTEWS obtained seismic data from 134 stations of other countries as well.

It was informed that in 2018, the InaTEWS was developed to be the 4.0 InaTEWS. The new version of the system was actually a development of a new version of 4.0 Decision Support System (DSS) which was completed with a database of 18,000 tsunami scenarios covering the Indonesian tsunami prone areas. To support the new version of the 4.0 DSS, the Easy Wave of tsunami modelling coding was used to replace the TunAWI. The new version of DSS had a capability to put all type of earthquake mechanism sources as an input to the tsunami modeling to make a pre-calculated tsunami scenario as well as an “on the fly” tsunami simulation.

Regarding the dissemination system, the InaTEWS used several communication modes. On its role as National Tsunami Warning System (NTWS), InaTEWS used SMS, email, fax, Warning Receiver System (WRS), website, and social media. A new mechanism of Location Based Service (LBS) had been established to complete the dissemination mechanism. The system was able to disseminate earthquake information to the people in the 3 closest districts from the earthquake source through SMS. As a Tsunami Service Provider (TSP) for the Indian Ocean, InaTEWS used TSP Website, email, fax, SMS and GTS to disseminate the warning notifications. However, there were many tsunami prone areas that had not been covered yet by the warning dissemination, due to the lack of Warning Receiver System tool installation. To overcome this problem, the 4.0 InaTEWS had developed an android and iPhone based application of the earthquake information and tsunami warning that could be easily downloaded.

The BMKG, as the agency which operates the InaTEWS, had participated and conducted several international and national activities. On 5 September 2018, together with the Indian Ocean countries, the BMKG participated at the exercise Indian Ocean Wave 18 (IOWave18, IOC/2018/TS/138VOL.1) to examine the end to end system of the InaTEWS. The M 9.3 Sunda Trench tsunami scenario was implemented on the exercise. There were 3 Indonesian tsunami prone areas that participated in the IOWave18 by involving their communities to examine their evacuation plan through a tsunami drill. A table top exercise was implemented as well on the exercise at 11 locations including National Tsunami Warning Centres (NTWCs), National Disaster Management Offices (NDMOS), Local Disaster Management Offices (LDMOs), and Media institutions. More than 3,000 participants were involved in the exercise.
In collaboration with the IOTIC of UNESCO, BMKG conducted the Post-IOWave18 Regional Workshop in Jakarta from 15 to 17 November 2018 in order to evaluate the implementation of the IOWave18 Exercise. It could contribute to a better understanding of the gaps as well as enhance preparedness in the Indian Ocean Region. Indian Ocean countries consisted of 28 Member States, 12 of them sent their delegation to attend the workshop. A Training of Trainers on Tsunami Evacuation Map, Plans and Procedures (TEMPP-3) had been conducted in the BMKG Training Centre, in Citeko, Indonesia, from 22 November to 1 December 2018. Seventeen participants and 7 trainers were involved in this capacity building activity. From August to September 2018, a survey of 1992 tsunami eyewitness in Flores was conducted to preserving past tsunami information for future community preparedness.

As a member of the Working Group on Tsunami on Tsunami Warning and Mitigation System for the South China Sea Region, the BMKG participated at the regional training on “Strengthening Standard Operating Procedures for Tsunami Warning of the South China Sea Tsunami Advisory Center (SCSTAC)” held in Beijing, China, from 8 to 11 May 2018 by sending two participants. As a part of the SCSTAC operational test, one participant from the BMKG was involved at the hosting programme of international staff to be a short term secondment at the SCSTAC. This programme was held from 22 October to 21 December 2018 in Beijing, China.

To enhance tsunami preparedness capacity, in 2018 the BMKG conducted a training of Earthquake Field School (EQFS) in 2 locations. The training was targeted for LDMO officers, Police, School, media and community regarding the earthquake information and tsunami warning products, as well as the evacuation plan. In 2019, the EQFS is planned to be conducted in 30 tsunami prone locations.

The Chair, Mr Sai-Tick Chan, inquired about the most efficient communication method of warnings in Indonesia’s experience. Ms Suci responded that from past experiences satellite communicated sirens and mobile disseminated messages (SMS) were very effective. However, radio was also very powerful and broadly available. Mr Musa from BMKG indicated that local people received the warning via SMS locally for example in Palu, but through local networks the delivery of messages seemed to be more robust.

Mr Bun Leong Saw inquired on the status of buoys deployed for tsunami warning. Ms Suci indicated that all previously installed buoys were off service due to vandalism. For next year Indonesia intended to install several systems including Cable System for monitoring. Mr Daryono from BMKG indicated that Indonesia was no longer considering deployment of tsunami buoys.

4.1.2 Malaysia

Dr Bun Liong Saw, Director of the Malaysian Meteorological Department (MMD), presented its report providing an update on the status of the Tsunami Early Warning System in Malaysia. He reported that the Malaysian government decided to set up the Malaysian National Tsunami Early Warning System (MNTWES) to overcome the lack of capability in carrying out tsunami watch and the issuance of tsunami warning for the nation. MMD was currently operating a total of 77 seismological stations, 17 tide gauge stations, 18 coastal cameras and 53 tsunami sirens.
Figure 1. Location of Malaysian Seismological Stations

Figure 2. Location of Malaysian Tide Gauge Stations

Figure 3. Location of Malaysian Coastal Camera Stations
Mr Bun Liong Saw indicated future plans of Malaysia to enhance readiness and improve early warning and respond to potential natural disasters by:

- Development of Location Based Short Message System (SMS);
- Conducting public awareness’s campaigns and drills on the earthquake and tsunami (10 campaigns yearly);
- Increasing the number of seismological stations, tide gauge stations and tsunami sirens (12th Malaysian Plan, 2021–2025).

### 4.1.3 Philippines

Mr Ishmael Narag, Philippine Institute of Volcanology and Seismology (PHIVOLCS), presented the report of Philippines. He reported that the Philippines, through the country’s national warning centre, the Philippine Institute of Volcanology and Seismology of the Department of Science and Technology (DOST-PHIVOLCS), continued to implement its two national programmes on earthquake and tsunami monitoring and warning, with its aim to implement projects and activities that significantly contribute to its ultimate goal in keeping communities safe from earthquakes and tsunami events. For 2018, additional seismic stations were commissioned to the Philippine Seismic Network (PSN) that monitors earthquakes that may generate tsunami waves that may have a significant impact to the Philippines. Sea-level monitoring stations were maintained to verify the generation of tsunami waves after any occurrence of shallow offshore large-magnitude earthquake. Notable events were monitored by this monitoring system including recent earthquake sequences along the Philippine Trench and the major offshore earthquake on 29 December 2018, the latter generating small sea-level oscillations recorded by two sea-level stations in Mindanao Island.

Mr Narag indicated that in light of the Indonesian tsunami events due to the 2018 Palu, Sulawesi earthquake and activity of the Anak Krakatau Volcano, DOST-PHIVOLCS had initiated an internal discussion for the review and revision of its standard operating procedures for tsunami advisory and warning. Capacity building of the local government and academia on numerical simulation of tsunami had been initiated to better appreciate tsunami inundation maps in their areas of interest for land-use and development planning, formulation of evacuation plans and development of tsunami awareness materials. Enhanced tsunami risk
estimates were achieved through better characterization of tsunami sources using results of crustal deformation studies and adopted tsunami damage functions for selected building types.

Mr Narag reported that a collaborative research project between Japanese universities, the University of the Philippines and DOST-PHIVOLCS on numerical modelling of tsunamis using JAGURS and tsunami deposits in the Philippines was currently implemented to identify tsunami events beyond historic times. The study would further improve the tsunami event database and contribute in understanding of the recurrence interval of these events.

Dr Untung Merdijanto, BMKG Executive Secretary, inquired about the sea level monitoring network stations. Dr Narag responded that they had access to an extended network of sea level stations.

Mr Daryono (BMKG) inquired about public awareness and education in the region given recent events. Mr Narag responded that they were intensifying public awareness in the more prone to risk communities facing the Manila Trench.

Mr Xu (NMEFC) inquired about the automatic solution by SWIFT. Mr Narag responded that there was an automatic solution and manual treatment for significant events.

4.1.4 Singapore

Ms Weilin Hu, Executive Meteorologist, Meteorological Service Singapore (MSS), presented the report of Singapore. Singapore’s report mainly shared about the potential impact of seismic events on Singapore, and the roles and responsibilities of the MSS in monitoring and assessing seismic hazards in the region. She raised some concerns regarding the recent tsunami event triggered by the undersea landslide caused by the eruption of Mount Anak Krakatau. During the tsunami event, MSS had received no bulletins or information from the TSPs to notify the tsunami event. She indicated Singapore would like to propose for the regional centres to issue preliminary advisories for detected non-seismic tsunami even if the cause of the tsunami is still being established. Following the Exercise PacWave18, Singapore proposed Tsunami Service Providers (TSPs) to coordinate forecast of arrival times and wave heights in the tsunami bulletins to minimise the inconsistency in advisory information, and to standardize the formats of the bulletins.

