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Intergovernmental Oceanographic Commission

PLANS AND PROCEDURES FOR TSUNAMI WARNING AND EMERGENCY MANAGEMENT

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Guidance for countries in strengthening tsunami warning and emergency response through the development of Plans and Standard Operating Procedures for their warning and emergency management authorities

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This manual has been developed as an activity of the IOC Working Group on Tsunamis and Other Hazards related to Sea Level Warning and Mitigation System (TOWS-WG) Task Team on Disaster Management and Preparedness with generous support from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and input from the TOWS-WG Task Team on Tsunami Watch Operations.

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The manual is based on papers and presentations prepared for a programme of training workshops conducted in countries of the Indian Ocean, Southeast Asia and South China Sea Region during 2008-2010, part of the project entitled "Strengthening Tsunami Warning and Emergency Responses: Training Workshops on the Development of Standard Operating Procedures for Indian Ocean and Southeast Asian Countries".

The content is based largely on training materials developed by the Intergovernmental Coordination Groups (ICG) for the Pacific Tsunami Warning and Mitigation System (PTWS) and the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) and their respective Tsunami Information Centres, in particular the UNESCO-IOC-NOAA International Tsunami Information Centre (ITIC), Hawaii, USA. It includes contributions from international experts in the fields of tsunami science, early warning and mitigation, disaster management and community awareness, in particular Dr Laura Kong (Director, ITIC), Masahiro Yamamoto (Retired, Senior Advisor, UNESCO-IOC Tsunami Unit and Japan Meteorology Agency, JMA), Dr Charles McCreery (Director, Pacific Tsunami Warning Centre, PTWC), David Coetzee (Capability & Operations Manager, New Zealand Ministry of Civil Defence & Emergency Management), Brian Yanagi (Retired, Disaster Management Specialist, ITIC), Tony Elliott, (Retired Head of ICG/IOTWMS Secretariat, IOC-UNESCO), Dr Fauzi (Retired Senior Tsunami Advisor for DGMET of Oman; Retired Programme Officer, UNESCO IOC in Oman; Retired Director of Earthquake and Tsunami Center, BMKG of Indonesia), Rick Bailey (Head, Tsunami Warning & Ocean Services, Australian Bureau of Meteorology), Dr Yuelong Miao (National Manager, Tsunami Warning Services, Australian Bureau of Meteorology), Russell Arthurton (IOC-UNESCO Consultant), Dr Jane Cunneen (former Programme Specialist, ICG/IOTWMS Secretariat, IOC-UNESCO). Other contributors included Sanny Jegillos (Regional Disaster Risk Reduction Adviser, Bureau for Crisis Prevention and Recovery, United Nations Development Programme), Ardito Kodijat (Programme officer, Disaster Risk Reduction and Tsunami Information Unit, IOC-UNESCO Indian Ocean Tsunami Information Centre), Dr Srinivasa Kumar Tummala (Head of ICG/IOTWMS Secretariat, IOC-UNESCO, former in-charge Indian Tsunami Early Warning Centre, INCOIS, India), Dr Stuart Weinstein (Deputy Director, PTWC), Kelly Sponberg (Lead, International Extension and Public Alert Systems RANET), and Dr Yohko Igarashi (Senior Scientific Officer, Administrative Division, Seismological and Volcanology Dept, JMA).

Production of the manual has benefitted from a wealth of published and unpublished information, including technical and guidance documents from national and international organizations, manuals and guides of the IOC and UN-ISDR (United Nations Office for Disaster Risk Reduction) and individual country contributions.

David Coetzee
Chair, TOWS-WG Task Team on Disaster Management and Preparedness
UNESCO Intergovernmental Oceanographic Commission

FOREWORD

National tsunami warning and emergency management authorities must have aligned and robust tsunami warning and response plans and procedures to ensure timely and effective tsunami warnings are issued and impacted communities respond effectively to them. While significant improvements have been made in this regard, the Intergovernmental Coordination Groups (ICGs) of the four Tsunami Warning and Mitigation Systems acting under the aegis of the UNESCO-Intergovernmental Oceanographic Commission have all identified that gaps still remain. Collectively, they have agreed that a guideline that sets a standard for tsunami warning plans and procedures, and that is endorsed and published by the IOC Working Group on Tsunamis and Other Hazards related to Sea Level Warning and Mitigation System (TOWS-WG) is required to guide countries.

This manual answers the call for guidance from the ICG Member States. It is a product of collaboration between the four ICGs through the TOWS-WG, taking into account training materials and expertise across all the systems. It is therefore relevant to all the ICGs, and it establishes a reference point for global consistency with regard to planning for and responding to tsunamis.

I congratulate the TOWS-WG for establishing this further important building block in our aspiration towards tsunami resilience across the globe, and I thank in particular the TOWS-WG Task Team on Disaster Management and Preparedness, as well as the TOWS-WG Task Team on Tsunami Watch Operations, the long-established Pacific Tsunami Warning and Mitigation System, and its International Tsunami Information Centre (ITIC) and Pacific Tsunami Warning Centre (PTWC) for their contributions to this manual.

Vladimir Ryabinin
Executive Secretary
Intergovernmental Oceanographic Commission

BACKGROUND TO THIS DOCUMENT

In mid-2006 one year after the 2004 Indian Ocean Tsunami, the ITIC and IOC noted a glaring gap in country capacities -- most countries did not have well-tested tsunami protocols and procedures that are the cornerstones for effective tsunami warning. The 2006 conclusion was based on the outcomes from the Regional Tsunami Workshop on Mitigation, Preparedness and Development of Tsunami Early Warning Systems in the Indian Ocean Region June 2006, the Third session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System August 2006, the UNESCO-IOC XXth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System May 2006, the International Round Table Dialogue on Earthquake & Tsunami Risks in Southeast Asia and the South China Sea Region April 2006, the IOTWS WG 6 Capacity Questionnaire, and the Tsunami Early Warning Systems in the Indian Ocean and Southeast Asia, Report on Regional Unmet Needs (UNESCAP, 2009).

In response, the ITIC, IOC, and partners developed 'Strengthening Tsunami Warning and Emergency Responses End-to-End Standard Operating Procedures Training Workshops' to assist countries in developing their tsunami warning operations, especially in the Indian Ocean. Between 2008-2010, regional training workshops and technical visits to four countries (Myanmar, Pakistan, Philippines, Viet Nam) were conducted as part of a capacity building project funded by UNESCAP Regional Multi-Donor Voluntary Trust Fund for Tsunami Early Warning Arrangements in the Indian Ocean and Southeast Asia. The Project emphasized Standard Operating Procedures (SOP) as a key requirement for ensuring efficient, timely, and consistent responses by stakeholder agencies, principally NTWCs and EMAs.

Within this Project, guidance on response operations was developed and training workshops conducted using tsunami operations practitioners who shared their expertise, experience, and advice. The generic set of operational templates, checklists, and timeline-driven actions provided a common starting SOP point for countries to customize to meet their specific needs and tsunami threat. Training Manuals, developed under the lead of the ITIC and in close partnership with experienced practitioners in tsunami warning and emergency response, included reference, best practice, decision support tools, and templates and guidance materials covering key components, requirements, and activities to enable an effective and timely warning and evacuation against tsunamis.

The one-week intensive training course targeted tsunami warning centre and emergency response agencies and their staff, and included a live tsunami exercise where participants used the tsunami standard operating procedures learned about and created during the week. The exercise evaluates the feasibility of the created SOPs, and illustrates how operational readiness is improved through the regular drills and exercises to identify gaps and correct responses before an actual emergency.

These Training Materials, which are summarized in this IOC Manual and Guide, constitute a set of globally consistent procedures and protocols for tsunami warning and emergency response, and have been the backbone of numerous training courses since 2004. Overall since 2005, the ITIC and IOC have conducted over 100 international capacity-building missions, with 70 in the last five years since 2010. About 40% were conducted for the Pacific region or countries, 50% for the Indian Ocean region or countries, and 10% Caribbean region. Together, they represent part of the USA and IOC's collaborative contribution to national capacity building and training on end-to-end tsunami warning and tsunami standard operating procedures to countries of the Indian and Pacific Oceans and Southeast Asia, and the Caribbean region.

The development of Standard Operating Procedures is a dynamic process, and each event is unique in its generation and impact, and so also in its response. In every event, we learn a little more about the science of tsunamis and how to better mitigate against their impact. There are always lessons learned which we must apply (modifying our SOPs accordingly) before the next event occurs. And so with time, this Manual and Guide will evolve too.

EXECUTIVE SUMMARY

Introduction

This manual seeks to assist countries participating in the IOC-coordinated regional Tsunami Warning and Mitigation Systems in strengthening their existing tsunami warning and emergency responses through the development of Tsunami Warning and Emergency Response Plans and Standard Operating Procedures (SOPs). It relates to tsunami warning authorities (referred to as National Tsunami Warning Centres - NTWCs) and to tsunami emergency management authorities (referred to as Emergency Management Agencies - EMAs), promoting alignment, interoperability and consistency among all stakeholders in the end-to-end tsunami warning system.

The Tsunami Warning System (TWS)

An end-to-end Tsunami Warning System (TWS) includes the following components:

- Knowledge of the hazards and risks to coastal communities from tsunamis and planning for their potential impact
- Access to information from the ICG Tsunami Service Providers and/or National Tsunami Warning Centres on the earthquake characteristics, a tsunami assessment and forecast, and tsunami observations
- Capability to evaluate the information received in order to determine the threat to their communities
- Ability to quickly disseminate and communicate clear, understandable, and actionable warnings to prepared coastal communities in advance of the oncoming tsunami; and
- Capacities at national, local and community levels for effective tsunami emergency response.

A TWS is best defined in an end-to-end National Tsunami Warning and Emergency Response Plan, with a minimum requirement being the existence of such a document approved at the national level. The main purpose of this guideline is to describe the collective components of the TWS and the allocation (and description) of responsibilities and actions for each component, then designating relevant authorities for each action. The plan may also contain the concepts, thresholds, target times, systems, procedures, and templates used in the tsunami warning chain and a concise description of the tsunami threat for the country (or reference to the relevant documents). In some countries this Plan may need to be split into two plans, a National Tsunami Warning Plan and a Tsunami Emergency Response (TER) Plan, to recognise different functions and responsibilities. In either respect, the overall content and end-to-end processes should be complementary.

This guideline describes the TWS and its supporting documents, with a specific focus on tsunami warning plans and SOPs for tsunami warning authorities and emergency response plans and SOPs for key responding agencies.

Tsunami warning

The NTWC provides warnings of potentially dangerous tsunamis to EMAs and in many cases direct to the communities of the sovereign nation in which it resides and which it serves. It operates on a 24/7 basis to receive earthquake and tsunami information from ICG Tsunami Service Providers (TSPs) of its choice, evaluates the information in terms of the tsunami threat to the country's coastal communities, and issues warnings about threats. Each country formally nominates a Tsunami Warning Focal Point (TWFP) to the IOC for receipt and national management of tsunami threat information received from TSPs.

Some countries have established their own NTWC as the national tsunami warning authority, which have the independent capacity to continuously monitor seismicity in real-time using local and global seismographic networks to locate and determine the magnitude of potentially tsunamigenic earthquakes. This capacity allows them to assess the threat of a tsunami empirically (based mainly on the earthquake magnitude) or through tsunami

modelling in the same manner as done by a TSP. Such national assessments may be shared with the TSPs and the NTWCs of other countries.

Whether a NTWC has its own in-house seismic processing facility and tsunami monitoring and assessment capability, or whether it relies on the seismic and tsunami threat information contained in notifications from TSPs (and other NTWCs), the next steps are common to all NTWCs. These are the formulation and dissemination of official national warnings to the EMA and other recipients in accordance with the National Tsunami Warning and Emergency Response Plan. A NTWC must respond quickly, be as accurate as possible, and be reliable in order to be effective.

In order to achieve this, an NTWC should have regularly exercised and tested SOPs in place for efficiently receiving the earthquake and tsunami information from TSPs (and other NTWCs), or generated by themselves, evaluate and assess the threat to their country before issuing clearly understood threat alerts to national authorities responsible for emergency management and public safety. In some cases NTWCs may issue warnings directly to the public and media, but still in consultation with EMA.

This guideline describes the essential functions of a NTWC and the relationship of an NTWC to ICG Tsunami Service Providers (TSPs) and other NTWCs. It is supported by Annexes containing more detail and examples.

Tsunami emergency response

In association with other authorities, government agencies, and community groups, EMAs must establish and maintain preparedness for an effective tsunami response through hazard risk assessment and the establishment of emergency response plans and accompanying procedures that focus on public awareness, public alerting, and evacuations. These plans and procedures must acknowledge that notifications from a NTWC may provide little response time – a tsunami generated by a local earthquake may impact within minutes, and they can occur at any time of the day or night. In such cases, natural warning signs (e.g. unexpected sudden drop in sea level indicating the pending arrival of the tsunami crest, although not always the case) may be able to provide much more timely warnings than waiting for the seismic information to feasibly reach the sensors, be analysed and tsunami forecasts and warnings generated and issued.

During tsunami events EMAs must immediately interpret the warnings issued by the NTWC, and then decide on the appropriate response actions. Accordingly, they must also operate on a 24/7 basis in order to disseminate warnings (if required), instructions and other safety information to agencies at all applicable levels of government, threatened communities, and the media, in accordance with the National Tsunami Warning and Emergency Response Plan. They are also responsible for informing the public of the “All Clear” when the threat is over. Through the activation of Emergency Operations Centres (EOCs) at the respective levels of government, EMAs must coordinate an appropriate emergency response amongst all participating agencies.

This guideline covers the linkage between the NTWC and the EMA with a description of the procedures to be adopted by the latter as recipients or potential recipients of warnings from their NTWC, and their subsequent response actions. It is supported by Annexes containing more detail and examples.

GLOSSARY

Definitions were extracted from *Tsunami Glossary 2016* (IOC/2008/TS/85 Rev.2) and the UNISDR terminology on disaster risk reduction (2009)

End-to-End Tsunami Warning

The series of chronological events related to tsunami risk knowledge, monitoring and warning, communication dissemination, and response to protect lives and property. Warnings are most effective when there is continuous public awareness and preparedness to support appropriate public action.

Emergency Management Agency (EMA)

The agency responsible for the organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps. EMAs are also referred to as Civil Protection Agencies and/or Disaster Management Offices/Organisations.

For the purpose of this guideline, it is acknowledged that that responsibilities for Emergency Management may be assigned at the national, regional or local level, or at all of these levels, and that the responsibilities may be different at the respective levels. The guidance in this document must be applied by countries in accordance with the allocation of the responsibilities for tsunami emergency response at these respective levels.

Intergovernmental Coordination Group (ICG)

The ICGs are comprised of Member States, TSPs and TICs in the respective ocean basins. As primary subsidiary bodies of the IOC of UNESCO, the ICGs meet to promote, organize, and coordinate regional tsunami mitigation activities, including the issuance of timely tsunami warnings. Currently, there are ICGs for tsunami warning and mitigation systems in the Pacific Ocean, Indian Ocean, Caribbean and adjacent regions, and the north-eastern Atlantic, Mediterranean and connected seas.

