



**UNESCO / IOC
INTERNATIONAL TSUNAMI INFORMATION CENTER (ITIC)**

**ITIC TRAINING PROGRAMME - INTERNATIONAL (ITP-INTL)
TSUNAMI WARNING CENTER OPERATIONS**

**14-24 October 2019
Nuku'alofa, Tonga**

The ITIC Training Program has focused since 2005 on improving operating procedures for tsunami warning and emergency response as essential for successful tsunami warning. While infrequent, tsunamis can be extremely deadly because of their no-notice, quick onset and immediate impact in minutes. In order to warn quickly and have the public evacuate when necessary, agencies must pre-plan and have protocols and procedures which are well-known to every stakeholder and to the public, and which are well-exercised and practiced. For local tsunamis, communities must also know the natural tsunami warning signs and self-evacuate immediately to safe areas.

This training follows the tsunami warning chain from detection and threat analysis to warning dissemination, and cancellation. Topics will include earthquake and tsunami science, warning center operations, use of the Pacific Tsunami Warning Center products and decision-support tools, and public information or media engagement. Emphasis is on the importance of Standard Operating Procedures (SOPs) for enabling consistent and rapid tsunami warning. SOP development is a dynamic process, and each event is unique in its generation and impact, and so also in its response. With every event, we learn more about the science of tsunamis and how to better warn and mitigate against their impact.

Resource Persons:

Dr. Laura Kong, Director, International Tsunami Information Center (ITIC), Honolulu, HI, USA
Dr. Dailin Wang, Senior Oceanographer, PTWC, Honolulu, HI, USA (Week 1)
Masahiro Yamamoto, (Retired) Senior Tsunami Advisor, UNESCO/IOC Tsunami Unit, Japan (Week 2)

PROVISIONAL AGENDA

9 October 2019

| Session | Start Time | End Time | Topic | Location, Speaker |
|---------|------------|----------|---|-------------------|
| 1 - 3 | | | MONDAY, 14 OCTOBER, DAY 1 | |
| | | | Opening, Course Overview, Tsunami Early Warning, Tsunami Warning Center (TWC) Operations | |
| 1.1 | 9:00 | 9:30 | Opening Welcome and Introductions | ITIC, Tonga |
| 1.2 | 9:30 | 9:45 | Logistics | Tonga |
| 1.3 | 9:45 | 10:00 | Course Overview, Manual, Materials, TW Tools | Laura Kong, ITIC |
| 1.4 | 10:00 | 10:30 | Responding Rapidly and Effectively: Tsunami Warning and Emergency Response Requirements | Kong |

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|-------|-------|-------|--|-------------------|
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| 2.1 | 10:45 | 11:15 | Tsunami Warning Center Overview: What do Tsunami Warning Centers (TWCs) do? What do TWCs provide to Tsunami Emergency Response (TER) agencies? Challenges in Detection and Tsunami Threat Assessment | Dailin Wang, PTWC |
| 2.2 | 11:15 | 11:35 | IOC TWC and TER SOP Manual, End-to-end Tsunami Warning – Stakeholder and their needs, Roles and Responsibilities, Standard Operating Procedures, and their linkages | Kong |
| 2.3 | 11:35 | 12:00 | NTWC Competencies (draft approved at ICG/PTWS-XXVIII, 2019) | Kong |
| | 12:00 | 13:00 | LUNCH | |
| | | | TWC Standard Operating Procedures (SOPs), Earthquake Science | |
| 2.4 | 13:00 | 13:30 | TWC SOPs and Checklists: TWC Templates and examples for Distant, Regional, and Local Tsunamis: Monitoring, Detection and Evaluation, Communications, Message Dissemination (IOC MG 76) | Wang |
| 3.1 | 13:30 | 14:15 | What earthquake science you need to know to warn for and respond to tsunami warnings? Earthquake Seismology - what, where, how, when, and damage caused | Kong |
| | 14:15 | 14:30 | COFFEE / TEA BREAK | |
| | | | TWC Operations - Earthquake source characterization | |
| 3.2 | 14:30 | 15:15 | TWC Operations: Real-time Earthquake Detection and Fast Source Characterization, Methods and Limitations: Locating Earthquakes (seismometers, seismic stations, sparse networks and hypocentral bias, etc) | Kong |
| 3.3 | 15:15 | 16:15 | TWC Operations: Locating Earthquakes: Hands-on | Kong |
| | 16:15 | 16:30 | Tsunami Warning Decision-Support Tools - Overview: Message Alerts, (CISN, USGS web site (CMT, ShakeMap, PAGER), Sea level monitoring (Tide Tool, IOC Sea Level Monitoring web site); Global Historical Tsunami Databases, Tsunami Travel Time (TTT) calculation, TsuCAT | Kong |
| 3 - 4 | | | TUESDAY, 15 OCTOBER, DAY 2 | |
| | | | TWC Operations - Earthquake source characterization | |
| | 9:00 | 9:15 | Review and Today's Agenda | Kong, All |
| 3.4 | 9:15 | 10:00 | TWC Operations: Real-time Earthquake Detection and Fast Source Characterization, Methods and Limitations: Estimating Magnitudes (macroscopic intensity and instrumental), Slow Earthquakes | Kong |
| 3.5 | 10:00 | 10:30 | TWC Operations: Estimating Magnitude: Hands-on | Kong |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| 3.5 | 10:45 | 11:15 | continued | Kong |
| 3.6 | 11:15 | 12:00 | TWC Operations: Real-time Earthquake Detection and Fast Source Characterization, Methods and Limitations: Determine Fault Mechanisms (Double-couple 1st motions to W-Phase Centroid Moment Tensors) | Kong |
| | 12:00 | 13:00 | LUNCH | |
| | | | TWC Operations – Earthquake source characterization, Travel Time Forecasting | |
| 3.7 | 13:00 | 13:45 | TWC Operations: Determining Fault Mechanism: Hands-on | Kong |
| 4.1 | 13:45 | 14:30 | What tsunami science you need to know to warn for and respond to tsunami warnings? Tsunami generation, propagation, and inundation - what, where, how, when, and damage caused | Wang |
| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| 4.2 | 14:45 | 15:30 | TWC Operations: Travel Time Forecasting – Methods, Limitations, Uncertainty, Sensitivity Studies (Location, Depth, Magnitude) | Wang |