4.1.5 Viet Nam

Dr Xuan Anh Nguyen, Director of the Institute of Geophysics (IGP) within the Viet Nam Academy of Science and Technology (VAST), presented the report of Viet Nam. He indicated that IGP was responsible for issuing earthquake information and tsunami warnings in Viet Nam. IGP was in charge of National seismic network, which consisted of nearly 40 broadband seismometers. Along with this network, IGP also maintained the temporal seismic network for induced earthquake monitoring. In 2018, the seismic station network was in good condition and worked well. The project “Development of multi-hazards warning system for coastal areas in Viet Nam” was in progress. This system was tested in Danang city and Quang Nam province in December 2018. IGP was carrying out some research projects on seismicity, seismotectonics and seismic hazard in the territory of Viet Nam and adjacent sea areas (2017–2023). The results of these projects were expected to contribute to earthquake and tsunami warning system for the region.

Dr Untung Merdijanto (BMKG) expressed interest about the integrated multi-hazard coastal warning system. Dr Anh responded that the Central Steering Committee for Natural Disaster Prevention and Control which belongs to the Ministry of Defence was the coordinator of the system, through the National Committee for Search and Rescue. They developed the system and integrated the work of the IGP though the Ministry of Natural Resources.
5. REPORT FROM NWPTAC

Mr Ryosuke Sakakibara, Scientific Officer in the International Tsunami Information Section of Earthquake and Tsunami Observation Division of Japan Meteorological Agency (JMA), presented its report.

6. REPORT FROM SCSTAC TRIAL OPERATION

Mr Zhiguo Xu (NMFEC) presented a report on trial operation of the South China Sea Tsunami Advisory Center (SCSTAC). He recalled that the ICG/PTWS at its 27th session (ICG/PTWS-XXVII/3) decided to commence the trial operation of SCSTAC in the first semester of 2018. The trial operation was announced by the IOC Secretariat to WG-SCS Member States through Circular Letter 2706 (CL-2706).

Mr Xu recalled the background and process of establishment of SCSTAC under the guidance of the IOC. The ICG/PTWS at its 23th session (ICG/PTWS-XXIII/3) decided to establish a Regional Working Group for Tsunami Warning and Mitigation System for the South China Sea region. At its 24th session (ICG/PTWS-XXIV/3), China submitted the framework plan for Tsunami Warning and Mitigation System of the South China Sea region. The ICG/PTWS (IOC/ICG/PTWS-XXV/3 REV.) at its 25th session agreed to establish a Tsunami Warning and Mitigation System for the South China Sea region, and a Task Team on the establishment of SCSTAC was built to guide the construction of SCSTAC. During the 25th session, the ICG/PTWS further accepted the offer from the National Marine Environmental Forecasting Center of China to host the SCSTAC. Under the guidance of the Intergovernmental Oceanographic Commission of UNESCO and with the strong support from the government of China, the capabilities of earthquake monitoring and tsunami warning had been enhanced substantially. The Tsunami Warning and Mitigation System of the South China Sea had been established and had capacity to issue tsunami bulletins for the South China Sea region. The ICG/PTWS decided at its 27th session (IOC/ICG/PTWS-XXVII/3) to commence the trial operation of SCSTAC in the first semester of 2018.

Mr Xu provided a detailed introduction of the tsunami warning system of SCSTAC, including the earthquake monitoring and tsunami detection system, tsunami warning and tsunami hazard assessment system, and the tsunami information dissemination system. The Decision Supporting System (DSS) tailored for SCSTAC integrated the earthquake and sea level monitoring, tsunami scenario database, tsunami simulation tools in real-time, tsunami product generating and issue system, which greatly shortened the time of response for tsunami warning. SCSTAC served as an advisory system for nine countries: Brunei, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam. In order to ensure its operation, SCSTAC had a team of 12 staff to support the 24/7 operation shifts. Once a larger earthquake happened in the South China Sea region, the watch stander would provide a rapid, reliable and effective tsunami advisory service for Member States.

Mr Xu presented the Standard Operating Procedure (SOP) of SCSTAC. If an earthquake with magnitude $\geq 6.0$ occurs in the South China Sea region, the watch stander will be informed; the seismic automatic processing system provides the preliminary earthquake parameter, if there is no tsunami threat, a tsunami information will be sent, if it poses a tsunami threat, the tsunami arrival time and costal wave amplitude are estimated for costal forecasting points, and the initial bulletin will be issued in 8–12 minutes. The focal mechanism for strong earthquake is computed based on W-phase method after the earthquake within 15–30 minutes. The watch stander reevaluates the tsunami hazard by real-time tsunami forecasting model, send the subsequent tsunami bulletins, check the sea level data and determinates if a tsunami has occurred and how large it is, based on the sea level observation system. The
detailed timeline table for tsunami information and tsunami threat messages are listed in the report.

In order to evaluate the trial operation performance, Mr Xu presented the key performance indicators and the target values during the trial operation, including the elapsed time from earthquake to issuance of initial tsunami products with preliminary earthquake parameters, the probability of detection of earthquake with Mw ≥ 6.0 occurs in the South China Sea region, the accuracy of preliminary earthquake parameter on hypocenter/magnitude/depth, the accuracy of the estimated time of arrival and amplitude of the tsunami if triggered, the percentage of Member States that received tsunami products issued by SCSTAC, percentage of time the SCSTAC was operating and able to respond to a tsunami event, and the regular communication tests.

Mr Xu reviewed the earthquake that happened in the location of Northern Molucca Sea, which was the only one earthquake with magnitude not less than 6.0 within the South China Sea region, as the key performance indicator. According to the evaluation result, the response process for this earthquake operated per the criteria and SOP, and the evaluation result satisfied the indicator for trial operation. Mr Xu introduced the tsunami warning service for China’s coastal line for 47 earthquakes with larger magnitude that occurred in global oceans in 2018, and gave enough evidences on the capability of tsunami warning. The content of emergence response for Mw 7.5 Palu earthquake which struck the island of Sulawesi, Indonesia on 28 September 2018 was also briefly introduced in his report. The preliminary earthquake parameters, the rapid focal mechanism solution, the finite source model inversion with teleseismic body wave, and non-linear tsunami simulation with finite fault model were presented in his report.

During the trial operation, SCSTAC conducted the following additional activities to enhance the capabilities of tsunami warning in the South China Sea region:

- Regional training on “Strengthening Standard Operating Procedures for Tsunami Warning and the use of the ICG/PTWS SCSTAC Tsunami Advisory products” held in Beijing, China, from 8 to 11 May 2018.

- Following its announcement through an UNESCO/IOC Circular Letter, Ms. Arianne Gail Rivera, from the Philippine Institute of Volcanology and Seismology (PHIVOLCS), and Mr Gatut Daniarsyad, from the Indonesian Meteorological, Climate and Geophysical Bureau (BMKG), were nominated and worked as the first batch of international staffs of SCSTAC from 22 October to 21 December 2018.

- Technical Training Activities for Watching Standers, including earthquake and sea level data analysis, tsunami forecasting with simulation tools, tsunami message dissemination and tsunami routine drilling.

- Carried out the tsunami drilling in the South China Sea region on 5 November 2018.

- Built an Inventory on Tsunami Educational Materials posted on the SCSTAC website.

In the final part of his report, Mr Xu evaluated the performance of existing seismic and sea level networks, and pointed out that more available seismic and sea level stations in the South China Sea region could support rapid, reliable, and effective tsunami warning. The Member States should pay more attention on the seismic and sea level data exchange and sharing. Mr Xu reported on SCSTAC planned actions in 2019.

Mr Daryono (BMKG) inquired about the type of information sent by SCSTAC to Member States, if that was a notification or the information itself. He indicated that their experience in the IOTWMS was that TSPs send the notification only, and not the information. Mr Xu
responded that same as PTWC and NWPTAC, the SCSTAC in its full operation phase would issue text and graphical products through email, fax and password protected website.

Mr Bun Liong Saw inquired about the possibility of sharing seismic data with other Member States and about location of existing sensors. Mr Dakui Wang responded that under cooperation with the China Earthquake Administration (CEA) there was seismic data that had been shared through dedicated password protected websites. Mr Bun Liong Saw also inquired if there were plans to install additional sea level stations or buoys in the South China Sea that could be shared with Member States. Mr Wang responded that there was plans by China to install additional sea level stations or buoys in the South China Sea that could potentially be shared for the operation of SCSTAC.

Mr Ryosuke Sakakibara, Japan Meteorological Agency (JMA), inquired about the potential overlap of AoRs of SCSTAC and NWPTAC after the full operation of SCSTAC. After a discussion on this matter, the group noticed that the Draft User’s Manual of the SCSTAC might need some small changes before it is endorsed by the ICG/PTWS at its 28th session.

The Group agreed to re-open the period for comments on the Draft User’s Manual of the SCSTAC for two weeks and asked the Secretariat to send an email to Member States asking for final comments within 2 weeks.

7. REPORT OF SCS REGIONAL TRAINING IN 2018

Mr Zongchen Wang (SCSTAC, China) provided a brief introduction of the regional training workshop on “Strengthening SOPS for Tsunami Warning and the use of the ICG/PTWS SCSTAC Tsunami Advisory Products”. The goals and objectives included the following three aspects: (i) to strengthen tsunami warning and emergency plans and procedures, (ii) to increase capacity of operational staff to efficiently and effectively respond, and (iii) to improve understanding and use of SCSTAC products, as well as NWPTAC and PTWC new enhanced products.