National Tsunami Warning Centre (NTWC)

The national centre officially designated by the government to be responsible for the monitoring and issuing of tsunami warnings and other related statements within their country according to established national Standard Operating Procedures.

For the purpose of this guideline, it is acknowledged that in some countries different terminology may be used for the authority designated with the responsibility for tsunami warning, or that the NTWC may not be a ‘centre’ as such. The guidance provided in this document applies to the entity responsible for tsunami warnings, regardless of these differences.

Response Plan

A document that establishes the framework for a response process. It includes a descriptor of the hazard or hazards that it applies to, sets the responsibilities of all the stakeholders, and provides an outline of processes - i.e. thresholds, sequence, timelines, mechanisms, systems etc. to respond quickly and effectively.

Standard Operating Procedure (SOP)	A written document that describes the actions to be taken in a system or process. A SOP describes each individual activity in a sequence of activities, documenting who does what, when, where, and how for each activity. SOPs need to be strictly followed to ensure a complete and effective activity, regularly reviewed and approved. Staff must be trained and their competency at performing the activities as per the SOP should preferably be assessed.
Tsunami Coordination Committee	A coordinating committee composed of the key stakeholders responsible for the TWS.
Tsunami Emergency Response (TER)	The actions taken to ensure public safety by responsible agencies after notification by the TWFP, typically the NTWC. It includes Standard Operating Procedures and Protocols for emergency response and action, organizations and individuals involved and their roles and responsibilities, contact information, timeline and urgency assigned to action, and means by which both ordinary citizens and special needs populations (physically or mentally handicapped, elderly, young children, transient, and marine populations) will be alerted. For tsunami response, emphasis is placed on the rapidness, efficiency, conciseness, and clarity of the actions and instructions to the public. A Tsunami Emergency Response Plan should also include post tsunami actions and responsibilities for search and rescue, relief, rehabilitation, and recovery.
Tsunami Information Centre (TIC)	Centres that provide education, outreach, technical and capacity building assistance to Member States and the public in preventing, preparing, and mitigating measures for tsunamis. Among other activities, the centres manage post event performance surveys, serve as a resource for the development, publication, and distribution of tsunami education and preparedness materials and information on tsunami occurrences, and may support risk assessment and mitigation activities. A Tsunami Information Centre has been established in each of the regional Tsunami Warning Systems within the ICG framework
Tsunami Service Provider (TSP)	A centre that monitors seismic and sea level activity and issues timely tsunami threat information within an Intergovernmental Coordination Group (ICG) framework to NTWC / TWFP and other TSPs operating within an ocean basin. The NTWCs/TWFPs may use these products to develop and issue tsunami warning for their countries. TSPs may also issue Public messages for an ocean basin and act as NTWC providing tsunami warnings for their own countries. Each ICG has TSPs. Bi-lateral, multi-lateral and sub-regional arrangements may also exist to provide products for a subset of Member States within an ICG. The criteria may or may not be established by the ICG.

Tsunami Warning Focal Point (TWFP) A 24x7 point of contact (office, operational unit or position, not a person) officially designated by the NTWC or the government to receive and disseminate tsunami information from an ICG TSP according to established National Standard Operating Procedures. The TWFP may or may not be the NTWC.

Tsunami Warning System (TWS) The objective of people-centred early warning systems is to empower individuals and communities threatened by hazards with knowledge to act in sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life and damage to property and the environment. An "end to end" TWS is a series of chronological events related to tsunami risk knowledge, monitoring and warning, information dissemination, and response capability to protect lives and property.

READER'S GUIDE

Section 1 is a short introduction to set the scene for the subsequent Sections.

Section 2 sets the context by describing the components of an end-to-end Tsunami Warning System (TWS), and showing how these components relate to each other. It also describes the documents that support the TWS. The over-arching policy set by a National Tsunami Warning and Emergency Response Plan which in turn is supported by Standard Operating Procedures (SOPs) that describe the detail of specific actions in the warning and emergency response chain. Other supporting documents include Operations Manuals, User Guides, Standards and Guidelines, process flow charts, and checklists.

Section 3 focuses on the first steps in the end-to-end TWS and the National Tsunami Warning and Emergency Response Plan, i.e. monitoring and detection, assessment and warning. It describes the role of the National Tsunami Warning Centre (NTWC), which has the primary responsibility to issue official warnings of a tsunami threat to its disaster management offices at national, state and/or local levels - depending on the in-country arrangement. It describes the role of the NTWC in the assessment of its country's risk from tsunamis, its relationship with Tsunami Service Providers (TSPs), the receipt and interpretation of seismic and sea level data and other information, the formulation of official warning messages and warning cancellation messages and their issuance to the EMAs, other authorities, and the public depending on national arrangements. It covers two possible modes of NTWC operation, those without and with in house real-time earthquake monitoring and source characterization capabilities. NTWC routine operations when there is no event are also covered.

Section 4 continues along the TWS chain, focusing on Tsunami Emergency Response (TER). It describes the role of the EMA, whose primary responsibility is to ensure that warnings are received from the NTWC and its response plans are activated efficiently and rapidly, with localised public warnings, or safety alerts relayed to agencies, Emergency Operations Centres (EOCs) and communities at risk, and the public in the shortest possible time. The chapter describes the SOPs to be followed upon the receipt of warning and warning cancellation notifications by the EMA from the NTWC. To recognise the end-to-end warning system, the chapter also briefly covers the routine activities and responsibilities of an EMA to develop tsunami preparedness, such as through the installation and maintenance of public alert systems, planning of evacuations, implementing media and public information flow arrangements, and in sustaining and building community education and awareness of the tsunami hazard.

Section 5 is a general bibliography of documents that were researched in the development of this manual.

Section 6 (Annexes) contains more detail on the development of plans and/or SOPs for NTWCs and EMAs:

- **Annex A** relates to NTWCs and provides guidance and operations templates, flow-charts, checklists for assessing local and distant earthquakes and tsunamis.
- **Annex B** relates to EMAs and provides guidance on planning for evacuations, public alerting and public awareness.
- **Annex C** contains references to specific country national and local case studies on tsunami plans, manuals, and SOPs.

1. INTRODUCTION

An effective tsunami warning system is achieved when all people in vulnerable coastal communities are prepared to respond appropriately and in a timely manner upon recognizing that a potential destructive tsunami may be approaching. Meeting this challenge requires round the- clock monitoring with real-time data streams and rapid alerting, as well as prepared communities, a strong emergency management system, and close and effective cooperation and coordination between all stakeholders.

To ensure the long-term sustainability of a tsunami warning and mitigation system, it should be noted that:

- Tsunami warning arrangements should be part of an all-hazards (natural and man-made) long-term strategy, particularly since they are low frequency but high impact events.
- System redundancy is required to ensure reliability.
- Clearly understood and actionable public safety messages are essential.
- Media partnerships for warning, as well as preparedness, are critical.
- Awareness activities must be continuous and on-going. Tsunamis are low frequency, high impact natural disasters that are short-fused with little time to act unless well-prepared beforehand.
- National, provincial, and local Tsunami Coordination Committees ensure stakeholder coordination and implementation of the end-to-end tsunami warning.

At the strategic level, tsunami warning plans set the policy environment for tsunami warning systems. They provide a high-level description of the operational concepts in this regard. For instance, they allocate roles and responsibilities, set performance targets, and describe types of notifications issued and the criteria for them. This manual provides guidance on the development of tsunami warning and emergency response plans.

At the operational level, Standard Operating Procedures (SOPs) are the foundations of an effective and reliable warning system. SOPs are descriptions and procedures on agreed steps by organizations used in coordinating who, what, when, where and how for tsunami early warning and response. They are a set of written instructions for well-structured, time-driven organization activities. SOPs document, for a specific activity, the way activities will be performed and who has responsibility for performing them, thus ensuring the consistent application of processes in meeting organizations' responsibilities. They are living documents that are modified as lessons are learnt or systems and processes change.

SOPs are particularly essential for tsunami warnings given the requirement for rapid, effective response. This manual provides guidance to National Tsunami Warning Centres (NTWCs) and Emergency Management Agencies (EMAs) on the development of SOPs for end-to-end tsunami warning systems. It describes the nature of the activities of the respective organisations involved, the procedures they need for declaring tsunami warnings and activating the tsunami emergency response plans, how the procedures should be aligned among stakeholders, and the content of the SOPs.

2. END-TO-END TSUNAMI WARNING SYSTEM

2.1 What is a Tsunami Warning System (TWS)?

End-to-end tsunami warning involves a number of stakeholders who must work together in a coordinated way and have a good understanding of each other's roles, responsibilities, authorities, and action during a tsunami event. Planning and practicing in advance of the real event, helps to familiarize agencies and their staff with the steps and decision-making that need to be carried out without hesitation in a real emergency. Tsunami resilience is built upon communities' awareness and response preparedness with regard to the tsunami hazard.

An end-to-end TWS includes the following four components:

- Knowledge of the hazards and risks to coastal communities from tsunami inundation, and planning for them;
- Access to information from the Intergovernmental Coordination Group (ICG) Tsunami Service Providers (TSP) and/or NTWCs of earthquake, tsunami assessment and prediction, and tsunami detection, and the capability of an NTWC to evaluate the information received in order to determine the threat to their communities;
- Ability to quickly disseminate and communicate clear, understandable, and actionable warnings to prepared coastal communities in advance of the oncoming tsunami; and
- Capacities at national, local and community levels for effective tsunami emergency response.

An end-to-end TWS involves many stakeholders who must be able to work in coordination and with good understanding of each other's roles, responsibilities, authorities and actions during a tsunami event. For an end-to-end TWS, the principal stakeholders involved are:

- Tsunami Service Provider(s) (TSP)
- National Tsunami Warning Centres (NTWCs)
- Emergency Management Agencies (EMAs)
- The Public

Figure 2.1 The four key components of systematic people-centred early warning systems. Source: ISDR Platform for the Promotion of Early Warning (UN-ISDR. n.d.)

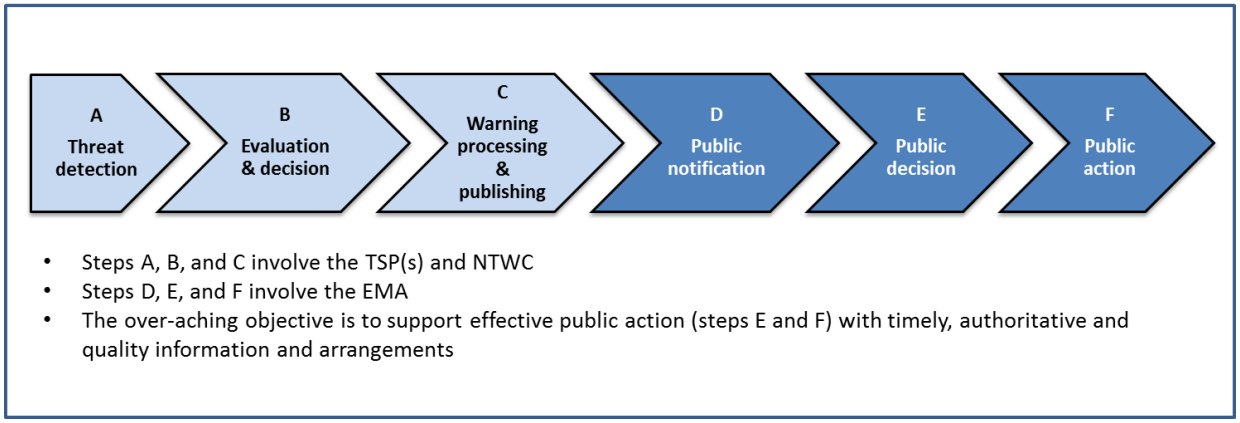


Figure 2.2 End-to-End Warning and Response Steps during a tsunami

The graph above illustrates the six consecutive steps involved in an end-to-end warning and response process chain during a tsunami event. (These steps involve a formal warning situation, and do not necessarily apply for natural warnings/local source tsunamis).

Ultimately, a TWS will be judged on its capacity to save lives and minimise damage and losses. Therefore, the best possible outputs of the first three stakeholders will only be effective when all persons in vulnerable coastal communities are prepared and respond in a timely manner upon recognition that a potential destructive tsunami may be approaching.

2.2 Understanding the end-to-end system

For a TWS to operate effectively, coordination between the stakeholders in the warning and emergency response chain is essential. Not only do individual stakeholders need to have tested plans and procedures in place, but their plans and procedures must also link seamlessly. For instance, all stakeholders should understand the timescales and uncertainties involved in:

- The detection of an earthquake event and the ability of a TSP (or NTWC with a seismic processing capability)
- The assessment by a NTWC of threat information and the issue of a warning
- The response of the EMA to the warning and onwards communication of information to communities under threat
- If required, the execution of evacuations.

The system should operate seamlessly, following a predetermined course set by the plans of all four components of the system, and should support the on-going communications amongst key operational agencies and the free flow of information.

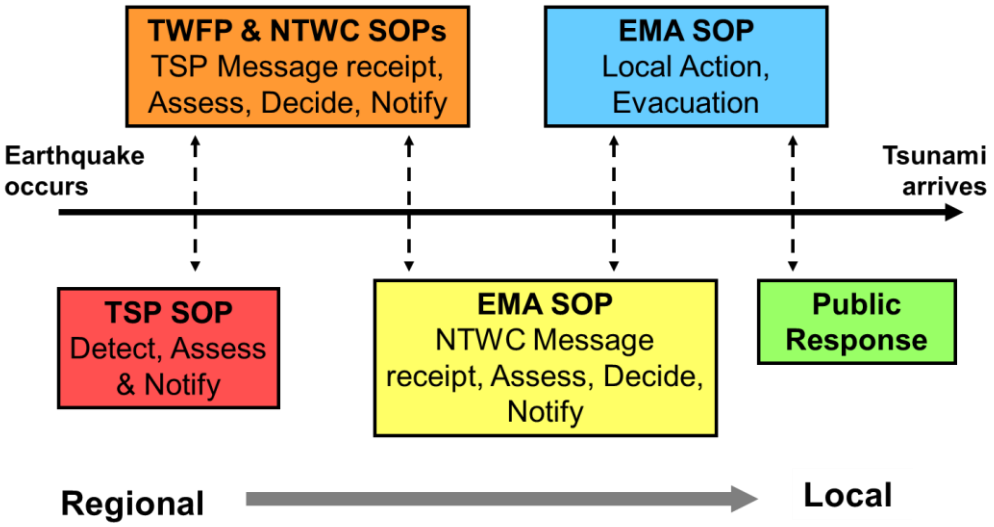


Figure 2.3 End to End Warning and Response (Source: ITIC). Note these steps do not necessarily apply for natural warnings/local source tsunamis.