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| 4.3 | 15:30 | 15:45 | Tsunami Warning Decision-Support Tools - Overview: Message Alerts, (CISN, USGS web site (CMT, ShakeMap, PAGER, Sea level monitoring (Tide Tool, IOC Sea Level Monitoring web site); Global Historical Tsunami Databases (WDS/NCEI web tools), Tsunami Travel Time (TTT) calculation, Tsunami Coastal Assessment Tool (TsuCAT) | Kong |
| 4.3 | 15:45 | 16:15 | TWC Operations: Travel Time Forecasting - Hands on, TTT | Wang, Kong |
| 4-5 | | | WEDNESDAY, 16 OCTOBER, DAY 3 | |
| | | | TWC Operations – Travel Time and Wave Amplitude Forecasting | |
| | 9:00 | 9:15 | Review and Today's Agenda | Wang, All |
| 4.4 | 9:15 | 10:00 | TWC Operations: Travel Time Forecasting - Hands on, TTT (continued) | Wang, Kong |
| 4.5 | 10:00 | 10:30 | TWC Operations: Wave Amplitude Forecasting – Methods (PTWC ATFM, SIFT, RIFT), Limitations, Uncertainty, Sensitivity Studies (Location, Depth, Magnitude) | Wang |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| | 10:45 | 12:00 | continued | Wang |
| | 12:00 | 13:00 | LUNCH | |
| | | | TWC Operations - Wave Amplitude Forecasting, PTWC SOPs | |
| 4.6 | 13:00 | 14:30 | PTWC Operations: Wave Amplitude Forecasting - Hands on, TsuCAT | Wang, Kong |
| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| 4.7 | 14:45 | 15:30 | Hands on completion, Group Presentation | Wang |
| 5.1 | 15:30 | 16:15 | Pacific Tsunami Warning Center: Crisis Event SOPs: Earthquake and Sea Level Monitoring (Data networks and acquisition, quality-control/health status), Earthquake Analysis Methods, Threat Analysis, Forecasting, Products, Dissemination (PTWC Operations, Systems and Procedures Manual) | Wang |
| 5-6 | | | THURSDAY, 17 OCTOBER, DAY 4 | |
| | | | PTWC SOPs, TWC Performance Indicators | |
| | 9:00 | 9:15 | Review and Today's Agenda | Wang, All |
| 5.2 | 9:15 | 9:45 | TWC Operations: Sea Level Monitoring - Methods, Instruments, Limitations, Challenges. | Wang |
| 5.3 | 9:45 | 10:15 | Tsunami Warning Decision-Support Tools - Overview: Message Alerts, (CISN, USGS web site (CMT, ShakeMap, PAGER, Sea level monitoring (Tide Tool, IOC Sea Level Monitoring web site) ; Global Historical Tsunami Databases (WDS/NCEI web tools), Tsunami Travel Time (TTT) calculation, TsuCAT | Kong |
| 5.4 | 10:15 | 10:30 | Pacific Tsunami Warning Center Enhanced Products - Why, What, Criteria, Staging of Products; Explanation of Each Product: Public Text, Graphical Deep-Ocean Tsunami Amplitude, Coastal Tsunami Amplitude, Coastal Tsunami Amplitude Polygons, Tsunami Amplitude Statistics, Coastal Tsunami Amplitude KMZ file. Tsunami Warning Center Performance Indicators - PTWC | Wang |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| | 10:45 | 11:30 | continued | Wang |
| 5.5 | 11:30 | 12:00 | NTWC and TER Guidance on how to use PTWC Enhanced Products for National Warnings and Evacuation - Land and Marine Threats and Public Safety: Flow Charts, Criteria Tables, Timeline-driven SOPs, Message Templates (IOC MG 76) | Kong |
| | 12:00 | 13:00 | LUNCH | |
| | | | Tonga Tsunami Warning Hazard Assessment, SOPs | |
| 6.1 | 13:00 | 13:45 | Tonga Tsunami Warning Hazard Assessment using RIFT | Wang |
| 6.2 | 13:45 | 14:30 | Presentation of Tonga, Samoa & Solomon Islands Tsunami Warning SOPs; Presentation from NEMO (SOP) Presentation from Geology (SOP) | Tonga, Samoa, Solomon Islands |