The training lasted 3.5 days from 8 May to 11 in Beijing after the inauguration ceremony of SCSTAC which was held in the morning of the first day. Seven seasoned trainers respectively from IOC, ITIC, PTWC, NWPTAC, SCSTAC and PHIVOLCS presented lectures to 24 trainees from Viet Nam, Malaysia, Thailand, Indonesia, Brunei, Philippines and China.

The content of the training was organized in five parts. Firstly, seismotectonic and historical as well as potential tsunami hazard in the South China Sea (SCS) region. Eight earthquake tsunami sources consisted of East Taiwan, North, central and South Manila trench, Negros trench, Sulu trench, Cotabato trench and Sulawesi trench. Also, available evidence indicated that submarine landslide was another potential tsunami source. Luckily, there was no volcanic tsunami source in this region. Secondly, for better understanding the SCSTAC products, as well as PTWC and NWPTAC enhanced products, Dr Ye Yuan, Dr Dailin Wang and Mr Satoshi Harada gave detailed explanations about techniques, limitations and uncertainties of their respective products. In the third part, three tsunami service providers introduced what they did from earthquake detection to products issuance. In response, all participants from NTWC or NDMO in the South China Sea region shared their national tsunami warning procedures. For the widespread application of operational technologies, ITIC and PTWC developed and shared their software, like TideTool. TideTool was used to decode and display sea level data; TsuDig provided global historical DB; TTT SDK and TsuCAT were available for tsunami travel time calculation and coastal assessment. The fourth part was on dissemination which was responsible for delivering tsunami messages by multiple channels when disaster happens. Meanwhile, people should know what to do when they receive the
messages. For local tsunamis, people should further learn to move to a safe place immediately by reading natural tsunami signals instead of waiting for the official messages. A learning activity, similar to an exam, about what happens and when at tsunami chain was developed in the fifth part. Then, all tsunami colleagues discussed about gaps of current technologies, challenges and future plans.

Finally, a table-top tsunami exercise was carried out to deepen understanding tsunami warning procedures. All participants visited SCSTAC and listened to the introduction of the tsunami warning operations in the field.

8. REPORT FROM SCSTAC INTERNATIONAL STAFF

Ms Gail Rivera (PHIVOLCS, Philippines) and Mr Gatut Daniarsyad (BMKG, Indonesia) reported that following the acceptance of their candidatures submitted in response to Circular Letter 2724, they joined as international staff the South China Sea Tsunami Advisory Center (SCSTAC) trial operation from 22 October to 21 December 2018. The participants were trained on SCSTAC End-to-End system (Earthquake detection to dissemination of tsunami information) using historical events and worst-case scenarios. They were also taught on how to install programmes, basic troubleshooting and how the tsunami modelling embedded in the system were developed. Part of Secondment also included a field visit to Qingdao City, Shandong, where a regional office of the National Marine Environment Forecasting Centre (NMEFC) was located.

Participants were also able to carry out their research on M 7.5 Palu Earthquake and Tsunami of 28 September 2018 where they investigated the seismotectonics, aftershock relocations and simulation of the focal mechanism using Kiwi Tools and the rapidinv program. After the secondment, participants continued the research project under the supervision of SCSTAC staff. A research paper was planned to be published as part of their output.

Ms Suci Dewi Anugrah (BMKG) inquired about the Tsunami Mitigation Group. Mr Gatut responded that they were in charge of preparing and conducting tsunami preparedness including public awareness materials like brochures, and preparing drills and developing evacuation routes for coastal areas.

It was suggested for the future to include within the content of the training DSS and Antelope aspects and include the possibility for trainees to participate as watch standers.

Dr Dakui Wang (NMEFC) reported that the training would be continued during 2019 and thanked the trainees for their recommendations.

9. REPORT FROM OTHER ORGANIZATIONS


The Chair inquired if there was any cooperation or division of labour with ITIC. Mr Kodijat indicated there was close cooperation with ITIC, for example on the International Tsunami Survey Teams (ITSTs). The IOC Assembly at its Twenty-third Session (IOC-XXIII/3) held in Paris from 21 to 30 June 2005 established the four Intergovernmental Coordination Groups (ICGs) and agreed the division of areas. In each of these there was a Tsunami Information Centre (TIC) with main responsibility for the respective region. This was done also by sharing and continued communication among TICs, including at the annual meeting of the TWS Working Group.
Dr Narag, PHIVOLCS, indicated their interest on preserving data and information from previous events. He expressed hopes that this research area could also be implemented for the South China Sea region by IOTIC.

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

Mr Zhiguo Xu reported on the sea-level monitoring capabilities available to SCSTAC within and surrounding the South China Sea region, and presented the report on evaluation of the seismic and sea level data availability in the SCS region.

Mr Xu recalled the background on the network of seismic and sea level core stations in the South China Sea region for enhancing tsunami capability. The Fourth meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (ICG/PTWS-WG-SCS-IV/3) held in Jakarta, Indonesia, the 11 and 12 February 2015, requested the IOC and PTWC to compile the inventory of seismic and sea level stations in the South China Sea region, and further decided to establish the networks of seismic and sea level stations for tsunami warning. At the Fifth meeting of the ICG/PTWS-WG-SCS held in Manila, Philippines, the 2 and 3 March 2016, SCS-WG decided to continue to compile the inventory of seismic and sea level stations. During the Sixth meeting held in Shanghai, China, from 1 to 3 March 2017 (ICG/PTWS-WG-SCS-VI/3), the ICG/PTWS SCS-WG confirmed the lists of seismic and sea level stations, and provided the detailed information for all the stations by each Member States. The ICG/PTWS-WG-SCS at its Seventh meeting, held in Hanoi, Vietnam, from 6 to 8 March 2018, requested SCSTAC to present a report on data availability of seismic and sea level core stations.

Mr Xu indicated there were 151 **seismic core stations**, and 69 sea level core stations. He indicated that there were two important Key Performance Indicators (KPI) to evaluate the overall operation of the stations. SCSTAC prepared a quarterly report on data availability, including the percentage of availability of core stations, the continuous rate and average latency for each station. According to the analysis of all the stations from 1 January to 31 December 2018 by SCSTAC, there were 51 seismic stations that could be accessed publicly, 45 seismic stations were available in real time, the percentage of availability of core seismic station was about 30%, and most of stations delivered continuous rate more than 90% with an average latency of less than 1 minute. Among the sea level core stations in the inventory, 15 sea level stations could be accessed publicly and provided sea level data in real time, the percentage of availability of core sea level station was about 21.7%. Among those tidal gauges, most of stations contributed real time data with high continuous rate and average latency lower than 10 minutes. Two new sea level stations were added to the inventory of core stations, including “Shek” tidal gauge from Hong Kong, China, and “Davo” station from Philippines.

With respect to the distribution of existing seismic and sea level stations, Mr Xu assessed the monitor capabilities for seismic and sea level based on a theoretical method. He presented the minimum detection time and the lower limit of magnitude for earthquakes occurred within the South China Sea region and surrounding areas. He presented the evaluation on minimum detection time for current publicly-accessible tidal gauge and all the sea level core stations in the South China Sea region. Finally, SCSTAC identified the paucity of seismic and sea level stations close to the major tsunami sources within the South China Sea region. Mr Xu encouraged the Member States to contribute more seismic and sea level station for tsunami warning service in the South China Sea region.

Chairman Mr Sai-Tick Chan recalled that the matter of data exchange had been discussed at length in other sessions of the WG-SCS and an analysis of seismic stations data
gaps was presented at the previous session of the WG-SCS. Important gaps that were reported were along the Manila Trench and Celebes Sea.

Dr Bung Liong Saw thanked SCSTAC for the report of seismic and sea level data availability and supported an increased exchange of data, in particular of sea level data, and also an increased coverage. He indicated Malaysia’s willingness to share more data. Mr Dakui Wang (NMEFC) thanked Mr Bung Liong Saw for his kind words and indicated that China was volunteering to host a training/workshop in 2019 for all Member States focus on seismic and sea level data sharing.

Secretariat inquired if all Member States were using the provided Seedlink server address to retrieve data from SCSTAC. From the responses it became clear that this facility had not yet been fully exploited by all Member States.

The Group agreed to include a specific training topic on seismic data exchange using the dedicated SCSTAC Seedlink in the proposed IOC Training Workshop on enhancing the capacity of observation in the South China Sea region scheduled for 2019.

Chair Mr Sai-Tick Chan inquired whether the Quarterly Reports of data availability were made available to Member States. Mr Xu responded that they would be available on SCSTAC website. Secretariat suggested to use a format like ORSNET, which produces a weekly email on “health of stations”.

Chair Mr Sai-Tick Chan requested comments about the availability and exchange of sea level data in the region and inquired SCSTAC how the sea level data could be exchanged. Mr Xu reported that SCSTAC received data from 18 stations through GTS and could also download the data from the IOC Sea Level Station Monitoring Facility.

Mr Bung Liong Saw thanked SCSTAC and indicated that the Malaysian Meteorological Department had 17 sea level stations from which they shared six, three located in the South China Sea region.