The respective SOPs in an end-to-end warning system must be aligned and linked seamlessly with each other. In particular, the NTWC SOPs must link with the TSP SOPs, the national EMA SOPs with the NTWC SOPs, and the local action/evacuation SOPs must link with the national EMA SOPs. In addition, local action SOPs must recognise the arrangements that were invested in as part of tsunami preparedness. It is therefore clear that joint planning between the respective stakeholders in the development of SOPs is essential.

Note: The time available for emergency response (perhaps only minutes) may be less than the time it takes to feasibly receive, analyse the information and issue a science-based warning. In such cases, coastal communities must be ready to self-evacuate, based on their awareness of natural warnings without waiting for official instructions. The EMAs at national and local level are responsible for public awareness and education in this regard.

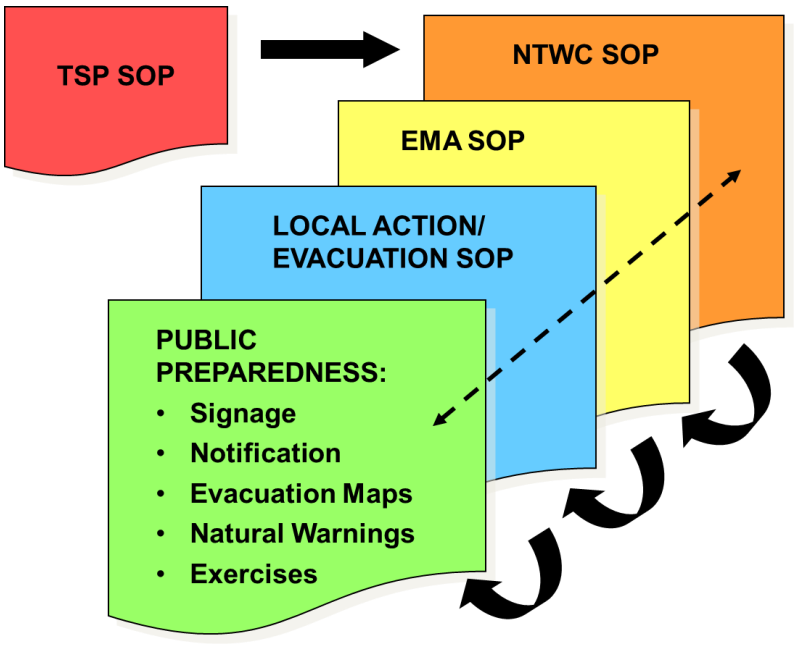


Figure 2.4 Alignment of SOPs and Preparedness Arrangements (Source: ITIC)

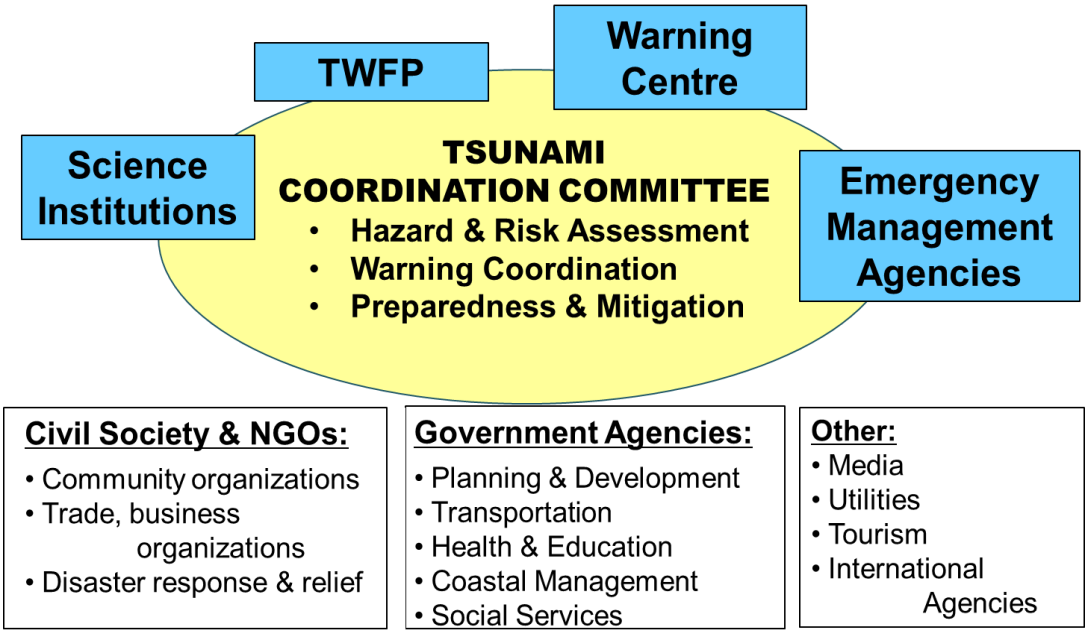


Figure 2.5 Participants in a Tsunami Coordinating Committee (Source: ITIC)

2.3 Tsunami Coordination Committees

A mechanism to promote effective understanding and coordination between all the stakeholders involved in a TWS and the establishment of a National Tsunami Warning and Emergency Response Plan is the establishment of Tsunami Coordination Committees (TCCs) at all levels of government. TCCs should meet regularly to collectively inform, decide, and share information among government officials. Minimum stakeholders include TWFPs, NTWCs, EMAs, and the scientific community who can provide advice on research to improve all aspects of the end-to-end system. Inclusion of public affairs and media/education/outreach stakeholders encourages the building of partnerships for efficient, consistent and accurate delivery of information. EMAs are the best placed to coordinate TCCs.

2.4 Documents supporting a TWS

2.4.1 National Tsunami Warning and Emergency Response Plan

A TWS is best defined in an integrated end-to-end National Tsunami Warning and Emergency Response Plan, with a minimum requirement being the existence of such a document at the national level. The main purpose of this document is to describe the collective components of the TWS and the allocation (and description) of responsibilities and actions for each component. The plan may also contain the concepts, thresholds, target times, systems, procedures, and templates used in the tsunami warning chain, and a concise description of the tsunami threat for the country (or reference to the relevant documents). Having all this information in one document ensures a common understanding among all those with responsibilities under the TWS and form the basis for enhancements and changes of the TWS. Where local level tsunami warning plans exist, they must recognise, align with and complement the national plan.

A National Tsunami Warning and Emergency Response Plan does not include procedures. It is a higher level document that describes the system and its components and that assigns roles and responsibilities. In turn each component and responsibility will require detailed SOPs as separate yet synchronised documents. Without the existence of a National Tsunami Warning and Emergency Response Plan as the base descriptor of the TWS, there is a risk of SOPs being developed in isolation of each

other resulting in unaligned or uncoordinated activities and actions.

A National Tsunami Warning and Emergency Response Plan should typically include the following chapters:

- The purpose of the plan
- The Roles & Responsibilities for:
  - Tsunami hazard and risk assessment (national/local)
  - TSP (short description who they are and the type of bulletins they provide)
  - Receipt & assessment of TSP bulletins (if applicable)
  - Receipt/development & assessment of national information (if applicable)
  - Dissemination of warnings to EMAs and other response agencies and authorities
  - Alerting of local communities and mariners
  - Deciding and taking emergency response measures such as evacuations
  - Cancellation of warnings and "All-Clear" to return
  - Media management (formal role of the media as part of the system if any)
  - Public education (on-going)
- The warning concept (thresholds, threat levels, danger zones as applicable)
- The types of warnings (including describing when each type will be used, and how the information is to be used by recipients)
- Key stakeholder addresses
- A glossary (definitions of terminology [1] used in the plan)

Additionally, the document may include the templates used for each type of warning, target response times and a concise tsunami hazard-risk description for the country.

Since some planning for tsunami warning and emergency response is common to that for other natural hazards, an all-hazards approach will help to sustain TWS participation in countries where the frequency of tsunamis is low.

2.4.2 Standard Operating Procedures (SOPs)

Activities and actions to be covered by SOPs range from the receipt of data, its processing and analysis, decision-making, warning communication, public alerting, and evacuations. These SOPs are best supported by tools such as flow-charts, timelines, criteria/decision tables and response checklists.

Stakeholders need to understand the time implications of their linked processes in order to collectively achieve the timelines for the delivery of warnings specified in the National Tsunami Warning and Emergency Response Plan, recognising that different response times will apply for local, regional and distant (far-field) earthquakes.

2.4.3 Other supporting documents

Besides the National Tsunami Warning and Emergency Response Plan and SOPs, a TWS may be supported by a range of other supporting documents developed by either TSPs, NTWCs or EMAs. These supporting documents should be maintained and updated as necessary to ensure their continuing currency and relevance to circumstances that may change over time. Examples of supporting documents are:

Operations Manual

An Operations Manual provides detail of how the technical components of a TWS stakeholder work. The target audience is staff of operational centres. It includes information on data streams, communications links, analysis software, messaging software, dissemination and notification methods, and general troubleshooting. An Operations Manual also provides details on what actions to take when a system has failed. This can be computer hardware failure, a communications link failure, a software problem, etc. Manuals also include non-event routine activities to ensure that the NTWC and its staff are always ready for a real event. An example of a NTWC Operations Manual is the

[1] Through its TOWS Working Group (Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems), IOC is promoting the harmonization of the procedures associated with tsunami warning systems, including their terminology. Pending the adoption by the IOC of terminology that can be applied globally, the countries must apply locally agreed terminology and definitions.

Pacific Tsunami Warning Center (PTWC) Duty Station Operations Manual, which covers all technical details to perform its roles and responsibilities both as a TSP and NTWC.

Operational Users Guide

An Operational Users Guide provides general information on tsunamis and the tsunami threat, on procedures and the TWS's criteria for action, along with sample messages. The target audience is customers receiving information (EMA, other agencies/authorities, stakeholders, and/or public). It includes a general description of the TWS – seismic data, sea-level data, the hierarchical structure of the TSP and NTWC, message dissemination, public safety actions and responses, including evacuation. Guidance on what the user can expect from the TWS is provided, including how to interpret messages and suggestions for taking action, and definitions of the terms used in the Guide. A regional example is the Operational Users Guide for the PTWS, Second edition (IOC, 2011 [2]).

Supporting Tsunami Emergency Response Plans

In giving effect to their responsibilities under the National Tsunami Warning and Emergency Response Plan, EMAs will have to plan specifically for aspects such as public alerting, evacuations and public awareness. These are best dealt with in separate plans with their own subsets of SOPs. An example of a local plan is the Emergency Operations Plan of the City and County of Honolulu, Hawaii, USA (2014), which contains tsunami-specific annexes for warning, messages, and evacuation.

Standards and Guidelines

NTWCs and EMAs also develop and maintain standards and guidelines to support event analyses and assessment, response planning and activities. For example, NTWCs follow international standards for the deployment of high-quality seismic and sea level monitoring networks and the sharing of data in real-time, the reporting of earthquake source parameters and tsunami observations, and issuance of alerts using standard communication protocols. NTWCs may also have a responsibility to support local authorities with the development of consistent inundation maps. EMAs may develop standards for hazard zones and evacuation mapping, land use planning and signage. EMAs also have a responsibility to develop programmes of public awareness and education.

2.4.4 Support tools

Plans and SOPs can be supported by a range of support documents which serve as important tools during an event. These include flow charts, criteria tables, timelines and checklists, and are discussed below:

Flow charts

Flow charts are used to indicate the steps to be to be followed in the execution of an SOP. They can also be used to show decision trees or to demonstrate systems. They can be electronically nested to provide step-by-step instructions, or they can simply serve to illustrate a process.

Examples of flow charts demonstrating a process are given in Annex A.2.1 and B.5.1.

[2] http://unesdoc.unesco.org/images/0018/001800/180097e.pdf

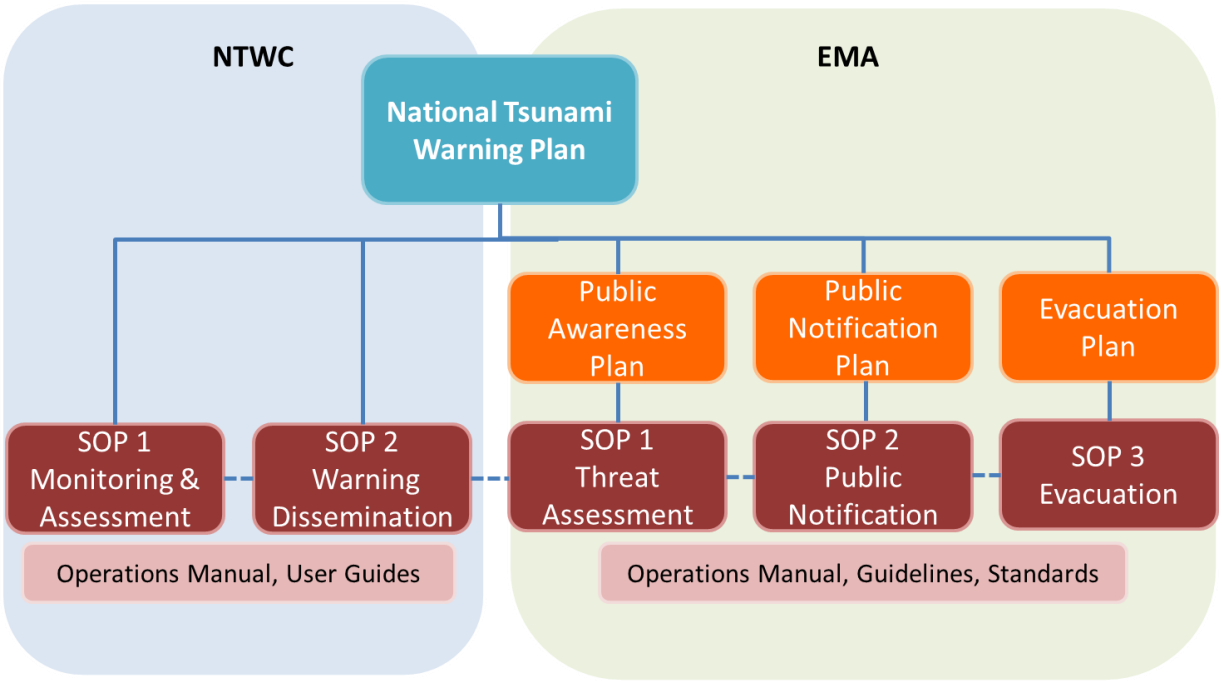


Figure 2.6 Hierarchy of Tsunami Warning Documents

Criteria tables

Criteria tables offer a useful tool to support decision-making. They bring confidence to decision makers and ensure decisions are appropriately considered and are consistent.

The development of criteria tables draws on understanding of the tsunami hazard. The better the respective tsunamis scenarios are understood, the better the quality of the criteria table will be and consequently the more confident decision makers can be. It is therefore important that criteria tables are developed jointly between tsunami scientists/hazard analysts, NTWCs and EMAs.

Examples of a criteria tables are given in Annex A.2.2 and B.5.2.

Timelines

Timelines are used to ensure that the execution of activities described in SOPs is sequenced appropriately against time. They should therefore be different for distant, regional and local source events.

One approach in developing a timeline is to start from the point of the initial warning or from the point that shaking is felt or the onset of an earthquake. The timeline is then extended in appropriate intervals (for example starting with 5 minutes, then moving to 15 minutes, 30 minutes and eventually 1 hour intervals – until the point of warning cancellation). The response activities are then documented against each point in time.