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| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| 6.3 | 14:45 | 16:15 | Presentations continued. Review, Discussion and Ways Forward | Kong, Wang, All |
| 6-7 | | | FRIDAY, 18 OCTOBER, DAY 5 | |
| | | | SOPs, Atypical earthquakes causing tsunamis, Local Source Tsunami Response | |
| | 9:00 | 9:15 | Review and Today's Agenda | Kong, All |
| 6.3 | 9:15 | 10:00 | Review, Discussion and Ways Forward, continued | Kong, Wang, All |
| 7.1 | 10:00 | 10:30 | Other atypical earthquakes causing tsunamis – Palu | Wang |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| 7.2 | 10:45 | 11:15 | Other atypical earthquakes causing tsunamis – Anak Krakatau | Kong |
| 7.3 | 11:15 | 12:00 | Local-Source Tsunami Response Best Practice (approved at ICG/PTWS-XXVIII, 2019). Discussion | Kong, All |
| | 12:00 | 13:00 | LUNCH | |
| | | | Decision Support Tools | |
| 7.4 | 13:00 | 14:00 | Tsunami Warning Decision-Support Tools - Overview: Message Alerts, (CISN, USGS web site (CMT, ShakeMap, PAGER, Sea level monitoring (Tide Tool, IOC Sea Level Monitoring web site); Global Historical Tsunami Databases (WDS/NCEI web tools), Tsunami Travel Time (TTT) calculation, TsuCAT | Kong, All |
| | 14:00 | 14:30 | continued | Kong, All |
| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| | 14:45 | 16:00 | continued | Kong, All |
| | 16:00 | 16:15 | Summary – Week 1 | Kong |
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| | | | SATURDAY-SUNDAY, 19-20 OCTOBER - FREE DAYS | |
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| 8-9 | | | MONDAY, 21 OCTOBER, DAY 6 | |
| | | | Lessons Learnt from Past Tsunamis | |
| | 9:00 | 9:15 | Review and Today's Agenda | Kong, All |
| 8.1 | 9:15 | 9:45 | Lessons Learned from Past Tsunamis - Warning (Hawaii 1946-1994; Chile 1960; Nicaragua 1992 / Java 2006 / Mentawai 2010; Sumatra 2004; Tonga 2006; Samoa/Tonga 2009 (doublet); Chile 2010; Japan 2011; Bengkulu 2012; Haida Gwaii 2012; Kaikoura NZ 2016, Indonesia 2018) | Kong, Yamamoto |
| | 9:45 | 10:30 | continued | |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| 8.2 | 10:45 | 11:15 | Lessons Learned from Past Tsunamis - Response (Hawaii 1986, 1994; Papua New Guinea 1998; Samoa/American Samoa 2009; Chile 2010; Japan 2011, Palu Indonesia 2018) | Kong, Yamamoto |
| | 11:15 | 12:00 | continued | |
| | 12:00 | 13:00 | LUNCH | |
| | | | Tsunami Ready, Tonga-Kermadec Trench Sources, Tonga Inundation Mapping | |
| 8.3 | 13:00 | 13:45 | TWC Operations: PTWC Routine Operations SOPs: Quality Control and redundancy, contingency and backup. (PTWC Operations, Systems and Procedures Manual) | Yamamoto |
| 8.4 | 13:45 | 14:05 | End-to-end Tsunami Early Warning and community preparedness: UNESCO IOC Tsunami Ready Pilot Programme - Guidelines and Steps | Kong |
| 8.5 | 14:05 | 14:30 | Preparing for Community Tsunami Evacuations: From Inundation to Evacuation Maps, Response Plans, and Exercises. (IOC MG 82) | Kong |
| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| 9.1 | 14:45 | 15:30 | Tsunami sources, hazards, risk and uncertainties associated with the Tonga-Kermadec Subduction Zone (IOC Experts Meeting, September 2018) | Kong, Tonga |