Mr Karyono from BMKG, Indonesia, reported that BMKG received data from 176 seismic stations. He showed a map of Indonesian stations. For sea level, Indonesia had 137 sea level stations: 109 are operated by BIG Indonesia (former Bakosurtanal) and the rest by IOC and BMKG. He provided that information as well to SCSTAC to indicate which stations could be useful to improve the system. They were not all available through international networks but could be made available for tsunami warning purposes.

Mr Karyono from BMKG, Indonesia, indicated some aspects related to Data Exchange contribution by Indonesia to SCS. He referred to issues of communication and maintenance. He suggested that an Agreement should be setup. Chairman inquired more details about the proposed Agreement. Mr Karyono responded that in Indonesia’s regulation exchange of data was only allowed based on agreements, signed by BMKG Head and heads of partner agencies. Mr Dakui Wang (NMEFC) asked about who should sign the agreement for the SCS. Mr Karyono responded that because BIG Indonesia was the owner of the stations, BMKG should first contact BIG Indonesia and then discuss with potential partners. Mr Triyono proposed that BMKG could discuss with BIG Indonesia on the stations that could be shared with Member States of the SCS. Mr Saw (Malaysia) inquired if the BIG data was useful for operational tsunami warning. Mr Karyono reported that the data had the same format and frequency useful for tsunami warning.

Mr Xu (NMEFC) indicated that in the second half of 2019 SCSTAC would develop dedicated download mechanisms for sea level data access by other Member States. Mr Dakui
Wang suggested that China could volunteer during the intersessional period to negotiate with potential Member States that could potentially contribute more sea level and seismic stations.

**The Group agreed** with the proposal of China which volunteered and nominated Dr Dakui Wang (dakui.nmefc@gmail.com) to serve as intersessional contact point to communicate with individual Member States of the WG-SCS regarding the arrangement for sharing more seismic and sea level stations to further enhance tsunami warning capability in the South China Sea region, especially for the Sulu Sea and Celebes Seas.


11. **PALU EARTHQUAKE AND TSUNAMI ON 28 SEPTEMBER 2018: POST-DISASTER SURVEY, LESSONS LEARNED AND IMPELLING TASKS**

Dr G. S. Prasetya presented a report on the Palu earthquake and tsunami.

Dr Triyono inquired about the arrival time at the Port Pantoloan sea level station (5 minutes and 20 seconds) which differed from the information available to BMKG during the event. Dr Gegar responded that they worked with BIG Indonesia for the data of Pantoloan. And also in Wani eyewitness indicated arrival time of 3 minutes and 40 seconds. He also indicated that the earthquake duration was around 2 minutes, after which the 5 minutes 20 seconds were counted.

Dr G S Prasetya presented a report on the Ana Krakatau volcano generated tsunami.

Chair Mr Sai-Tick inquired about the possibility of similar events in the same area in the future. Dr G. S. Prasetya responded that given the activity, current height and form of the Ana Krakatau there was a possibility of similar (but not bigger) events in the same zone.

BMKG presented a report on the Palu earthquake and tsunami and Ana Krakatau volcano generated tsunami

Mr Xu (NMEFC) inquired about the earthquake magnitude calculations on the Ana Karakatau event. A brief technical exchange took place on this matter.

Mr Ardito Kodijat (IOTIC) presented a report on the downstream response to the Palu earthquake and tsunami and the Ana Krakatau volcano generated tsunami.

Mr Bung Liong Saw inquired about the authority in Indonesia to issue evacuations and how the system worked in practice. Mr Kodijat and Chair Sai-Tick Chan provided information and commented on existing systems in Indonesia and on the possibilities of improvement using also new ITs and social media.

Mr Zongchen Wang (NMEFC), China, shared their preliminary research report on potential mechanism of Palu Tsunami: A case study based on numerical simulations. He reviewed this event quickly, then introduced the NTWC’s response. The first domestic bulletin was issued 9 minutes after the earthquake. Quantitative forecast result showed that the maximum tsunami amplitude was around 0.5 m. Due to lack of shared sea level data around the epicentre, the watch-standers followed the relevant news closely via the Internet. When they noticed the destructive waves impacted the Palu Bay from international news, NTWC issued another bulletin to confirm the local tsunami.

Based on the experience, a strike-slip fault, which displaces land horizontally, is unlikely to produce significant tsunamis. So numerical simulations were implemented, and the result showed the uniform strike-slip fault generated just 0.34 meter amplitude in Pantoloan station.
with 2 arc-min GEBCO topographic data. Even though the resolution was improved to 30 arc-sec, the modelling amplitude was still just 0.8 meter, far less than the observation of 1.8 meters. Then the bathymetric data with higher resolution took place of GEBCO data in Palu bay. Yet, there was still no improvement. The step-by-step simulation results indicated uniform strike-slip model could not result in the devastating tsunami in Palu bay.

Uniform slip mode was usually applied to the tsunami warning procedures because of time efficiency. Actually, this earthquake rupture process exhibited a significant spatial structure. NTWC inverted the finite fault slip by using teleseismic body waves. By light of this finite fault slip and GEBCO 30 arc-sec topographic data, the maximum modelling tsunami amplitude reached 1.4 meter in Pantoloan, which was very close to the observation. However, the wave amplitude in the south Palu was far less than the observations. Though higher resolution and refined bathymetric data was applied, the modelled run-up still cannot match the post-survey dataset along Palu Bay. So the tsunami was very less likely just generated by the earthquake.

According to shoreline retreat phenomena showed in the images of satellite and field survey, there might be a submarine landslide located in the northern and southern side of Pantoloan, respectively. So Pantoloan station was taken as a point source, and tsunami travel time was calculated. Considering a big wave trough observed about 5 minutes after the earthquake and almost 60 seconds rupture process as well as the field survey result, they assumed two landslide sources in the northern and southern joints of the four-minute contour and the coastline. The results indicated earthquake was the main contributor to the tsunami energy compared with the two hypothetical landslide tsunami sources in Pantoloan. Furthermore, two submarine landslides were superimposed on the seismic source. The results showed the leading and the second wave amplitudes agreed with the observations in Pantoloan. However, the tail wave energy was abnormally large after adding the landslide source. It was likely that much more complicated tsunami mechanisms existed, and more detailed on-site investigation and verification of submarine landslides should be needed.

The conclusion was that only earthquake was less likely to lead to such a tsunami in Palu Bay. As for submarine landslide, it was hard to make clear how many and where the sources were, but it very likely made a contribution. According to some videos spreading on the internet, landslides on the surface seemed also playing a role in the tsunami generation.

A brief technical exchange took place on this matter. The Group discussed about the state of knowledge and research on submarine landslides generated tsunamis, which might justify a call for an expert meeting to advise the WG-SCS on the matters. Ms Suci Dewi Anugrah, BMKG, indicated there were many research groups and other academic and governmental groups working on this field in Indonesia. There was no specific decision on this matter.

12. REPORT ON PACWAVE18 EXERCISE IN THE SOUTH CHINA SEA REGION

Mr Zhiguo Xu, SCSTAC, NMEFC, presented a report on Exercise Pacific Wave 18 (IOC/2018/TS/139 VOL.1 REV.2) among the Member States in the South China Sea region. The aim of PacWave18 was to test country preparedness arrangements, and operational procedures to respond and recover from a destructive tsunami, especially at the community level. PacWave18 was held from 1 September to 30 November 2018, the scenario of Manila Trench earthquake tsunami with Mw 8.8, focal depth of 30 km was triggered at 01:00 UTC. SCSTAC disseminated only one Dummy Message to SCS Member States via fax and email the 5 November 2018 at 01:00 UTC.
Ms Suci Dewi Anugrah (BMKG) indicated that they did receive the PacWave18 messages through fax and email.

Chair Mr Sai-Tick Chan suggested to take advantage of the presence of some Member States for which fax numbers were not working, they could report the right numbers. Several updates of the contact details took place following this suggestion.

Secretariat provided detailed information about how the Secretariat conducted the update and maintenance on the NTWC/TWFP/NTC data and its regular reporting to PTWC and JMA.

Indonesia suggested that for Exercise Pacific Wave 20 the list of scenarios should include a case where the impact on Indonesia coasts would be more significant.

The Group agreed and supported the holding of regular communication tests, four times per year, by SCSTAC when it enters into full operation.

13. CAPACITY BUILDING ACTIVITIES IN THE SOUTH CHINA SEA REGIONS IN 2019–2020

Mr Dakui Wang (NMEFC) introduced this item. He indicated that SCSATC would continue its International Staff Programme in both 2019 and 2020 under the instruction of the IOC Secretariat, and host two international staff each year. SCSTAC welcomed Member States to nominate candidates, who would be working in SCSTAC for two months if selected. International round-trip flights would be booked by SCSTAC directly and local expenses would be supported by SCSTAC through a certain amount of salary between 5,000–10,000 RMB per month depending on his/her experience and expertise. The International Staff Programme for 2019 was tentatively scheduled from September to November.

Mr Dakui Wang reported that SCSTAC would co-host a training workshop with IOC on enhancing the capacity of observation in the South China Sea region. The training would focus on seismic and sea level observations within the region. Each Member States was welcome to nominate up to 2 participants. SCSTAC would cover local expenses for both and round-trip air tickets for one of them, while IOC will cover the expenses of trainers. The training workshop was planned for September 2019 in Hangzhou, China, which would be confirmed and officially announced through IOC Circular Letter.