Another approach is to start at the point of tsunami impact, and then work backwards through the actions up to the initial warning. This method ensures that time constraints are understood and well considered, and plans and SOPs are realistic.

Examples of basic timelines are given in Annexes B.5.2 and B.5.3.

Checklists

Checklists apply to SOPs and support warning centre staff and emergency managers by ensuring that steps in the SOP are not missed. They also support supervisors by providing visibility of the progress of the execution of the SOP during a real event or exercise. Checklists break every activity described in the SOP down to individual steps and sub-activities. An essential checklist lists the important persons to be called upon, their contact information, and the order in which to call them during a tsunami warning.

Examples of basic checklists are given in Annexes A.2.4 and B.5.4.

Templates

Templates assure consistency and efficiency in alerting. Message templates place information in an expected format and order, along with standard explanatory language. This pre-scripted order reduces the time NTWC staff need to create the message, and similarly, since the order is the same every time (only the event details different), the amount of time recipients will need to read the message. Press releases can also employ templates to provide standard information in a standard format.

3. TSUNAMI WARNING

3.1 Introduction

Upon receiving earthquake and tsunami threat information from TSPs, NTWCs must respond rapidly with accuracy, and their operations must be reliable, robust, and redundant.

The information provided in this section is intended to act as a guide to assist NTWCs in the preparation of plans and SOPs. It offers guidance on what should be included, not just for event situations but also for daily operations such as duty shift staffing and office chores, data quality control, communication systems, and short- and long-term network and station maintenance and repair, and staff training. A country's tsunami hazard, combined with the capacities of the NTWC-designated agency, are often correlated with an NTWC's staff size and its roles and responsibilities. Plans and SOPs must be continuously updated and modified, based on the experiences obtained from routine daily and emergency operations, and from testing through conducting exercises. It is important that all stakeholders with responsibilities in the TWS chain are informed when there are important NTWC SOP changes to ensure 'no surprises' and alignment of their own SOPs.

3.2 Roles and Responsibilities of a TSP

A TSP is a centre that monitors seismic and sea level activity and issues accurate, timely tsunami threat information within an ICG framework to country NTWCs/TWFPs and other TSPs operating within an ocean basin. TSPs may issue public messages for an ocean basin but only with a generic tsunami threat statement to avoid potential conflict and public confusion with the tsunami warnings issued by the NTWCs. To do this, TSPs operate 24 hours per day, 7 days per week. A NTWC may elect to utilise services from more than one TSP. To respect country sovereign rights, TSPs cannot issue warnings for another country, but can of course act as the NTWC issuing warnings for its own country. TSP services are described in TSP User's Guides for each ICG.

Bi-lateral, multi-lateral and sub-regional arrangements may also exist for a TSP to provide products for a sub set of Member States within an ICG. The criteria may or may not be that established by the ICG.

The roles and responsibilities of a TSP (*Tsunami Watch Operations. Global Service Definition Document.* IOC Technical Series No. 130, 2016) are:

- Determine and provide timely initial earthquake information
- Determine more specific threat information using output from scenario databases produced by tsunami models, using earthquake source information and verified by sea level information
- Provide timely tsunami forecast information for use in preparation and issuing of national tsunami warnings by NTWCs/TWFPs
- Monitor tsunami propagation and provide updated information (observed tsunami amplitude measurements) in priority
- Provide timely standardized Situation Reports (SitReps) for use by other TSPs and NTWCs, as mandated by each ICG
- Serve as a backup centre to other TSPs, if required
- Serve as an NTWC for the country in which it resides

Box 3.2 TSP Core Responsibilities

The threshold at which TSPs commence services for an earthquake event is determined by the ICG for the TWS in each ocean basin. For example, in the IOTWMS, the threshold of Service Level 2 to provide tsunami information service is reached whenever earthquakes are recorded with magnitudes ≥ 6.5 Mwp within the Indian Ocean and magnitudes > 8.0 Mwp in the Pacific Ocean and southern Atlantic Ocean.

Non-emergency roles and responsibilities for a TSP which are essential in building preparedness and coordination (both internally and with NTWCs) include:

- Document and regularly review and update its Standard Operating Procedures (SOP), especially after events.
- Regularly test and carry out exercises to determine and report system performance against Key Performance Indicators (KPI) including communication channels to NTWCs/TWFPs, decision-support tools, etc.
- Perform calibration and validation of detection and forecasting tools and models.
- Review and update observations from seismic and sea level data streams.

3.3 ROLES AND RESPONSIBILITIES OF A NTWC

A NTWC is officially designated by the country to monitor and issue tsunami warnings and other related statements within their country according to established National Standard Operating Procedures. It provides the information to national emergency officials, and may also provide it directly to other agencies, the media, and the public. Information from the TSP can be used to assist NTWC decision-making.

The NTWC operates continuously on a 24 hours a day/7 days a week basis to receive earthquake and tsunami information from the TSPs and/or its TWFP. This information is evaluated to decide whether there is a significant tsunami threat. NTWCs may use sea-level networks that stream data in real, or near-real time, to independently verify the generation of a tsunami and evaluate its severity.

To achieve its responsibilities, NTWCs must have trained and experienced staff, adequate monitoring equipment and analysis tools, reliable communications, and sustainable resources. Depending on the needs of the country, and its resources, the NTWC may primarily rely on outside information sources (such as from the TSPs) to fulfil its duties, or it may also conduct its own seismic and sea level analyses, and tsunami forecasting when responding.

Alternatively, a country may have sufficient resources to establish its own NTWC with the capability to monitor and detect earthquakes and tsunamis, forecast tsunami propagation, make threat assessments and issue warnings to relevant authorities and communities.

The core responsibilities of the NTWC are:

- To receive, directly or through the designated country national Tsunami Warning Focal Point (TWFP), earthquake and tsunami information from the TSP(s) of its choice, and optionally, to independently monitor seismicity and tsunamis in real time.
- To analyse all information received and assess the tsunami threat for that country.
- To issue timely tsunami warnings or cancellations to EMAs and other stakeholder agencies in accordance with its National Tsunami Warning and Emergency Response Plan

Box 3.3 NTWC Core Responsibilities

3.4 NTWC Operations Manual

The NTWC Operations Manual is a detailed technical document that describes tsunami event response operations, and non-event or routine operations. The Manual covers NTWC operations sub-systems, and external and internal NTWC work processes, analyses methods, and communication.

NTWC event response covers the following activities:

- Receipt of real-time data streams, such as seismic and sea-level data, from TSPs or other countries' NTWCs;
- Detection and evaluation of the earthquake, assessment of tsunami threat and calculation of forecast, and confirmation of tsunami generation and its tsunami severity;
- Formulation and issuance of official warnings or other information products to the EMA, stakeholders, and/or the public
- Update or cancellation of warnings, and sharing of tsunami observations and impact.

NTWC non-event or routine operations cover the following activities:

- Routine and daily office operations and watch duty staffing
- Data quality control, equipment/instrument repair, and maintenance
- Data and warning communications
- Staff training and exercising
- Contingency planning or backup in case the primary tools become inoperable
- Education and training of stakeholders.

Additional Guidance and a template for a NTWC Operations Manual is provided in Annex A, along with examples of NTWC SOPs describing procedures using flow charts, timelines, checklists, and criteria tables, and the structure of threat information products.

3.5 NTWC SOPs

A NTWC must respond rapidly, be as accurate as possible, and be reliable in order to be effective. SOPs assure that each response is consistently conducted in as efficient a manner as possible. Unlike the detailed (and comprehensive) Operations Manual, SOPs are procedures or instructions, and in this sense, should be concise and easy to follow.

SOPs describe how each of the work flow activities in the Operations Manual is to be performed. The SOPs specify the step-by-step procedures for how the NTWC responds to events, and how it operates during times when there is no event. The SOPs should have sufficient detail to enable new NTWC staff to carry out their duties when a tsunami event alarm is triggered. To reinforce readiness, staff training and regular exercises are important for ensuring that NTWC SOPs are understood and that they can be performed seamlessly and quickly during an event.

For example, SOPs can govern:

- normal office and duty staffing;
- receipt of real-time parametric or waveform data from different seismic networks;
- data processing and analysis using various software and decision support tools;
- receipt and sending of earthquake and tsunami threat information through different telecommunication systems;
- decision-making and creation of warning and information products based on criteria tables and thresholds of action; and
- the call-down procedures for stakeholder contacts for warning coordination.

SOPs can also provide guidance on:

- what to do when instruments, communication channels, or computers are down,
- monthly communication test procedures, and
- annual station maintenance checklists.

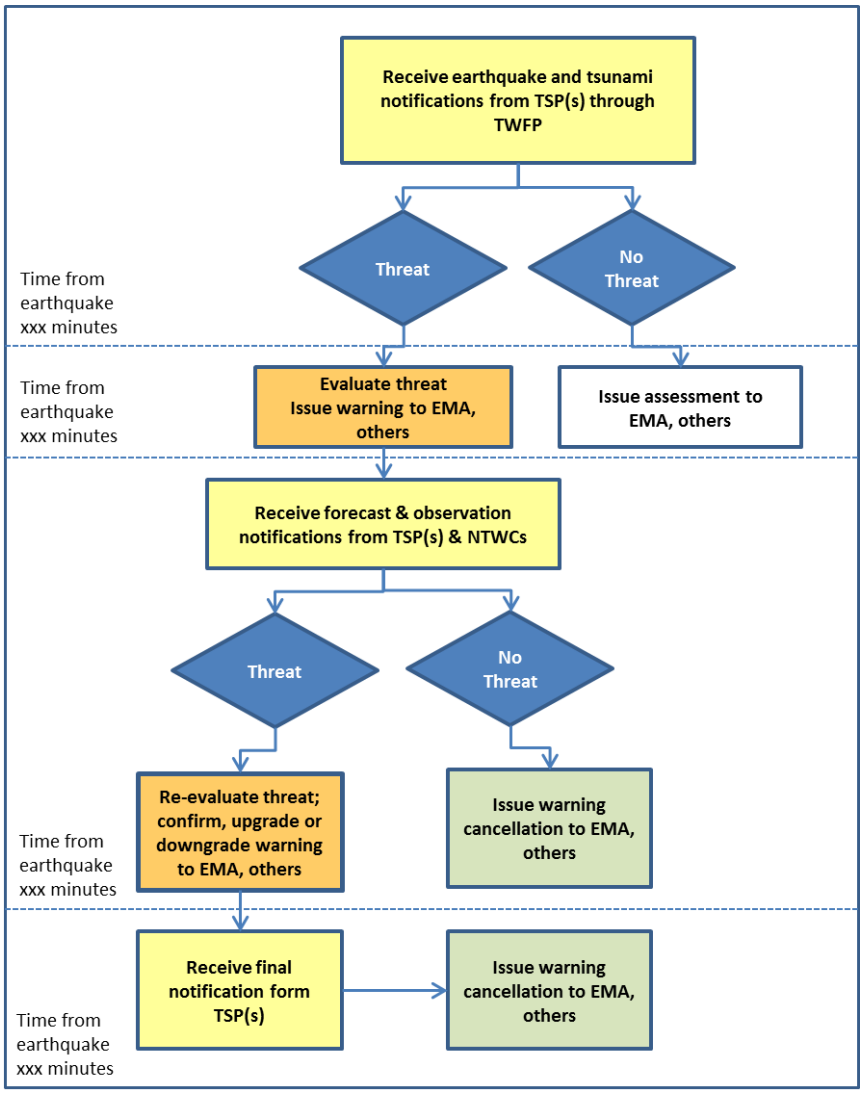


Figure 3.1 Simplified event flow chart for a NTWC. The NTWC is responsible for issuing a tsunami warning when there is a potential for a destructive tsunami to hit its coastlines. When waves are no longer dangerous, the NTWC will cancel the warning.

3.5.1 Minimum SOPs

When they only use information from TSPs or other national or international sources, NTWCs should have SOPs that at least cover the receipt of information, assessment of national threat, and issuance of official warnings or other information.

NTWCs should have the following minimum capabilities:

- Have real-time access to earthquake and tsunami information, and tsunami forecasts (arrival time and wave amplitude). A primary source would be ICG TSPs.
- Be able to assess, and revise if necessary, their tsunami threat, based on pre-determined criteria. Decision support tools, such as compilations of different spatial data sets including sea level data from coastal sensors as information layers in the context of time, assist with guiding duty staff decision-making on issuing, updating and cancellation of warnings.
- Create and issue timely information products to identified national stakeholders, according to the threat.
- Share their warning status and exchange data and observations freely and in a timely manner with TSPs and other NTWCs, such as through the WMO Global Telecommunications System (GTS), Internet, Fax, SMS, voice, or other means.

- Maintain adequate infrastructure and back-up facilities to continue operating during power cuts and national emergencies, such that:
  - All critical equipment on 30-min UPS,
  - Generator or alternative power backup, with 1-day of back-up capability,
  - All critical equipment operating in duplicate,
  - All critical communications circuits have back-up.

3.5.2 Advanced SOPs

Some countries have the independent capacity to continuously monitor seismicity in real-time using local and global seismographic networks to locate and determine the magnitude of potentially tsunamigenic earthquakes, or to use tsunami numerical modelling to provide tsunami forecasts. This capacity can reside in the NTWC or a specialized seismological or oceanographic agency, and enables the country to assess the threat of a tsunami in a way similar to a TSP. Such national assessments may be fed back to the TSPs and also inform other NTWCs.

These advanced NTWCs require in addition to the above minimum capability, computer applications and software tools for analyses, each with their own governing SOPs, to:

- Continuously monitor incoming seismic data, automatically detect and locate and size large earthquakes, and trigger event alarms to NTWC Duty Staff. This software should also allow staff to manually and iteratively improve the solution. The earthquake is the first (science-based) indication of a potential tsunami.
- Continuously monitor incoming sea level data from coastal and deep-ocean sensors, remove tidal components, and enable measurement of tsunami observations from the incoming data. The tools confirm a tsunami and its severity, and assist duty staff with decision-making on issuing, updating and cancellation of warnings.
- Calculate forecasts of tsunami arrival time and wave amplitudes for specific CFZs. The forecasts can come from a pre-calculated scenario database and/or real-time forecasts using the earthquake's Centroid Moment Tensor (CMT) solution as the tsunami source.

3.6 NTWC SOP Development

A country should decide what level of effort and sophistication it wants to commit for tsunami mitigation. Additional capabilities beyond a minimum NTWC require a commitment of additional resources, both in staffing and expertise, equipment, telecommunications, and most importantly, in sustainable funding.