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| 9.2 | 15:30 | 16:15 | Tonga Inundation Modeling and Mapping | Tonga |
| 9 | | | TUESDAY, 22 OCTOBER, DAY 7 | |
| | | | Tonga NTWC Competencies | |
| | 9:00 | 9:15 | Review and Today's Agenda | Kong, All |
| 9.3 | 9:15 | 9:45 | Using ComMIT interface for Tsunami Modelling: Features, Model Parameters & Output (Hands on Sessions: Group work) • Scenario generation and selection • Model results • Generate catalogue of scenario events (Major: Tonga Trench, New Hebrides, distant sources) | Tonga, All |
| | 9:45 | 10:30 | continued | |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| | 10:45 | 12:00 | continued | |
| | 12:00 | 13:00 | LUNCH | |
| 9.4 | 13:00 | 13:45 | Using Tide Tool, TTT, TsuCAT (Hands on Sessions: Group work) • Scenario generation: Local, Regional and Distant sources (Group work) | All |
| | 13:45 | 14:30 | continued | |
| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| | 14:45 | 16:15 | continued | |
| 9-10 | | | WEDNESDAY, 23 OCTOBER, DAY 8 | |
| | | | Tonga NTWC Competencies | |
| | 9:00 | 9:15 | Review and Today's Agenda (continue from Tuesday exercise) | Kong, All |
| 9.4 | 9:15 | 10:00 | Scenario generation: Local, Regional and Distant sources (Group work), continued | All |
| | 10:00 | 10:30 | continued | All |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| 9.5 | 10:45 | 11:30 | Scenario(s) vs SOP Discussions (Group work: Tonga, Samoa, Solomons) | Tonga, Samoa, Solomons, All |
| 10.1 | 11:30 | 12:00 | Table-top: Pac Wave Exercise (Local event: Travel time of 1 hour) - Derived from ComMIT | Tonga, All |
| | 12:00 | 13:00 | LUNCH | |
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| | 13:00 | 13:45 | Table-top: Pac Wave Exercise (Local event) | All |
| | 13:45 | 14:30 | Table-top: Pac Wave Exercise (Local event) | All |
| | 14:30 | 14:45 | COFFEE / TEA BREAK | |
| 10.2 | 14:45 | 15:30 | Table-top: Pac Wave Exercise (Regional event: Travel time of 1-3 hour) | All |
| | 15:30 | 16:15 | Table-top: Pac Wave Exercise (Regional event: Travel time of 1-3 hours) | All |
| 11-12 | | | THURSDAY, 24 OCTOBER, DAY 9 | |
| | | | Emerging Technologies, Summary SOPs, Competencies | |
| | 9:00 | 9:15 | Review and Today's Agenda | Kong, All |
| 11.1 | 9:15 | 9:45 | Improving Tsunami Warning - Emerging Techniques and Technologies: Earthquake Finite Fault Modeling, PTWC real-time GNSS/GPS detection of co-seismic deformation | Kong |
| 11.2 | 9:45 | 10:30 | Warning & Dissemination: Guideline | Tonga |
| | 10:30 | 10:45 | COFFEE / TEA BREAK | |
| 11.3 | 10:45 | 12:00 | Final SOP Reviews & Discussions/Tool kit for Competency assessments | Tonga, Kong, Yamamoto |
| | 12:00 | 13:00 | LUNCH | |
| | 13:00 | 13:45 | continued | |
| | | | Summary, Closing | |
| | 13:45 | 14:45 | continued | |
| 11.4 | 14:45 | 15:15 | Wrap-Up: Final SOP Reviews & Discussions/Tool kit for Competency assessments | Tonga, Kong, Yamamoto |
| | 15:15 | 15:30 | COFFEE / TEA BREAK | |
| 12 | 15:30 | 16:00 | Presentation of Certificates and Closing Ceremony | ITIC, Tonga |