Mr Wang also indicated that SCSTAC was keen to co-host another training workshop with ITIC in 2020 on SOP/SCSTAC products. Further arrangement and information would be made and announced in due time.

The Group agreed to conduct an IOC Training Workshop on enhancing the capacity of observation in the South China Sea region, at Hangzhou, China, from 21 to 25 October 2019, back to back with the SCS Workshop-11, at the kind invitation of SCSTAC/NMEFC, China.

14. NEXT MEETING

Dr Dakui Wang, indicated that China was willing to host the Ninth meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region in Guangzhou, Guangdong province, China, in 2020.

Ms Suci Dewi Anugrah (BMKG) suggested that at the next session the Group will discuss downstream tsunami preparedness.
Dr Bun Liong Saw indicated that Malaysia was volunteering to host the 10th meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region in 2021.

The Group decided to accept the offer of China to host the next meeting in March 2020 in Guangzhou, Guangdong province, China, with dates and venue to be discussed and determined in consultation with the Secretariat and the Chairperson. The Group welcomed the offer of Malaysia to host the 10th meeting in 2021.

15. ANY OTHER BUSINESS


Chair Mr Sai-Tick Chan presented a suggestion for continuity of TT-SCSTAC and a modification of its Terms of Reference.

The Group decided to continue the South China Sea Tsunami Advisory Center Task Team (TT-SCSTAC) with revised Terms of Reference, and elected Dr Yuan Ye as Chairperson of the revised TT-SCSTAC.

Chair Mr Sai-Tick Chan indicated that the Group need to renew or confirm its Chairship and nominate a Vice-Chair. China and Malaysia supported the continuity of Mr S. T. Chan as Chair of the WG-SCS. The Group decided to renew Mr S. T. Chan (China, Hong Kong) as Chair of the WG-SCS and keep open the nominations for Vice-Chair.

16. SUMMARY OF DECISIONS, RECOMMENDATIONS AND ACTIONS

Based on the reports and discussions, the WG-SCS adopted Recommendation ICG/PTWS-WG-SCS-VIII.1.

17. CLOSE OF THE MEETING

Chair Mr Sai-Tick Chan closed the meeting the 6 March 2019 at 11:20 am, thanked Indonesia for its kindness in hosting the meeting, and thanked the Secretariat, NWPTAC, and Member States for their very active participation. The Chair wished the Working Group continuous success and successful operation of the SCSTAC in the near future. He also thanked the support provided by the Secretariat.

On behalf of Indonesia, Mr Daryono from BMKG, Indonesia, thanked the Chair for his leadership, the Secretariat, NWPTAC, and Member States for its very active participation.

Mr Dakui Wang on behalf of NMEFC and China expressed its thanks to Indonesia and all Member States for its contribution to the South China Sea Tsunami Warning and Mitigation System, and indicated China looked forward to hosting the next meeting in Guangzhou.

Mr Narag, on behalf of Philippines, thanked Indonesia for hosting the meeting, wished all success to the operational phase of SCSTAC, and indicated it looked forward to the first meeting after SCSTAC entering into operation.

On behalf of Malaysia, Mr Saw thanked Indonesia for hosting the Working Group meeting, and wished all the best to the SCSTAC on its full operation.
Dr Nguyen Xuan Anh, Viet Nam, expressed its thanks to Indonesia, Member States, Chair and Secretariat for its support and indicated Viet Nam stand ready to make its best to contribute its scientific and operational support to the SCSTAC.

Ms Weilin Hu from Singapore thanked the ICG and Indonesia.

Ms Suci Dewi Anugrah (BMKG) thanked the participants and noted the group made important progresses at this meeting.
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-VII MEETING

4. REPORTS
   4.1. NATIONAL PROGRESS REPORTS
   4.2. REPORT FROM NWPTAC
   4.3. REPORT FROM SCSTAC TRIAL OPERATION
   4.4. REPORT OF SCS REGIONAL TRAINING IN 2018
   4.5. REPORTS FROM SCSTAC INTERNATIONAL STAFF
   4.6. REPORTS FROM OTHER ORGANIZATIONS

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

6. PALU EARTHQUAKE AND TSUNAMI ON 28 SEPTEMBER, 2018: POST-DISASTER SURVEY, LESSONS LEARNED AND IMPENDING TASKS

7. REPORT ON PACWAVE18 EXERCISE IN THE SOUTH CHINA SEA REGION

8. CAPACITY BUILDING ACTIVITIES IN THE SOUTH CHINA SEA REGIONS IN 2019-2020

9. NEXT MEETING

10. ANY OTHER BUSINESS

11. SUMMARY OF DECISIONS, RECOMMENDATIONS AND ACTIONS

12. CLOSE OF MEETING
ANNEX II

ADOPTED RECOMMENDATIONS

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

The South China Sea Region Tsunami Warning System: Seismic and Sea Level Core Stations, Full Operation of SCSTAC, Capacity Building and Next Meeting

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

Recalling that the Twenty-seventh Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS-XXVII) decided to continue the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (ICG/PTWS-WG-SCS-VII), chaired by Mr Sai-Tick Chan from Hong Kong Observatory, China,

Also recalling the recommendations agreed at the Seventh Meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (ICG/PTWS-WG-SCS-VII), held in Hanoi, Viet Nam, on 6–8 March 2018, and hosted by the IGP/VAST, Viet Nam,

Considering the summaries and actions/decisions agreed at the Third Task Team Meeting on Establishment of the South China Sea Tsunami Advisory Center, held in Hanoi, Viet Nam, on 5 March 2018, and hosted by the IGP/VAST, Viet Nam,

Having considered the reports of:

1. The Fourth meeting of the ICG/PTWS WG-SCS, held in Jakarta, Indonesia, 11–12 February 2015,

2. The Fifth meeting of the ICG/PTWS WG-SCS, held in Manila, the Philippines, 2–4 March 2016,

3. The Second Task Team Meeting on the Establishment of the South China Sea Tsunami Advisory Centre (SCSTAC), held in Beijing on 24–26 October 2016,

4. The Sixth meeting of the ICG/PTWS WG-SCS, held in Shanghai, China, 1–3 March 2017,

5. The Seventh meeting of the ICG/PTWS WG-SCS, held in Hanoi, Viet Nam, 6–8 March 2018,

Recognizes the paucity of seismic and sea level stations close to the major tsunami sources within the SCS region available to Tsunami Service Providers (TSPs);

Agrees with the proposal of China which volunteered and nominated Dr Dakui WANG (dakui.nmefc@gmail.com) to serve as inter-sessional contact point to communicate with individual Member States of the WG-SCS regarding the arrangement for sharing more seismic and sea level stations to further enhance the tsunami warning capability in the South China Sea region, especially for the Sulu Sea, Celebes Seas and North Borneo;

Requests SCSTAC to continue to generate quarterly reports on seismic and sea level core stations in the South China Sea region, including the percentage of availability of core stations, data availability and latency, and detection performance based on the up-to-date seismic and
sea level networks contributed by the Member States, and make available the reports on the SCSTAC website for reference by the Member States;

Agrees to conduct an IOC Training Workshop on enhancing the capacity of observation in the South China Sea region, which will include a specific topic on seismic data exchange using the dedicated Seedlink server of SCSTAC, on 21-25 October 2019 in Hangzhou, China, back to back with the 2019 South China Sea Tsunami Workshop (SCSTW-11), at the kind invitation of SCSTAC/NMEFC, China;

Welcomes SCSTAC’s proposal to continue with the International Staff Programme to host two experts from the Member States of the SCS-WG in 2019, with the travel and local expenses covered by SCSTAC, and requests the IOC to make the announcement to all Member States TNCs and NTWCs of WG-SCS regarding the matter;

Agrees to conduct a training workshop on strengthening SOPs and the use of ICG/PTWS SCSTAC advisory products in 2020 in China with the venue and date to be confirmed in due course;

Decides to submit the proposal agreed at the Seventh Meeting of the WG-SCS to the 28th ICG/PTWS session, on the full operation of SCSTAC in the second half of 2019 with minor amendments as in Annex I to this recommendation;

Requests SCSTAC to finalize the arrangements on the consistency of earthquake parameters in consultation with NWPTAC and PTWC before the full operation of SCSTAC;

Requests the ICG/PTWS to instruct potential arrangements among PTWC, NWPTAC and SCSTAC for the consistency of the format of tsunami bulletins;

Agrees and supports the holding of regular communication tests four times a year by SCSTAC, at the start of each quarter tentatively with prior notice given by IOC Secretariat, following its full operation, and requests all WG-SCS Member States to regularly update their contact information with IOC Secretariat following the established procedures;

Noting the need for the continued work of TT-SCSTAC in support of the initial operation of SCSTAC,

Agrees to continue the work of TT-SCSTAC in the next inter-sessional period of ICG/PWTS, with revised Terms of Reference as in Annex II to this recommendation and Dr Ye Yuan of China serving as the Chair;

Recalling that Mr Sai-tick Chan was elected Chair of WG-SCS at the 27th session of ICG/PTWS, French Polynesia, 2017,

Supports China’s nomination of Mr Sai-Tick Chan to continue serving as Chair of WG-SCS in the next intersessional period of ICG/PTWS, and requests WG-SCS Member States to send Vice-Chair nomination for WG-SCS, if any, to IOC Secretariat before the 28th session of ICG/PTWS;