NTWCs considering expanded capabilities should answer the following questions and develop its NTWC Operations Plan and SOPs accordingly:

- Will the NTWC be operating 24x7 with person(s) in the office, or on standby (for receipt of information from the TWFP, or other means)? Will the office be a dedicated tsunami warning centre or collateral within another centre?
- Does the NTWC have staff with seismological or tsunami background knowledge and/or advanced experience?
- Will the NTWC be running a national seismic network, or a sea level network, and sharing its data internationally?
- Will the NTWC have seismic processing and analysis capabilities to collect, locate, size, and determine the earthquake rupture, and then archive the data and earthquake information?
- Will the NTWC have sea level processing and analysis capabilities to collect and then measure, and archive the sea level and tsunami observations?
- Will the NTWC have tsunami wave forecasting capabilities (either through a scenario database lookup, or real-time forecasting)?

SOPs should be written, and then practiced, to ensure readiness. Flow charts, criteria tables, timelines, checklists, and pre-scripted templates are useful formats for conveying procedures that need to be followed quickly and correctly. Annex A gives examples of SOPs.

3.7 Core activities of a NTWC – event response operations

The NTWC must monitor and detect, assess, and provide information on the tsunami until the threat to its country is over. As quickly as possible after an alarm, the NTWC issues information to its users on the threat, and provides regular updates as new data is received and evaluated. A warning is cancelled after it is confirmed that tsunami waves are no longer dangerous. After cancellation, emergency officials can start search and rescue operations, and should assess whether it is safe for the public to return to evacuated areas ("All-Clear" issuance).

3.7.1 Earthquake detection and analysis

SOP: NTWCs without seismic processing capability

For NTWCs without seismic processing capability, the SOP for detection and analysis usually activates upon the receipt of information from the TSP for the region. Further analysis, if needed, is limited to comparison with other earthquake information sources. TSP bulletins are available through the GTS, other popular common communication protocols and registered user web sites. They provide earthquake information (hypocentre, magnitude), tsunami forecasts (time of arrival, wave amplitude for coastal forecast zones), and tsunami observations. Other sources of information may be the US Geological Survey, or other international or national seismic networks. For PTWC products, the USGS-supported California Integrated Seismic Network (CISN) real time earthquake display provides earthquake information as broadcast by the US Geological Survey National Earthquake Information Centre (NEIC) and includes tsunami information from the PTWC and US NTWC. CISN and other warning decision support tools are available from ITIC.

International earthquake source information is most timely for response to distant and regional tsunamis. In 2015, the average response time by the PTWC was about 5-7 minutes for earthquakes in the Pacific and Caribbean, with forecast information available about 20-30 minutes later.

In general, the NTWC response to local tsunamis should be immediate and should not wait for TSP information. The greatest emphasis should be placed on public preparedness and education, and self-evacuation triggered by the natural tsunami warning signs.

SOP: NTWCs with seismic processing capability

The SOP for a NTWC with in-house detection and processing facilities includes all the principal SOP elements for a basic NTWC. In addition this NTWC must adopt some of the procedures of the TSP.

Earthquake – (Analog or Digital Alarm paging Duty Staff)

1. Detect and analyse large earthquake
2. Assess tsunami threat based on pre-determined criteria
3. Issue initial tsunami warning message
4. Receive and/or carry out further seismic analysis and receive/calculate tsunami forecast
5. Detect and analyse sea level data for tsunamis
6. Re-assess tsunami threat
7. Issue supplementary warning message
8. Repeat steps 4-7 until "No dangerous tsunami waves coming ashore"
9. Issue tsunami warning cancellation message

Box 3.7.1 Principal NTWC event response steps on receipt of earthquake data

These NTWCs should also have the following capabilities:

- Have access to real-time seismic waveform and sea level data streams and analysis software to be able to report standardised earthquake and tsunami parameters, such as for earthquake magnitude (Mw), tsunami arrival time and wave amplitude. NTWCs may report different parameters nationally, such seismic intensity or a local earthquake magnitude.
- Have capabilities to determine, or have access to seismic waveform inversion techniques to characterize the earthquake faulting and rupture. For tsunamis, the current best practice is to calculate the Centroid Moment Tensor solution by inverting the W-phase in seismograms.

A country may choose to build its own seismic monitoring capacity if it has a local seismic and tsunami hazard since international networks would be too sparse and could not respond fast enough. Tsunami response times by the JMA for national events are typically about three minutes employing a pre-calculated scenario database, with seismic intensity information broadcast within one and a half minutes.

Earthquake monitoring and analysis

Over history, nearly ninety percent of tsunamis have been caused by shallow, submarine earthquakes along active subduction zones around the world. The monitoring of earthquakes also gives the earliest indicator of tsunamigenic potential as the seismic waves used for locating travel 50 to 100 times faster than tsunami waves. Rapid characterization of the earthquake is critical for assessing tsunamigenic potential. For speed, NTWC initial tsunami bulletins are based primarily on earthquake magnitude and location. NTWCs use automated seismic analysis systems, and low noise, short period, digital seismic data to quickly locate earthquakes, and broadband, high dynamic range data to estimate magnitude and fault rupture characteristics.

Real-time data from a number of national and international seismic networks (such as the Federation of Digital Seismographic Networks (FDSN), IRIS Global Seismic Network (GSN)) are used by TSPs and NTWCs to monitor seismicity. The data are shared in real time and in standard formats. Data from more than one network should be accessed to provide redundancy. Similarly, more than one communication pathway should be used to increase data reliability and avoid single points of communication failure. TSPs whose Area of Responsibility (AOR) includes local tsunami sources will use seismic data from networks close to those sources for initial appraisal. Data from more distant seismic networks can be used subsequently to refine the location and magnitude of the earthquake.

Earthquake parameters (hypocentres and magnitude) should be shared as quickly as possible amongst TSPs and NTWCs through the GTS, or by Internet to confirm and compare individual centre's solutions, whilst also improving redundancy of individual systems. As more seismic data becomes available, these parameters can be refined. With time, typically 10-20 minutes, characterizations of the earthquake's faulting become available through waveform inversions of long-period data. The earthquake's W-phase CMT solution is used to specify the tsunami source in tsunami numerical forecast models.

Earthquake information consists of the origin time, epicentre, depth, magnitude, focal mechanism and fault rupture characteristics, and their associated errors, as well as the seismic stations and arrival times used to form the solution. Earthquake information should:

- be timely (2–10 minutes);
- use an interoperable exchange format (e.g., CSS3.0, XML);
- clearly describe parameters used; and
- use a unique "id" or time tag so that revisions can be tracked.

Under the auspices of the IOC-UNESCO TOWS-WG Task Team on Tsunami Watch Operations, the TSPs have developed a Global Services Definition Document, and Key Performance Indicators have been established to set quality-of-service and system interoperability standards, and to ensure consistency on magnitude reporting, forecast amplitude threat thresholds, and earthquake-reporting geographic regions (IOC TOWS WG, 2016).

3.7.2 Tsunami detection and monitoring

SOP: Detection (NTWCs with sea level processing capability)

Once a large shallow earthquake has occurred, expected tsunami arrival times should be calculated. A point tsunami source should be assumed, at least initially, for the quickest calculations. Tsunami Travel Time calculation software (Geoware TTT) used by the PTWC is available from ITIC.

To confirm whether a tsunami has been generated, and if it is dangerous, coastal and deep ocean sea level sensors are monitored. Data are transmitted in real, or near-real time to TSPs and NTWCs, where they can be displayed using tools such as the web-based IOC Sea Level Monitoring site, the TideTool software used by the PTWC and available from ITIC, or other customized software.

Confirmation of a tsunami usually comes from sea-level stations located nearest the earthquake. In the case of local tsunamis, it is best to have a dense network of sea-level instruments so that close-by stations can confirm a tsunami within minutes of its generation. At the regional or distant scale, confirmation depends on a sparser network of coastal and deep ocean sensors and can take 1-2 hours.

Monitoring

Coastal and deep-ocean sea-level data are required to verify and monitor the generation and propagation of a tsunami, while coastal sea-level data is also important for the updating and cancellation of warnings. International sea-level monitoring networks, such as the Global Sea Level Observing System (GLOSS, WMO-IOC JCOMM) as well as national and regional stations, provide this data in near real time to NTWCs and TSPs, through the GTS or other routes (e.g. Internet, radio, land line, etc.) Data transmission is standard at every five to 15 minutes depending on the station's proximity to a tsunami source zone. In some instances, however, stations may not meet a TSP's requirements for rapid detection because they were deployed to monitor other long-term phenomena (e.g., mean sea level change related to climate change).

A tsunami is a wave train, with wave periods of five to 60 minutes depending on its specific generation mechanism. Tide gauges are used to monitor tsunamis as they arrive at the coast and deep-ocean tsunami detection instruments (or "tsunameters") are used to monitor tsunamis in the open ocean. Wave refraction, caused by segments of the wave moving at different speeds as the water depth varies, and shoaling, can result in extreme amplification in localised areas. Care must be taken in interpreting coastal sea-level data, as the signal may represent only a local response. In contrast, tsunameter signals have not been conditioned by shallow-water bathymetry, and therefore provide the most appropriate information for comparison to, or assimilation in, tsunami forecast models.

The IOC, on the recommendation of its TOWS Working Group, has established standards for tsunami sea level monitoring and reporting (IOC TOWS WG, 2011), and the JCOMM Data Buoy Cooperation Panel (DBCP) International Tsunameter Partnership (ITP) has prepared Tsunameter Equipment Performance Standards and Guidelines (JCOMM 10th Meeting of the Data Buoy Cooperation Panel (DBCP) Action Group for the International Tsunameter Partnership (ITP), Weihai, China, October 27, 2014).

3.7.3 Tsunami forecasting

SOP: NTWCs without tsunami forecast capability

The SOP for the minimum NTWC uses tsunami forecasts (time of arrival, wave amplitude for coastal forecast zones), and tsunami observations received primarily from the TSP for the region.

SOP: NTWCs with tsunami forecast capability

For TSPs and NTWCs, the numerical models utilized, and their associated SOPs, should:

- Use benchmarked and validated open-ocean propagation models, and sufficiently-detailed bathymetry and coastal topography data, to calculate off-shore or coastal wave amplitude.
- Employ a tsunami scenario database method when there is insufficient warning time, e.g., local tsunami threat. The pre-calculated database is calculated using different epicentres, depths, and magnitudes, including the most credible, worst-case scenarios.
- Use standard empirical relations to represent the earthquake faulting (magnitude, fault strike, dip, rake).
- Use appropriate Domain, Total Simulation Time and Time Steps.
- Include important coastal locations, sea level gauge locations, tsunameter locations as Coastal Forecast Points (CFPs) for ground-truthing.
- Provide tsunami amplitudes at appropriate/agreed offshore depths, and at the ICG level, for CFZs.
- Apply standard modelling procedures to derive wave amplitudes at the coast from the calculated offshore amplitudes.

Forecasting for tsunami warning

The main objective of a forecast model is to provide an estimate of wave arrival time and wave height.

In order to compute a forecast, the numerical model must simulate the two stages of tsunami modelling – wave generation and propagation. The earthquake source is used to constrain the tsunami source to generate the wave, and tsunami physics simplifies the computation to enable linear wave propagation across the basin, enabling forecasts of offshore wave amplitude to be made. Forecasting of wave amplitude on the coast involves non-linear calculations with a high resolution that currently take too long to be useful for tsunami warning. A simple quick proxy being used is to apply a Green's Law formulation (dependent only on water depth) to the deep-ocean wave amplitude to bring it to the shoreline. Real-time forecasts using the actual earthquake source derived from the W-phase CMT are possible, but only for regional and distant tsunamis hours away from impact. For local tsunamis, forecasts should utilize the scenario database approach.

A database of tsunami scenarios provides estimates of expected impact and can assist in warning and especially evacuation decision-making. The database contains pre-computed tsunami propagation models from many likely source locations and a range of magnitudes. When a tsunami event occurs, the scenario is selected from the database using the available seismic information for the earthquake event.

As the tsunami propagates across the ocean, it is recorded on sea-level gauges and tsunameter systems, and the marigrams are sent back to the TSPs or NTWCs which in turn measure the observed waves and uses them to calibrate and/or improve their tsunami forecast. The result is an increasingly accurate forecast.

3.7.4 Formulate and issue warnings and cancellations

The SOPs of all NTWCs should cover the formulation of official warnings or other information that is to be provided by the NTWC; and for the update of warnings and the issuance of warning cancellations. To facilitate seamless warning and emergency response, and when appropriate and with enough lead time, it is recommended that the issuance of a warning (when and where) be coordinated with the emergency officials responsible for evacuation.

Official warnings are issued by the NTWC, depending on the national protocols, to:

- EMAs
- Other Government agencies/authorities
- Media
- Direct to the public

Warnings and other information products should:

- Be issued in a timely manner to inform of the land and/or marine threat

- State if a potentially damaging tsunami has been, or may have been, generated.
- Must be updated if necessary and re-confirmed regularly (or at least hourly), until evidence is received to indicate there is no further tsunami threat.
- Are cancelled when the NTWC judges that destructive tsunami waves are no longer being generated. This does not mean that is it safe for the public to return to the water. Cancellation messages will therefore usually contain public advice to be cautious of strong currents for a further period.
- To support effective response, include generic public information about what to do and what not to do (Action Statements).

In addition to text products, NTWCs may issue graphical products, such as deep-ocean ('energy') or coastal wave amplitude forecast maps. Care must be taken to socialize every NTWC product so as to ensure appropriate interpretation and understanding.

Threshold threat levels and criteria tables

Criteria Tables serve as NTWC and EMA SOPs by guiding their decisions on what alert level to issue when a threat level is known. The NTWC, in consultation with the EMA, must determine the threshold levels in advance, taking into account inundation modelling, the vulnerability of their country's coastal communities and infrastructure, and response capability.

Simply, a Criteria Table should contain:

- Threat Thresholds, in terms of NTWC-determined Forecast Maximum Coastal Wave Amplitude and/or Earthquake Magnitude
- Alert Levels, such as Warning/Advisory/Watch/Information, Threat/No Threat, or Red/Orange/Yellow/Green, or other categories
- Emergency Response Actions that link the Threat and Alert to the response by the public

National thresholds may depend upon coastal morphology (e.g. thresholds will be higher for coastlines with cliffs than low-lying coastlines). The thresholds may also depend on whether a reliable forecast is available. For instance, a local source tsunami warning (that must be issued immediately) should use seismic thresholds related to the earthquake hypocentre and magnitude, or earthquake ground shaking, and/or a pre-computed tsunami scenario database using the first earthquake parameters. In the Pacific and Caribbean, recommended NTWC Criteria Tables depend on whether TSP PTWC quantitative forecasts are available.

Message products

As tsunamis are infrequent events, the terminology and the contents of a tsunami warning must be carefully designed so that EMAs, related agencies, and the public will be able to understand them without detailed instruction, thus enabling their immediate response. Their exact wording may vary from country to country, based on language or translations, terminologies, and recognised cultural differences. Authority for any action resulting from a warning, notably instructions for evacuation, usually rests with the EMA.

The following guidance is provided on tsunami message products:

- Message templates, with pre-scripted information, should be used.
- Messages should have a standard structure, and be as short and as concise as possible to provide the basic important threat information and actions recommended.
- Standard national messages may want to mimic TSP Public Bulletins, but include only country-specific information.