Accepts the offer of China to host the Ninth meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region in 2020.
Annex I

Draft Recommendation to be submitted to ICG/PTWS-XXVIII

Full Operation of South China Sea Tsunami Advisory Center

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**Recalling** that the Intergovernmental Oceanographic Commission (IOC) adopted Resolution EC-XLI.6, which encourages the Member States around the South China Sea and other regional seas, as appropriate, to actively promote the development, establishment and sustained operation of national and sub-regional Tsunami Warning and Mitigation Systems within the framework of ICGs,

**Recalling further** that the ICG/PTWS adopted Recommendation ICG/PTWS-XXIII.5, which established the Working Group for the South China Sea (WG-SCS), and Recommendation ICG/PTWS-XXIV.4 to establish a sub-regional Tsunami Warning and Mitigation System for the South China Sea region within the framework of the ICG/PTWS,

**Recalling further** that the ICG/PTWS adopted Recommendation ICG/PTWS-XXV.3, which approved the establishment of a WG-SCS Task Team on the Establishment of a South China Sea Tsunami Advisory Centre (SCSTAC), and accepted China’s offer to host the SCSTAC and

**Recommended** to initiate the establishment of the SCSTAC under the guidance of the WG-SCS,

**Recalling further** that the ICG/PTWS adopted Recommendation ICG/PTWS-XXVII.3, which decided to commence the trial operation of SCSTAC in late 2017, with specific date to be decided by the Steering Committee of the ICG/PTWS, and also **recalling** that the PTWS-SC at its virtual meeting accepted the proposal to start the trial issuance of SCSTAC products in January 2018,

**Recalling further** that the trial operation of SCSTAC started on 26 January 2018, decided by the Steering Committee of the ICG/PTWS on 11 September 2017, with satisfactory performance,

**Having considered:**

1. The report of the Fourth meeting of the ICG/PTWS-WG-SCS, held in Jakarta, Indonesia, 11–12 February 2015,

2. The report of the Fifth meeting of the ICG/PTWS-WG-SCS, held in Manila, the Philippines, 2–4 March 2016,

3. The report of the Second Task Team Meeting on the Establishment of the South China Sea Tsunami Advisory Centre (SCSTAC), held in Beijing, China, on 24–26 October 2016,

4. The report of the Sixth meeting of the ICG/PTWS-WG-SCS, held in Shanghai, China, 1–3 March 2017,
5. The report of the Seventh meeting of the ICG/PTWS-WG-SCS, held in Hanoi, Viet Nam, 6–8 March 2018, as well as the Third Task Team Meeting on the Establishment of the SCSTAC preceding ICG/PTWS-WG-SCS-VII on 5 March 2018,

6. The discussion in the Eighth meeting of the ICG/PTWS-WG-SCS, held in Jakarta, Indonesia, 4–6 March 2019,

Having considered the coordination among PTWC, NWPTAC and SCSTAC on consistency of earthquake parameters in the South China Sea region after the full operation of SCSTAC as follows:

1. Noting that SCSTAC responds to an earthquake with magnitude equal to or greater than 6.0 within its Area of Service (AoS), and to major earthquakes that occur outside but pose a threat to AoS,

2. SCSTAC takes the priority on determining earthquake parameters at its AoS,

3. For Centroid Moment Tensor (CMT) solutions of major earthquakes within SCSTAC’s AoS, the TSPs rely on their own operations,

Agrees to accept the document “Tsunami Advisory Products for the South China Sea Regional Tsunami Warning and Mitigation System” as an official publication within the IOC Technical Series upon endorsement of the IOC Assembly;

Agrees that the SCSTAC starts its full operation with target date set to the second half of 2019, and specific date to be decided by the Steering Committee of the ICG/PTWS;

Expresses appreciation to NWPTAC for its reliable interim tsunami services which was started in 2006 and will be stopped following the full operation of SCSTAC;

Requests PTWC to continue to provide tsunami services to the SCS region in parallel with SCSTAC during its full operation.
Annex II

Revised Terms of Reference of TT-SCSTAC

1. Evaluate and report on performance indicators for the SCSTAC.

2. Explore ways for facilitating the sharing and exchange of data, tsunami warning technologies and relevant information necessary for further enhancing tsunami warning advisory capability of the SCSTAC.

3. Consult with National Tsunami Warning Focal Points of the WG-SCS Member States for their latest requirements on Tsunami service/products.

4. Review and continue to improve the SOP and the contents of tsunami advisory products following the full operation of the SCSTAC.

5. Keep contact with PTWC and NWPTAC (JMA) for coordination, consistency, guidance and assistance.
ANNEX III

OPENING SPEECH

Dr MuhamadSadly, Deputy Head for Geophysics of the Agency for Meteorology, Climatology, and Geophysics of the Agency for Meteorology Climatology and Geophysics (BMKG)

Eighth Meeting of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region

Jakarta, Indonesia, 4 March 2019

Jakarta, 4 March 2019

Excellency

Deputy Head for Meteorology, Mr Mulyono Rahadi Prabowo,
Deputy Head for Climatology, Drs Herizal, M.Si,
Deputy Head for Instrumentation, Calibration, Engineering, and Communication Network, Mr Widada Sulisty,
Programme Specialist, Tsunami Unit, Intergovernmental Oceanographic Commission of UNESCO, Dr Bernardo Aliaga Rossel
Chair of Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region, Dr Sai Tick Chan
Participants from the South China Sea countries,

Ladies and Gentlemen

Good Morning,

First of all, I would like to welcome all international and national participants who have travels to Jakarta. It is a great pleasure to have all of you here for the Eighth Meeting of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region.

Ladies and Gentlemen

The South China Sea Working Group on Tsunami Warning and Mitigation System has a very important role of regional coordinating groups in advancing tsunami preparedness and early warning systems in regions. I am very glad that colleagues from the SCS neighbouring countries gather in Jakarta to conduct the meeting, to discuss a very important issue related to how we are safe people from a tsunami threat in this area.

I remember the 7.0 magnitude earthquake shocked southern Philippines in the last year. The 7.0 magnitude earthquake was recorded off the coast of the southern Philippines on Saturday, according to the US Geological Survey.

The US Pacific Tsunami Warning Center has warned of a tsunami threat for parts of the Pacific that were closer to the earthquake.

Another fact is a record of three tsunami events had struck the South China Sea Region According to the Tsunami Catalogue on the period of 1960 – 2000. Therefore, all of those has shown that tsunami risk in South China Sea is strongly real and needs serious handling. It is important for us, as part of the South China Sea, to establish the Tsunami Warning Mitigation System in this area.
Ladies and Gentlemen

There are two aspects need to be strengthened in the context of tsunami mitigation system in the South China Sea:

First is developing seismic and sea level monitoring as well as to develop a tsunami modelling to be able to provide a tsunami warning more accurate. Second is strengthening community to be more prepare for the tsunami hazard that may occurred at any time.

In terms of earthquake and tsunami monitoring in the South China Sea Region, it is important for us to have a strong collaboration through a possibility of data monitoring exchange. The community preparedness is needed due to the South China Sea tectonic setting that is quite possible for some areas in this region which have a very short of tsunami's lead time.

Ladies and Gentlemen

I hope this meeting will be support continuously and collaborate closely as well as active participation of all participants to achieve satisfactory and fruitful results on the subjects under discussion at the end of the meeting. I believe that the spirit of cooperation shown in the development process of the South China Sea Tsunami Advisory Center (SCSTAC) will become the best practice and a model for marine cooperation in the South China Sea region.

Ladies and gentlemen

I will end my speech by expressing my highest appreciation to the organizer. Without their hard work and dedication, it would be impossible for us to have this meeting.

Ladies and gentlemen, I would like to declare that Eighth Meeting of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region is officially opened.

Thank you very much for your attention.

Muhamad Sadly
Deputy Director of Geophysics of BMKG
LIST OF PARTICIPANTS

Chair
Mr Sai-Tick CHAN
Senior Scientific Officer
Geophysics, Time and Marine
Meteorological Services Division
Hong Kong Observatory
134A Nathan Road
Kowloon
Hong Kong
Tel: +852 2926 8451
Email: stchan@hko.gov.hk

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

China
Mr Fujiang YU
Director-General
National Marine Environmental Forecasting Center (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuiusi Road, Haidian District
Beijing 100081
China
Tel: +861062105732
Email: yufj@nmefc.cn

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

Mr Zongchen WANG
Tsunami Warning Division
National Marine Environmental Forecasting Centre (NMEFC)/Ministry of Natural Resources (MNR)
No.8 Dahuiusi Road, Haidian District
Beijing 100081
China
Tel: +86 10-62104561
Email: wangzc@nmefc.cn

Indonesia
Mr Rahmat TRIYONO
Head of Earthquake and Tsunami Centre
Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG)
Jl. Angkasa 1 No.2
DKI Jakarta 10610
Indonesia
Email: rahmat.triyono@gmail.com

Mrs Suci Dewi ANUGRAH
Government Officer
Earthquake and Tsunami Mitigation Agency for Meteorology Climatology and Geophysics (BMKG)
P.O. Box 3540 Jkt.
Jl. Angkasa I No.2 Kemayoran Jakarta Pusat
DKI Jakarta 10720
Indonesia
Tel: +6281289234241
Email: suci.anugrah@bmkg.go.id

Mr Gatut DANIARSYAD
Scientist, Earthquake Analyst
Earthquake and Tsunami Center
Agency for Meteorology Climatology and Geophysics (BMKG)
P.O. Box 3540 Jkt.
Jl. Angkasa I No.2 Kemayoran Jakarta Pusat
DKI Jakarta 10720
Indonesia
Tel: +6285649020994
Email: gatut.daniarsyad@bmkg.go.id
Mr Daryono DARYONO
Earthquake Information and Tsunami
Early Warning Center
Agency for Meteorology Climatology and
Geophysics (BMKG)
P.O. Box 3540 Jkt.
DKI Jakarta 10720
Indonesia
Tel: +62 8564 3380 474
Email: daryonobmkg@gmail.com

Yudo DWI HANGGODO PATRIABEKTI
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: patriabekti@gmail.com

Nova HERANDOKO
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: nova.heryandoko@bmkg.go.id

Hidayanti HIDAYANTI
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: yanti.0918@gmail.com

Admiral Musa JULIUS
Observer of Meteorology and Geophysics
Indian Ocean Tsunami Information Centre
(IOTIC)
Agency for Meteorology Climatology and
Geophysics (BMKG)
P.O. Box 3540 Jkt.
DKI Jakarta 10720
Indonesia
Tel: +6281296664986
Email: admiral.musa@bmkg.go.id

Tribowo KRISWINARSO
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: tribowokriswinarso@gmail.com

Ms Litanya OCTONOVIRILNA
Indian Ocean Tsunami Information Centre
(IOTIC)
Agency for Meteorology Climatology and
Geophysics (BMKG)
P.O. Box 3540 Jkt.
DKI Jakarta 10720
Indonesia
Email: vrilna@yahoo.com

Mr Urip SETIYONO
Staff
Agency for Meteorology Climatology and
Geophysics (BMKG)
P.O. Box 3540 Jkt.
DKI Jakarta 10720
Indonesia
Email: tiyorscp@gmail.com

Gloria SIMANGUNSONG
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: gloria.simangunsong@gmail.com

Ms Kian PURNA SINKI
Indian Ocean Tsunami Information Centre
(IOTIC)
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: kian.sinki@bmkg.go.id

Ajat SUDRAJAT
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: soedrajat@gmail.com

MSc. (Hons) PhD. G S PRASETYA
Tsunami Research Center Indonesia
Indonesian Tsunami Scientific Community
Jakarta, Indonesia
Email: gegar.prasetya@gmail.com

Malaysia

Mr Bun Liong SAW
Director
Malaysian Meteorological Department
Jalan Sultan
Petaling Jaya Selangor 46667
Malaysia
Tel: + (603) 7967 8225
Email: sawbl@met.gov.my

Philippines

Mr Ishmael NARAG
Supervising Science Research Specialist / Officer-in-Charge
Seismological Observation and Earthquake Prediction Division
Philippine Institute of Volcanology and Seismology
PHIVOLCS Building, C.P. Garcia Avenue
Diliman Quezon City Philippines
Tel: +63 24261468
Email: ishma01@yahoo.com

Ms Arianne Gail RIVERA
Science Research Assistant
Seismological Observation and Earthquake Prediction Division
Philippine Institute of Volcanology and Seismology
PHIVOLCS Building, C.P. Garcia Avenue
Diliman Quezon City Philippines
Email: rivera.ariannegail@gmail.com

Singapore

Ms Weilin HU
Executive Meteorologist
Central Forecast Office, Weather Services Department
Meteorological Service Singapore
PO Box 8 Changi Airport Post Office
Singapore 819643

Tel: +65 6542 9962 / +65 6542 5059
Email: Hu_weilin@nea.gov.sg

Viet Nam

Ms Phung NGOC ANH
The Marine Department of The National Boundary Commission
Ministry of Foreign Affairs of Viet Nam
No.58 Nguyen Du Str., Hanoi
Viet Nam
Tel: +84 936225288
Email: anisoara7412@yahoo.com

Xuan Anh NGUYEN
Director
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
Email: nxuananh05@gmail.com

Observers

Japan – NWPTAC

Mr Ryosuke SAKAKIBARA
Earthquake and Tsunami Observation Division
Japan Meteorological Agency, Tokyo
1-3-4 Otemachi Chiyoda-ku
Tokyo 100-8122
Japan
Email: r_sakakibara@met.kishou.go.jp

UNESCO (Technical Secretariat)

Mr Bernardo ALIAGA
Programme Specialist, Tsunami Unit
Intergovernmental Oceanographic Commission of UNESCO
7 Place de Fontenoy
75732 Paris Cedex 07, France
Tel: +33 1 45 68 03 17
Fax: +33 1 45 68 50 10
Email: b.aliaga@unesco.org

Mr Ardito M. KODIJAT
Head of the Indian Ocean Tsunami Information Centre
### LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIG</td>
<td>Agency of Geospatial Information</td>
</tr>
<tr>
<td>BMKG</td>
<td>Agency for Meteorology Climatology and Geophysics</td>
</tr>
<tr>
<td>CEA</td>
<td>China Earthquake Administration</td>
</tr>
<tr>
<td>DSS</td>
<td>Decision Supporting System</td>
</tr>
<tr>
<td>EQFS</td>
<td>Earthquake Field School</td>
</tr>
<tr>
<td>HKO</td>
<td>Hong Kong Observatory</td>
</tr>
<tr>
<td>ICG</td>
<td>Intergovernmental Coordination Group</td>
</tr>
<tr>
<td>IGP</td>
<td>Institute of Geophysics</td>
</tr>
<tr>
<td>InaTEWS</td>
<td>Indonesia Tsunami Early Warning System</td>
</tr>
<tr>
<td>IOC</td>
<td>Intergovernmental Oceanographic Commission</td>
</tr>
<tr>
<td>IOTIC</td>
<td>Indian Ocean Tsunami Information Center</td>
</tr>
<tr>
<td>ITIC</td>
<td>International Tsunami Information Center</td>
</tr>
<tr>
<td>ITST</td>
<td>International Tsunami Survey Team</td>
</tr>
<tr>
<td>JMA</td>
<td>Japan Meteorological Agency</td>
</tr>
<tr>
<td>LDMO</td>
<td>Local Disaster Management Office</td>
</tr>
<tr>
<td>MMD</td>
<td>Malaysian Meteorological Department</td>
</tr>
<tr>
<td>MSS</td>
<td>Meteorological Service Singapore</td>
</tr>
<tr>
<td>NDMO</td>
<td>National Disaster Management Office</td>
</tr>
<tr>
<td>NMEFC</td>
<td>National Marine Environmental Forecasting Centre</td>
</tr>
<tr>
<td>NTWC</td>
<td>National Tsunami Warning Centre</td>
</tr>
<tr>
<td>NTWS</td>
<td>National Tsunami Warning System</td>
</tr>
<tr>
<td>NWPTAC</td>
<td>Northwest Pacific Tsunami Advisory Center</td>
</tr>
<tr>
<td>PHIVOLCS</td>
<td>Philippine Institute of Volcanology and Seismology</td>
</tr>
<tr>
<td>PSN</td>
<td>Philippine Seismic Network</td>
</tr>
<tr>
<td>PTWC</td>
<td>Pacific Tsunami Warning Center</td>
</tr>
<tr>
<td>QEM</td>
<td>Quick Earthquake Message</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>SCS</td>
<td>South China Sea</td>
</tr>
<tr>
<td>SCSTAC</td>
<td>South China Sea Tsunami Advisory Centre</td>
</tr>
<tr>
<td>SCS-WG</td>
<td>Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message System</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>TEMPP</td>
<td>Tsunami Evacuation Map, Plans and Procedures</td>
</tr>
<tr>
<td>TIC</td>
<td>Tsunami Information Centre</td>
</tr>
<tr>
<td>TSP</td>
<td>Tsunami Service Provider</td>
</tr>
<tr>
<td>TT-SCSTAC</td>
<td>South China Sea Tsunami Advisory Center Task Team</td>
</tr>
<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
</tr>
<tr>
<td>VAST</td>
<td>Viet Nam Academy of Science and Technology</td>
</tr>
<tr>
<td>WRS</td>
<td>Warning Receiver System</td>
</tr>
</tbody>
</table>
In this Series, entitled