A standard message structure can include some or all of the following information:

- Header (who is the source, what type of message, when in local time)
- Earthquake Information
- Tsunami Evaluation
- Forecast (if applicable)
- Recommended Actions (depending on Threat Level)
- Estimated Time of Tsunami Arrival (ETA)

- Potential Impacts
- Tsunami Observations
- Next Update and Additional Information Contact (local authority)

Messages should be pre-scripted to enable immediate and efficient creation. Templates, in which the basic text does not change, allow easy fill-in of event information by Duty Staff (or that can automatically be filled in with incoming TSP message parameters). If an automated process or graphical user interface (GUI) is used, there should be options to 'review before send' and 'manual entry'.

The order of the information in the messages may be a function of the recipients, e.g. the public are more interested in what actions they should take, and less interested in the scientific details which can go later in the message if necessary.

3.8 Core activities of a NTWC – post and non-event operations

3.8.1 Post-event activities

Post-event activities include reviews of the event response in order to adjust and improve SOPs. The SOPs and event logs may also be key documents in any post-event formal enquiries. Additionally, the NTWC may be responsible for the finalization of the earthquake parameters, and the archiving of the event seismograms and tsunami marigrams and observations. Archived tsunami marigrams and observations significantly contribute to the verification of tsunami simulation models, resulting in the improvement of forecast accuracy. NTWC scientists may also participate in post-tsunami surveys to assess tsunami impacts and collect perishable tsunami data to be used to improve tsunami models and mitigation practices.

3.8.2 Non-event operations

Routine activities to support NTWC event response operations include:

- Ensuring NTWC staff readiness through in-office warning centre operations training.
- Ensuring high-quality data streams and reliable, robust communications through routine maintenance and regular communication line testing.
- Creation and maintenance of 'users guides' for different customers receiving tsunami warning services. Common users would be the EMA and other government responders, the media, and the public.

Non-event activities to support the country's tsunami mitigation programme include:

- Cooperation with the EMA to specify threat forecasts zones, develop concepts to support timely evacuation, conduct exercises, and engage in public awareness and education.
- Cooperation with the EMA and technical and science institutions in conducting tsunami hazard assessments, inundation modelling and vulnerability assessments.
- Optionally, undertaking research to improve the accuracy, timeliness, and effectiveness of tsunami warning through better threat analyses and more robust warning dissemination.

NTWCs acquire data and disseminate warning messages through multiple communications paths. They should have redundant methods and services as backups in case of primary service failures. Routine communications tests must be carried out to ensure that telecommunications paths are working. A NTWC should provide a 'User's Guide' for their EMA which will receive, and have to interpret and take action on the NTWC messages. Warning messages must be clearly understood. Additionally, if (subject to national protocols) NTWC and/or EMA warnings are simultaneously transmitted to the public via the media, the media also need to know what the messages mean. For this, education and training of the stakeholders and the public to socialize the warning services and products needs to be conducted.

4. TSUNAMI EMERGENCY RESPONSE

4.1 Introduction

The information provided in this section is intended to act as a guide to assist in the preparation of National EMA Tsunami Emergency Response (TER) plans and SOPs. It covers the role of EMAs during tsunami events as well as their role in the development and maintenance of tsunami response capability. Because of the variations in the sizes and complexities of EMAs, their plans and SOP contents will vary from one country to another.

Some of the responsibilities attributed to the EMA in this section may also apply to EMAs at the local level depending on the division of responsibilities in individual countries. For the purpose of this manual, countries must apply the content as applicable to the national EMA or local EMAs.

4.2 The Roles and Responsibilities of a EMA

The EMA is responsible for public safety and the welfare of the community in the event of an emergency. In association with other government agencies and relevant organisations, it must establish and maintain preparedness for tsunami response through hazard risk assessment and TER plans and accompanying SOPs that focus on public awareness and preparedness, threat assessment, public alerting, and response measures - such as evacuations. These plans and procedures must acknowledge that notifications from a NTWC may provide little response time – a tsunami generated by a local earthquake may impact within minutes, and they can occur at any time of the day or night.

During tsunami events the EMA must immediately interpret the warnings issued by the NTWC to decide if all or some of the communities are impacted, and decide on the appropriate response action. Accordingly, it must disseminate warnings, instructions and other safety information to agencies, local EMAs, threatened communities at threat and to the media in accordance with the National Tsunami Warning and Emergency Response Plan. It is also responsible for informing agencies and the public of the "All Clear" when the threat is over.

Specifically, the EMA plays a leading role in:

- Conducting tsunami hazard assessment through cooperation with NTWCs, technical and science institutions, and then presenting the information to emergency managers and the public in an understandable manner. Potential local, regional, and distant tsunami hazard sources, their travel times and potential amplitudes at the shore and the extent of flooding inland must be understood. Moreover, tsunami hazard inundation maps need to have been created beforehand as the basis for developing community-based tsunami evacuation maps.

The core responsibilities of the EMA in a tsunami warning are:

- To receive official tsunami warning and cancellation messages from the NTWC.
- To conduct further threat assessments and decide appropriate action.
- To communicate the warnings, with instructions, via public alerting systems and the media.
- To activate appropriate emergency response measures, including deciding and managing evacuations.
- To communicate the "All Clear" when the threat is over.

Box 4.2 EMA core responsibilities in a tsunami emergency (subject to national protocols)

- Preparing the public for all hazards, including tsunamis, through awareness and education programmes, the communication of tsunami hazard risk assessment information to communities, and the involvement of communities in mitigation activities such as evacuation planning and drills. It should translate tsunami science in an understandable way to ordinary citizens.
- Developing plans, standards and guidelines for tsunami preparedness and response, including evacuations.
- Ensuring public alerting systems and procedures are in place to provide timely and effective information to the public and the media during tsunami events.
- To achieve its responsibilities in a tsunami warning situation, the EMA must have:
    - Qualified, experienced duty staff ready to respond at any time
    - Effective and tested communication links with the NTWC to ensure they will receive official tsunami warning messages, and are able to discuss these with the NTWC
    - SOPs and support tools in place that facilitate rapid decision-making and effective response
    - Readily available templates for the required types of messages
    - Public alerting systems in place and tested, including arrangements to liaise with the media
    - Evacuation procedures that are planned and tested.

4.3 Tsunami emergency response plans

TER Plans should be developed to specify the arrangements for:

- Public awareness and education
- Receipt of warnings (from the NTWC), threat assessment and decision criteria
- Activation of response arrangements, including public notification mechanisms
- Evacuation arrangements.

These plans must be based on the EMA's understanding of the tsunami hazard risk, assumptions on available resources, preparedness arrangements and the level of public awareness. They should contain information about the roles, structures, priorities, responsibilities, and concepts (or options) pertaining to the topic.

Guidelines for the development of a TER plans are given in Annex B.0

4.4 Tsunami emergency response SOPs

SOPs describe how the operational activities that are covered in the TER plans are to be performed. Specific SOPs must therefore be created for each individual TER plan. They must be trained to ensure that response staff are familiar with them, and they must be exercised to identify gaps or improvements that are to be made.

SOPs should be sufficiently detailed so that mistakes or omissions in the execution of operational activities are avoided, and so that the activities are executed in a consistent way. Useful support tools in this regard include flow charts, criteria tables, timelines and checklists (see examples in 4.5.4).

The respective SOPs must be synchronised so that they follow seamlessly and support each subsequent component.

Figure 4.1 below illustrates the high-level TER activities that require plans and/or SOPs:

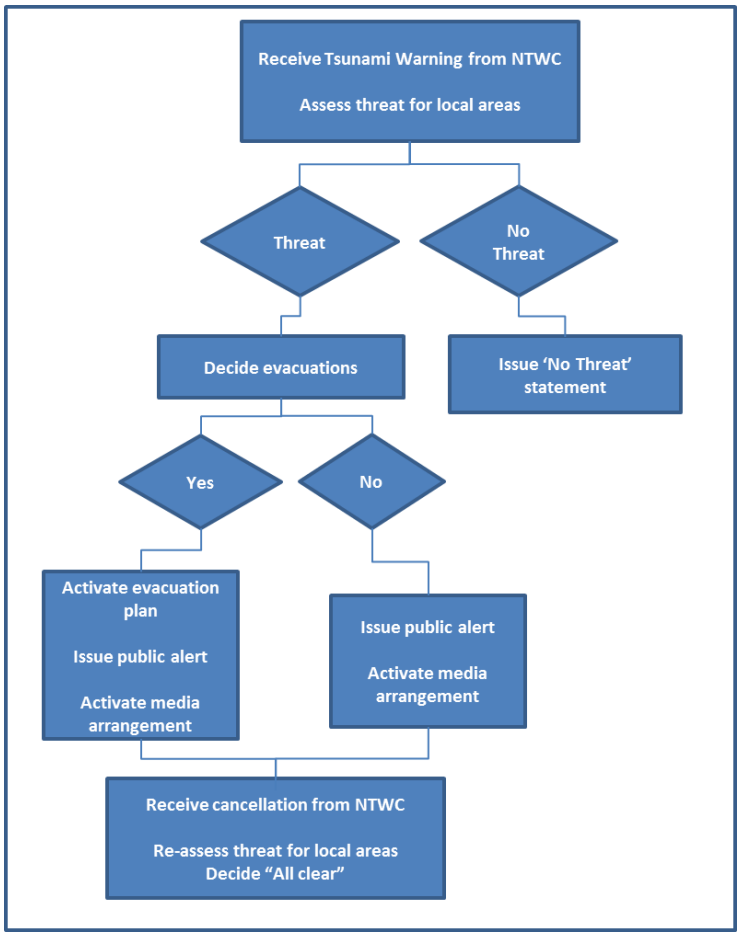


Figure 4.1 Simplified flow chart for a EMA tsunami response process

4.5 Development of TER plans and SOPs

EMAs should consider the following when developing TER plans and SOPs:

- Major earthquakes and tsunamis can cause numerous fatalities and injuries, property damage and loss, and the disruption of normal life support and services. They can also have significant impacts on regional economic, physical and social infrastructures.
- The extent of casualties and damage will reflect factors such as the time of day or night at which the tsunami strikes, weather conditions and tides, population density, building construction, community readiness and the possible triggering of secondary consequences such as fires and floods.
- Tsunami warning information is conservative and often limited. Its potential lack of quality, accuracy, and timeliness will need to be considered in response planning.
- Local emergency management officials and emergency services should understand that they would have to act on their own initiative and responsibility during local source events.
- Successful evacuations will be affected by the number of evacuees involved, the time of the day or night and access routes available. Appropriate pre-event threat assessments and evacuation zone mapping are essential to avoid over-evacuation.
- Emergency services will likely be stretched and unable to support evacuations.

4.5.1 TER plans for public awareness

An effective TWS is achieved when all people, especially those in coastal communities, respond appropriately to an official warning or upon recognition that a potentially destructive tsunami may be approaching. Raising public awareness of the tsunami hazard must therefore be planned for, and mechanisms established for the promotion and monitoring of awareness on a community-led and community-owned, sustainable basis.

In most countries, the EMA serves as the lead agency for public awareness. However, NTWCs as the organizations responsible for the scientific evaluation of the tsunami threat, should also work closely with the EMA sharing the responsibility.

In relation to tsunami warnings, the public must have an understanding of:

- The tsunami hazard
- Official warnings (who issues them, what information they will contain, when to expect them and when not, and how they will be communicated)
- Natural warning signs (what to look out for and how to respond to them)
- Informal warnings (what they are, and where to find official information)
- Evacuation zones, routes and safe areas, or
- How to respond where evacuation zones are not defined.

Challenges with respect to public awareness planning include:

- Creating and maintaining awareness among communities where destructive tsunamis recur only in very long time intervals.
- The changing demographics of coastal areas and, in many countries, seasonal influxes of visitors to their shores.
- Complacency due to the presence of sirens and other public alerting mechanisms
- The credibility of warnings due to false alarms.

Guidelines for the development of public awareness plans are provided in Annex B.2.

4.5.2 TER plans and SOPs for receipt of warnings

The arrangements for the receipt of warnings by the EMA from the NTWC and subsequent assessment and decision machining must link closely with the arrangements for public notifications (4.5.3 below). A one-plan approach by the EMA that encompasses warning receipt, assessment, decision-making, public notification and media managements in one document is therefore often used. The guidance in Annex B.3 takes this approach.

Regardless of the documentation approach used, the arrangements and processes for the 24/7 receipt, assessment and decision about public notifications must be clearly documented and well understood by all stakeholders in the end-to-end tsunami warning process.

4.5.3 TER plans and SOPs for public notifications

The arrangements to alert and inform communities must be clearly documented and responsibilities assigned. These include the public alerting systems that will be used, when and how they will be used, who initiates them, as well the arrangements with regard to the media.

In many countries the issuance of warnings to the public is directly by the NTWC. In either respect, national agreement must be made on which organisation has responsibility for issuing public warnings. EMAs and NTWCs must be coordinated in any messaging to avoid confusing the community, which may lead to disastrous consequences.

It is particularly important that public information during warnings (as well as "All Clear" notifications) should be clear and understandable, in several languages if appropriate (e.g., in tourist areas), accurate, reliable, frequent and credible. The information should be specific to the situation and in the advice or instructions on how the community should respond.

Public alerting

Public alerting systems should be ubiquitous and synchronised, be capable of reaching people irrespective of what they are doing and where they are, and be easy to access and use. They should be reliable, not create or add risk, provide appropriate lead-time (if possible) and be authenticated.

Besides using bespoke mechanisms such as sirens, successful/sustainable public alerting systems should also use existing facilities and organizational structures such as radio and television, social media, websites, and institutions such as emergency services, Coastguard, port authorities, beach safety staff, schools, hospitals, NGOs, etc.

However, timely activation of public alerting systems may not be possible in the case of local source (near field) tsunamis or they may be eliminated by the earthquake damage itself. The public must therefore understand the limitations of these systems, and be aware that they must take personal responsibility to self-evacuate in response to natural warning signs in the first instance. The limitations of public alerting systems and how to respond to them are essential elements of on-going public awareness programme.

SOPs for public alerting should cover (among others):

- The decision and activation process (to issue a public alert)
- The templates to use (including where to find them and how to complete them)
- The sign-off process (to approve the content before it is communicated)
- The alerting channels to use (including how to access them)
- The repeat and close process.

Guidelines on public notification planning are provided in Annex B.3.

Media

The broadcasting media has the advantage of conveying information in real time to many people simultaneously. During a tsunami event they will also have a heightened interest in access to information. In the absence of official information, the media is likely to find their own (unofficial) information which may be inaccurate and cause public response that is counter to the response advised or instructed by emergency managers.

A formal arrangement between the EMA, NTWC and the designated television and radio stations for the transmission of official information during an emergency should be established. The arrangement may include a provision for training or orientation of news staff and announcers to ensure they will understand the information they will be receiving and what tsunami safety information to broadcast.

Where the media does not receive warnings directly from NTWCs, ready media release templates containing public advice for the suite of possible tsunami scenarios must be maintained by the EMA. It is also essential that the EMA has official spokespersons available to the media and public during a tsunami warning.

SOPs for media arrangements should cover (among others):

- The process for the activation for media arrangements
- The media channels that will be used (and how to access them)
- The templates to use (including where to find them and how to complete them)
- The sign-off process (to approve the content before it is passed on to the media)
- The process for arranging media conferences (who, how frequent, where etc.)
- The designation of official spokespersons
- The repeat and close process

Guidance on the development of a Media Plan are provided in Annex B.3.

4.5.4 TER plans and SOPs for evacuations

A key element of TER planning involves the evacuation (or self-evacuation) of exposed people and key assets (e.g. emergency vehicles and important information) to safe areas, or, in the case of harbour craft, to deep water.

The trigger for commencing the evacuation process at the local level by emergency managers may be the receipt of a tsunami warning (from the NTWC or EMA). For the public in exposed areas, the trigger may be the activation of public alerting mechanisms. Alternatively, the trigger for the public could be the natural warning itself (feeling a strong earthquake).

EMAs should therefore keep in mind that the planning required for local, regional and distant source tsunamis will differ. A distant source tsunami will allow several hours to evacuate, while a regional source tsunami will allow much less and local source tsunami may not allow a timely official instruction. The amount of time required to execute an evacuation should therefore be analysed and factored into the

decision-making procedure for the respective scenarios.

Tsunami evacuation plans must include the identification of evacuation zones for the respective scenarios, evacuation routes, safe areas, signage and the resources required to support evacuations.

SOPs for evacuations should cover (among others):

- The decision process (including the criteria to support decision making)
- The evacuation zones that will apply under the respective scenarios
- The evacuation routes that will be used
- The assembly areas or shelters that will apply
- Mobilisation of resources to support the evacuation, including directing traffic and provision of services at assembly sites
- The communication channels that will be used to notify affected communities
- On-going communication mechanisms with affected communities
- The return process.

It is evident that tsunami evacuation plans and SOPs should link with emergency relief plans and SOPs, and that public awareness is critical to support effective evacuations. Awareness programmes must include publicly visible signs and maps to identify evacuation zones, evacuation routes, and safe areas.

Guidelines for evacuation planning are given in Annex B.4.

5. GENERAL BIBLIOGRAPHY

Kong, Laura S.L. 2007. A Global Tsunami Reduction Strategy: Building Effective Tsunami Warning and Mitigation Systems, Proceedings, 4th International Workshop on Coastal Disaster Prevention, Future Disaster Management of Tsunami and Storm Surge in Asia, 1-2 December 2007, Yokohama, Japan

New Zealand MCDEM. 2008. Mass Evacuation Planning, DGL 07/08. Available at http://www.civildefence.govt.nz/resources/publications/ (Accessed July 4, 2016)

New Zealand MCDEM. 2009. Tsunami Advisory and Warning Plan, Supporting Plan (Revised October 2014) [SP 0109]. Available at http://www.civildefence.govt.nz/resources/publications/ (Accessed July 4, 2016)

New Zealand MCDEM. 2015a. Guide to the National Civil Defence Emergency Management Plan. Available at http://www.civildefence.govt.nz/cdem-sector/cdem-framework/guide-to-the-national-civil-defence-emergency-management-plan/ (Accessed July 4, 2016)

New Zealand MCDEM. 2015b. Tsunami Evacuation Zones. Director's Guideline for Civil Defence Emergency Management Groups. Available at http://www.civildefence.govt.nz/resources/publications/ (Accessed July 4, 2016)

UN/ISDR. 2006. Third International Conference on Early Warning, Developing Early Warning Systems: A Checklist, 27-29 March 2006.

UN/ISDR. 2009. UNISDR terminology on disaster risk reduction, Available at http://www.unisdr.org/we/inform/publications/7817 (Accessed 4 July 2016).

UNESCO IOC. 2004. International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU), ITSU Master Plan (3rd ed.), IOC/INF No. 1124 revised, Paris.

UNESCO IOC. 2006. Tsunami Teacher. Available at http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1441&Itemid=2420&lang=en DVD copies for PC and Macintosh computers are available free of charge from the IOC Tsunami Unit, Paris, or from ITIC (itic.tsunami@noaa.gov).

UNESCO IOC. 2008. Tsunami Preparedness: Information Guide for Disaster Planners. IOC Manuals and Guides No. 49. Paris, UNESCO. Available at http://unesdoc.unesco.org/images/0016/001600/160002e.pdf (Accessed 28 January 2013).

UNESCO-IOC. 2010. Strengthening Tsunami Warning and Emergency Responses: One-week Training Workshops on the Development of End-to-End Tsunami Standard Operating Procedures (SOPs): Course Manual 2008–2010, Alerting, Media and Local Preparedness.

UNESCO IOC. 2011a. Operational Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS). IOC Technical Series No. 87 Second edition. Paris, UNESCO. Available at http://unesdoc.unesco.org/images/0018/001800/180097e.pdf (Accessed 4 July 2016).

UNESCO IOC. 2011b. Fourth session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Report of the Inter-ICG Task Team on Sea Level Monitoring for Tsunami. Available at http://unesdoc.unesco.org/images/0019/001930/193023e.pdf (Accessed July 4, 2016)

UNESCO IOC. 2014. Tsunami, The Great Waves, Revised Edition. Paris, UNESCO. 16 pp., illus. IOC Brochure 2012-4 (English, French, Spanish), revised 2014. Available at http://unesdoc.unesco.org/ulis/cgi-bin/ulis.pl?lin=1&catno=148609 (Accessed 4 July 2016). UNESCO IOC. 2016a. Tsunami Glossary, Third Edition. Paris, UNESCO. IOC Technical Series, No. 85.(English, French,

Spanish, Arabic, Chinese) (IOC/2008/TS/85 rev.2)

UNESCO IOC. 2016b. TSUNAMI WATCH OPERATIONS Global Service Definition Document, Paris, UNESCO. IOC Technical Series, No. 130 (English). Available at http://unesdoc.unesco.org/images/0024/002469/246931E.pdf (Accessed 19 Jan 2017).

UNESCO IOC. 2015 draft. User Guide for National Tsunami Warning Centres (NTWCs), Indian Ocean Tsunami Warning and Mitigation System (IOTWS)

UNESCO IOC – NOAA ITIC, 2016c. Strengthening Tsunami Warning and Emergency Response Standard Operating Procedures training course, 2008-present. Available at http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=1061&Itemid=2255 (Accessed 4 July 2016).

USAID. 2007. The Tsunami Warning Centres Reference Guide. Available at http://www.meted.ucar.edu/communities/hazwarnsys/haz_tguide.php (Accessed 28 January 2013).

ANNEXES

Annex A GUIDELINES FOR NTWC SOPs

This Annex provides templates and guidance for the development of tsunami Standard Operating Procedures (SOPs) used by National Tsunami Warning Centres (NTWC).

A country's National Tsunami Warning and Emergency Response Plan places the responsibility of tsunami warnings with its NTWC. NTWC roles, responsibilities, activities, software and tools, and operational procedures for event response and non-event routine activities are described and specified in its reference Operations Manual. For responding quickly during an actual tsunami event, flow charts, criteria tables, timelines, checklists, and message templates serve as the most useful decision support tools for Duty Staff. NTWC services and products are described in its Operational User's Guide provided to customers.

A.1 NTWC Operations Manual Template

The following is a template for a Table of Contents for a NTWC Operational Manual. The Manual should cover operations and activities of the NTWC. A simplified version may be developed for NTWCs that don't have the full suite of technical capabilities. The Manual should be approved by the overarching Authority and include version control information that summarizes update to the Manual over time. Additional notes and guidance for each Chapter is available from ITIC.

COVER:

NATIONAL TSUNAMI WARNING CENTRE OPERATIONS MANUAL
Operated by*** Institute***
Approved by***title, name, date***
Revision No.

TABLE OF CONTENTS

Chapter 1. General information
a. Purpose of the document
b. Role/Mission of NTWC
c. Products of NTWC
d. Assignment of responsibilities and duty schedule of the staff
e. Annual Progress Report and Tsunami/Earthquake Summary report
f. SOP revisions and distribution procedures

Chapter 2. Operation and Maintenance of Seismic and Sea Level Observation Network
a. Specification of seismic stations and inventory database
b. Data transmission/communication procedure/routes
c. Station and Network Management
d. Data exchange system with other NTWC and International Seismic networks
e. Daily, weekly, monthly check list and reports
f. Trouble shooting

Chapter 3. Event Alarm operations procedures and criteria for a local tsunamigenic earthquake
a. General Information of the system
b. Warning/Information that will be provided by NTWC
c. Basic instructions for determining level of threat and issuing tsunami warning

   i. *General*
   ii. *Seismic data analysis*
   iii. *Sea level data analysis*
   iv. *Tsunami threat assessment – arrival time and wave impact forecasting*
   v. *Decision making – tsunami warning*
   vi. *Continued Monitoring and issuance of follow-up information*
   vii. *Tsunami warning cancellation*
d. Updating or upgrading of tsunami warning
e. Multiple earthquakes in a same time-window or multiple areas of service responsibility

Chapter 4. Event Alarm operations procedures and criteria for a tele-tsunamigenic earthquake
(topics same as for local tsunamigenic earthquake)

Chapter 5. Dissemination/communication of Warning and Information
a. Message products
b. Dissemination methods
c. Communication Tests

Chapter 6. NTWC Routine Operations, Training, and Centre Maintenance Guide
a. Exercise/drill/training of staff
b. Final event list determined by the NTWC
c. Tuning of the processing and evaluation parameters

Appendix 1 Seismological Network and Data Processing System – Instruments, Data Collection, Analysis Tools

Appendix 2 Earthquake Magnitude Estimation

Appendix 3 Sea Level Network and Data Processing System – Instruments, Data Collection, Analysis Tools

Appendix 4 Tsunami Historical Database, Tsunami Travel Time and Wave Amplitude Forecasting Techniques

Appendix 5 Establishment of Operation Centres - Staffing, Infrastructure, Equipment, Information Technology Requirements

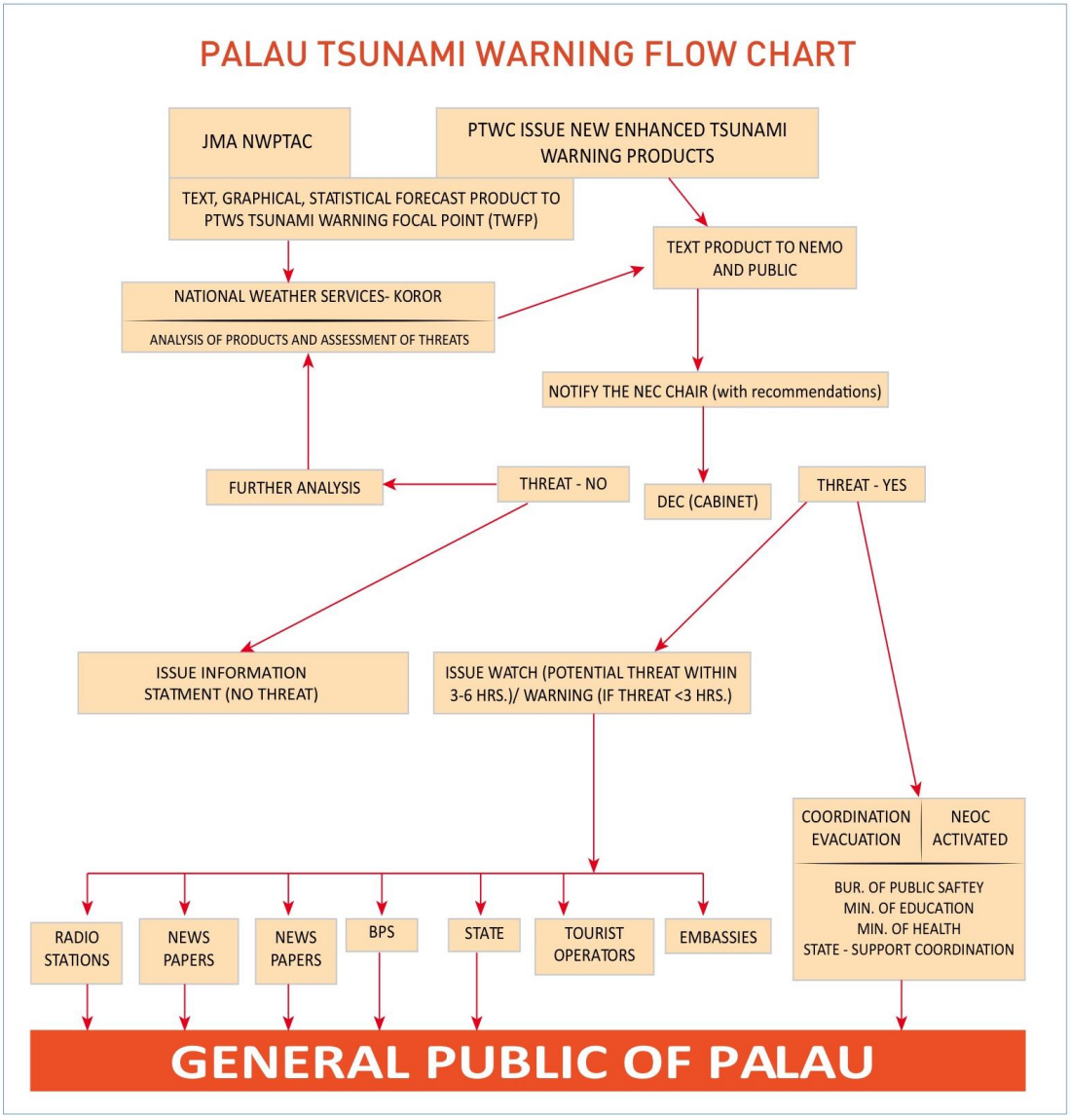
A.2 SUPPORT TOOLS FOR NTWC SOPs: EXAMPLES

A.2.1 FLOW CHARTS

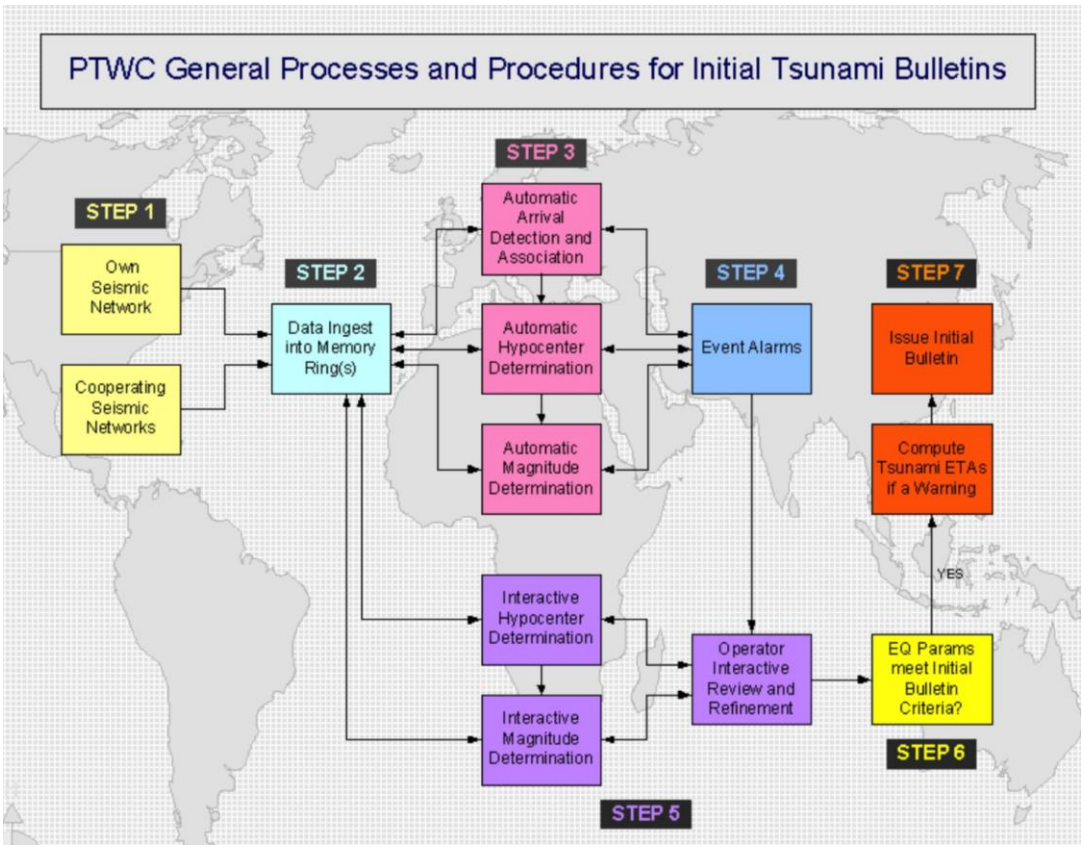
High-level communication flow chart showing the primary agencies or stakeholders involved in the warning chain from the international tsunami advisory centres to national and local warning and emergency response authorities and to the public.