**Reports of Meetings of Experts and Equivalent Bodies**, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans S. Fourth Session of the Joint
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IOCARIBE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Inter calibration
11. First Session of the IOC Consultative Group on Ocean Mapping (*Also printed in French and Spanish*)
12. Joint 100-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Inter calibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica (*Spanish only*)
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IOCARIBE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources (*Also printed in French and Spanish*)
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Inter calibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (*Also printed in French*)
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIPE Group of Experts on Recruitment in Tropical Coastal Demersal Communities (*Also printed in Spanish*)
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IODE Group of Experts on Effects of Pollutants
36. First Consultative Meeting on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IOCARIBE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CCPS Working Group on the Investigations of ‘El Niño’ (*Also printed in Spanish*)
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Inter calibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. Cancelled
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic (*Also printed in French*)
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (*Also printed in Spanish*)
55. Fifth Session of the IOC-UNEP-IODE Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications
60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the ICAEA-IUNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercomparison
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans (Also printed in French)
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. Fourth Joint IOC-WMO Meeting for Implementation of IGOS XBT Ship-of-Opportunity Programmes
70. Sixth Joint IOC-WMO Meeting of Experts on Technical Aspects of Data Exchange
71. Fourth Session of the IODE Group of Experts on Marine Information Management
72. Third Session of the IOC-IHO Committee for the General Bathymetric Chart of the Oceans
73. Seventh Session of the Joint IOC-WMO-CPICS Working Group on the Investigations of “El Niño” (Spanish only)
74. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Seas and the Gulf of Mexico (Also printed in Spanish)
75. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
76. First Session of the Joint IOC-IHO Group of Experts on the Global Sea-Level Observing System
77. Third Session of the IOC-IHO Group for the General Bathymetric Chart of the Oceans
78. Eighth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans
79. Sixth Session of the JSC Ocean Mapping
80. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
81. Ninth Session of the JSC Ocean Mapping
82. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean Sea and its Geological/Geophysical Series
83. First Session of the IOC-IHO Group of Experts on Marine Information Management
84. Sixth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Pacific
85. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
86. Ninth Session of the JSC Ocean Mapping
87. Second Joint IOC-JGOFS in Carbon Dioxide
88. Eighth Session of the JSC Ocean Mapping
89. Sixth Session of the JSC Ocean Mapping
90. Sixth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans
91. First Session of the IOC-IHO Group for the Global Sea-Level Observing System
92. Fifth Session of the IOC-IHO Group CO, Advisory Panel Meeting
93. Tenth Session of the JSC Ocean Mapping
94. First Session of the Joint GCM-WMO Working Group on the Implications of Climate Change on Coral Reefs
95. Third Session of the IOC Editorial Board for the International Chart of the Western Indian Ocean
96. Fourth Session of the IOC Group of Experts on the Global Sea-Level Observing System
97. Joint Meeting of GEMS and GEEP Core Groups
98. First Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
99. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
100. First Meeting of the Officers of the Editorial Board for the International Bathymetric Chart of the Western Pacific
101. Fifth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans
102. Second Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans
103. Fifteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans
104. Fifth Session of the IOC Consultative Group on Ocean Mapping
105. Fifth Session of the IODE Group of Experts on Marine Information Management
106. IOC-WMO Special Consultation on Marine Biodiversity
107. Sixth Joint IOC-WMO Meeting for Implementation of IGOS XBT Ship-of-Opportunity Programmes
108. Third Session of the IODE Group of Experts on Technical Aspects of Data Exchange
109. Second Session of the IODE Group of Experts on Technical Aspects of Data Exchange
109a. First Session of the IOC-IHO Group for the Global Sea-Level Observing System
110. Second Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans
111. First Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate
112. Sixth Session of the Joint IOC-JGOFS C02 Advisory Panel Meeting
113. First Meeting of the IOC-JGOFS Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS)
114. Eighth Session of the Joint IOC-IHO Group for the Investigations of “El Niño” (Spanish only)
115. Second Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Central Eastern Atlantic (Also printed in French)
116. Tenth Session of the Officers Committee for the Joint IOC-IHO General Bathymetric Chart of the Oceans (GEBICO), USA, 1996
117. IOC Group of Experts on the Global Sea-Level Observing System (GLOSO), Fifth Session, USA, 1997
121. IOC-WESTPAC Co-ordinating Committee for the North-East Asian Regional Global Ocean Observing System (NEAR-GOOS), Second Session, Thailand, 1997
122. First Session of the IOC-IUCN-NOAA Ad hoc Consultative Meeting on Large Marine Ecosystems (LME), France, 1997
123. Second Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), South Africa, 1997
124. Sixth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico, Colombia, 1996 (also printed in Spanish)
125. Seventh Session of the IODE Group of Experts on Technical Aspects of Data Exchange, Ireland, 1997
126. IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), First Session, France, 1997
127. Second Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 1998
128. Sixth Session of the IOC Consultative Group on Ocean Mapping (OGOM), Monaco, 1997
129. Sixth Session of the Tropical Atmosphere - Ocean Array (TAO) Implementation Panel, United Kingdom, 1997
132. Sixteenth Session of the Joint IAC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), United Kingdom, 1997
134. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean (IOC/EB-IBCWIO-IW3), South Africa, 1997
136. Seventh Session of the Joint IOC-JGOFS C02 Advisory Panel Meeting, Germany, 1997
137. Implementation of Global Ocean Observations for GOOS/GCOS, First Session, Australia, 1998
139. Second Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Brazil, 1998
140. Third Session of IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS), China, 1998
143. Seventh Session of the Tropical Atmosphere-Ocean Array (TAO) Implementation Panel, Abidjan, Côte d'Ivoire, 1998
144. Sixth Session of the IODE Group of Experts on Marine Information Management (GEMIM), USA, 1999
145. Second Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), China, 1999
146. Third Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Ghana, 1999
147. Fourth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC); Fourth Session of the WCRP CLIVAR Upper Ocean Panel (UOP); Special Joint Session of OOPC and UOP, USA, 1999
149. Eighth Session of the Joint IOC-JGOFS C02 Advisory Panel Meeting, Japan, 1999
150. Fourth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), Japan, 1999
151. Seventh Session of the IOC Consultative Group on Ocean Mapping (OGOM), Monaco, 1999
152. Sixth Session of the IOC Group of Experts on the Global Sea level observing System (GLOSS), France, 1999
153. Seventeenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), Canada, 1999
154. Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y el Golfo de Mexico (IBCCA), Septima Reunión, Mexico, 1998
155. IHO Guiding Committee for the General Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (IBCCA), Seventh Session, Mexico, 1998
156. Initial Global Ocean Observing System (GOOS) Commitments Meeting, IOC-WMO-UNEP-ICSU/Imlp-Illl/III, France, 1999
157. First Session of the ad hoc Advisory Group for IOCARIBE-GOOS, Venezuela, 1999 (also printed in Spanish and French)
158. Fourth Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), China, 1999
162. Eighth Session of the IODE Group of Experts on Technical Aspects of Data Exchange, USA, 2000
163. Third Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 2000
164. Fifth Session of the IOC-IUCN-NOAA Coastal Panel of the Global Ocean Observing System (GOOS), Poland, 2000
165. Third Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), France, 2000
166. Second Session of the ad hoc Advisory Group for IOCARIBE-GOOS, Cuba, 2000 (also printed in Spanish and French)
167. First Session of the Coastal Ocean Observations Panel, Costa Rica, 2000
168. First GOOS Users’ Forum, 2000
170. First Session of the Advisory Body of Experts on the Law of the Sea (ABE-LOS), France, 2001 (also printed in French)
171. Fourth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, Chile, 2001
172. First Session of the IOC-SCOR Ocean CO2 Advisory Panel, France, 2000
173. Fifth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Norway, 2000 (electronic copy only)
174. Third Session of the ad hoc Advisory Group for IOCARIBE-GOOS, USA, 2001 (also printed in Spanish and French)
175. Second Session of the Coastal Ocean Observations Panel and GOOS Users’ Forum, Italy, 2001
176. Second Session of the Black Sea GOOS Workshop, Georgia, 2001
177. Fifth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), Republic of Korea, 2000
178. Second Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Morocco, 2002 (also printed in French)
179. CANCELLED
180. Sixth Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Australia, 2001 (electronic copy only)
231. Primeras reuniones del Grupo de Trabajo Regional para América Central del Grupo Intergubernamental de Coordinación del Sistema de Alerta contra los Tsunamis y Atenuación de sus Efectos en el Pacífico (ICG/PTWS), Managua (Nicaragua) del 4 al 6 de noviembre de 2009 (Resumen dispositive en español e inglés)

232. Segundas reuniones del Grupo de Trabajo Regional para América Central del Grupo Intergubernamental de Coordinación del Sistema de Alerta contra los Tsunamis y Atenuación de sus Efectos en el Pacífico (ICG/PTWS), San Salvador (El Salvador) del 28 al 30 de septiembre de 2011 (Resumen dispositive en español e inglés)

233. Primeras reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 27 de diciembre de 2010 (Resumen dispositivo y recomendación en español e inglés)

234. Segundas reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 20 de abril de 2012 (electronic copy only)

235. Ad hoc reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 17 de febrero de 2019 (electronic copy only)

236. Ad hoc reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 29 al 30 de septiembre de 2014 (Resumen dispositivo y recomendación en español e inglés)

237. Terceras reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 16 al 18 de octubre de 2012 (electronic copy only)

238. Séptimas reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 13 de febrero de 2014 (Resumen dispositivo y recomendación en español e inglés)

239. Ad hoc reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 27 de enero de 2012 (electronic copy only)

240. Tercera reunión del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 9 de diciembre de 2010 (electronic copy only)

241. Ad hoc reuniones del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 25 de octubre de 2012 (electronic copy only)

242. Segunda reunión del Grupo de Trabajo Regional para el Mar del Norte de la India (NWIO), Teherán, República Islámica de, 24 al 25 de febrero de 2014 (Resumen dispositivo y recomendación en español e inglés)