Example of Republic of Palau Tsunami Warning Information Flow Chart (National Tsunami Support Plan 2015).

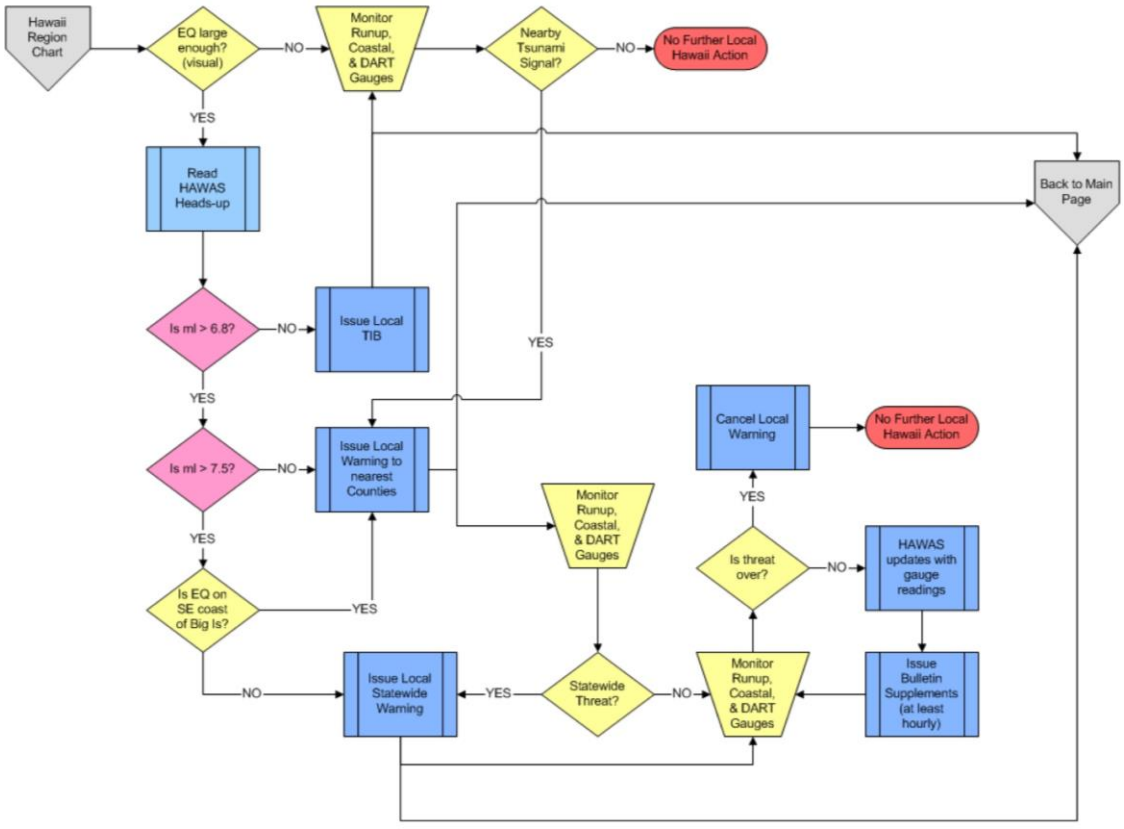
Flow charts can also graphically depict the decision-making tree to assess the tsunami threat and assign the appropriate alert level based on the pre-determined criteria.



Example of PTWC flow chart (2011) of procedures leading to issuance of its initial bulletin



Example of PTWC flow chart (2011) of procedures for a Hawaii Region event



A.2.2 CRITERIA TABLES

Example of Republic of Palau Tsunami Warning Arrangements and Criteria Table (2015)

Under the Intergovernmental Oceanographic Commission (IOC) Pacific Tsunami Warning and Mitigation System (PTWS), the Pacific Tsunami Warning Centre (PTWC) in Hawaii as well as the Japan Meteorological Agency (JMA) provide tsunami warning products to all Pacific countries and the national agencies will analyze and decide whether to issue or not to issue warnings. NWS Palau is an example of the formally designated authority to receive the PTWC tsunami warning products because of its 24/7 capability. The NWS Palau will determine the level of threat of a potential tsunami to the Republic of Palau from the products that will be provided by PTWC based on the following criteria:

PTWC Product Type	PTWC EQ Magnitude	Country's Alert Level	Estimated Time of Wave Arrival (ETA) at Country's Coast	Emergency Response Action
THREAT MESSAGE	H > 1 m	WARNING	ETA < 3 hrs. (*)	EVACUATE TSUNAMI EVACTUATION ZONES
THREAT MESSAGE	H > 1 m	WATCH	3 (*) < ETA < 6 hrs.	Prepare to evacuate
INFORMATION STATEMENT	H > 1 m	INFORMATION	ETA > 6 hrs.	Monitor event alert EM stakeholders
INFORMATION STATEMENT	H < 1 m			NO ACTION
MESSAGE	H > 1 m at distant coastline	To be determined from a disaster tsunami threat: PTWC message number 1	ETA > 3 hrs. (*)	Monitor event, alert EM stakeholders

See Annex B.5.2 for another example of a Criteria Table, which includes a second lower level of warning that calls for evacuating the beaches and harbours only.

A.2.3 TIMELINES

Sample SOP step-by-step templates for minimum and advanced NTWCs for Distant (far-field) and Local (near-field) tsunamis. The templates incorporate target time-lines for execution of the various stages of the NTWC's response procedures. The timeline-driven SOP event response templates were developed from the Course Manual for the "Strengthening Tsunami Warning and Emergency Responses" Project. (2008–2010), and updated to reflect real-time forecasting.

Example of NTWC SOP Timeline Template for a Local/Regional Earthquake and Tsunami. Minimum NTWC (TSP-dependent, in blue and black). Advanced NTWC (TSP-independent, Seismic Processing and Tsunami Forecasting, in red and black)

STEP	TIME since EQ*	ACTIVITY	ACTION AND PROCEDURES
1	1 min	Seismic Alarm Trigger	• Alarm sounds from automated seismic processing system • Feel earthquake and respond, receive phone call or other • For a strongly felt earthquake (greater than Modified Mercalli Intensity Scale VI), alert should be issued immediately to the public and EMA EOC advising to clear the beach
2	2 min	Earthquake Monitoring and Analysis	• Monitor RTED/CISN and other information tools • Receive Information provided by TSP/other Centres • Review/update automatic phase picks and solution. Perform Interactive analysis if required. Highest priority for review is earthquake magnitude and focal depth

3	3 min	Tsunami Threat Assessment	• Obtain ETA by look up in TSP Message
			• Obtain threat by look up in TSP Message
			• Calculate tsunami travel times/ETA to nearest coasts or refer to pre-calculated reverse tsunami travel time map ('bullseye' with country as centre
			• Estimate Threat by
			  ○ Tsunami Scenario Database look up
			  ○ Earthquake location, depth, magnitude as proxy for tsunami threat height and area

4	5 min	Issuance of warning and related information	• Use Country Criteria Table to decide on Alert Level. If warning thresholds (for earthquake magnitude or expected tsunami amplitude) are exceeded, issue warning to tsunami-threatened areas immediately. For warning, issue ETAs at forecast points.

5	7 min	Re-analysis, Tsunami monitoring	• Monitor for updates to earthquake parameters by TSP/other Centres
			• Obtain tsunami observations by loop up in TSP Message
			• Monitor sea level stations near the epicentre
			• Re-evaluation of focal parameters obtained using additional data.
			• Estimate Threat by
			  ○ Tsunami Scenario Database look up
			  ○ Real-time Tsunami Forecast modeling
			  ○ Earthquake location, depth, magnitude as proxy for tsunami threat height and area.

6	10 min	Re-assessment and issuance of new information	• Upgrade warning if observed tsunami higher than expected at Step 3 • Issue tsunami arrival and height observations (Downgrade or Cancel if tsunami is smaller or no tsunami is observed.)
7	10 min to hours	Information	• If tsunami is generated, tsunami information regularly issued until no tsunami threat exists. Neighboring and TSP information should be considered in evaluation.
8	Hours	Cancellation	• If tsunami threat no longer exists, tsunami warning cancellation is issued.
9	Days to weeks	Tsunami science survey	• Survey of tsunami run-up, inundation, and eyewitness observation along coastal area. • Survey of tsunami disaster on people, structures, geology, and social impact and early warning response
10	Week to months	Summary report	• Analysis of the warning centre and emergency response operational procedures • Revision and update of SOP as required

** times elapsed since earthquake are approximate and under ideal circumstances*

Example of NTWC SOP Timeline Template for a Distant Earthquake and Tsunami. Minimum NTWC (TSP-dependent, in blue and black). Advanced NTWC (TSP-independent, Seismic Processing and Tsunami Forecasting, in red and black)

STEP	TIME since EQ*	ACTIVITY	ACTION AND PROCEDURES
1	3 min	Seismic Alarm Trigger	• Alarm sound from an automatic seismic processing system • Monitor RTED/CISN and other information tools • Receive Information provided by TSP/other Centres
2	10 min	Earthquake Monitoring and Analysis, Tsunami monitoring	• Obtain ETA by look up in TSP Message • Review/update automatic phase picks and solution. Perform Interactive analysis if required. Highest priority for review is earthquake magnitude and focal depth • Calculate tsunami travel times/ETA to nearest international sea level stations and country • If ETA to country is within the predefined time, go to step 3. • Monitor sea level stations near the epicentre • If there is enough time, NTWC shall issue Information that event is under assessment for tsunami threat to the country. (If no tsunami is observed in the near source region, Information is issued that there is no tsunami threat.)

3	13 min	Tsunami Threat Assessment	• Obtain threat by look up in TSP Message
			• Estimate Threat by
			  ○ Tsunami Scenario Database look up
			  ○ Real-time Tsunami Forecast modeling
			  ○ Earthquake location, depth, magnitude as proxy for tsunami threat height and area.

4	15 min to hours	Issuance of warning and related information	• Use Country Criteria Table to decide on Alert Level. If warning thresholds (for earthquake magnitude or expected tsunami amplitude) are exceeded, issue warning to tsunami-threatened areas immediately. For warning, issue ETAs at forecast points. • If very distant, advise and wait until threat closer for warning.

5	20 min to hours	Re-analysis, Tsunami monitoring	• Monitor for updates to earthquake parameters by TSP/other Centres
			• Obtain tsunami observations by look up in TSP Message
			• Monitor sea level stations across the ocean
			• Re-evaluation of focal parameters using additional data, calculate CMT
			• Re-estimate Threat by
			  ○ Tsunami Scenario Database look up
			  ○ Real-time Tsunami Forecast modeling

6	30 min to hours	Re-assessment and issuance of new information	• Upgrade warning if observed tsunami higher than expected at Step 3 • Issue tsunami arrival and height observations (Downgrade or Cancel if tsunami is smaller or no tsunami is observed.)
7	30 min to hours	Information	• If tsunami is generated, tsunami information regularly issued until no tsunami threat exists. Neighboring and TSP information should be considered in evaluation.
8	Hours-days	Cancellation	• If tsunami threat no longer exists, tsunami warning cancellation is issued.
9	Days to weeks	Tsunami science survey	• Survey of tsunami run-up, inundation, and eyewitness observation along coastal area. • Survey of tsunami disaster on people, structures, geology, and social impact and early warning response
10	Week to months	Summary report	• Analysis of the warning centre and emergency response operational procedures • Revision and update of SOP as required

** times elapsed since earthquake are approximate and under ideal circumstances*

A.2.4 CHECKLISTS

Quick-reference checklist SOPs, sometimes referred to as 'cheat sheets', assist NTWC Duty Staff in efficiently carrying out the steps required to issue bulletins. Checklists are especially useful to ensure that steps are not forgotten during the fast response required for tsunami warning.

The initial bulletin will be based primarily on seismic information since it gives the quickest estimate of tsunamigenic potential. Supplemental messages are issued after more data are received, such as when the earthquake hypocentre and/or magnitude is updated, tsunami wave amplitude forecasts are available or are updated, and when tsunami observations can be reported. When there is a warning, the final message issued by the NTWC will be a Tsunami Warning Cancellation.

Further example templates for the issue of tsunami notifications including "Warning" and "Cancellation" are included in the New Zealand Tsunami Advisory and Warning Plan (see Annex C).

Example of NTWC simplified checklist for the issuing a tsunami messages

NTWC Checklist for Initial Message (simplified)

- Locate epicentre. Examine location map ☐
- Review automated solution. Re-pick phases if needed and relocate to finalize ☐
- Determine depth ☐
- Determine magnitude (Mwp) ☐
- Issue Earthquake Information Message (has no tsunami information) ☐
- Compare solutions from other NTWCs (CISN, USGS, other countries) ☐
- Select Message Type using Criteria Table ☐
- Call in other watch-standers to help (if a Warning) ☐
- Compute ETAs and TTT map (TTT) ☐
- Run Message Software to create message ☐

Before sending messages, check:

- Message Number (should be 1) ☐
  - Message Type (Warning, Advisory, Watch, Information, etc.) ☐
  - Which locations placed in Warning/Advisory status ☐
  - Customized information for unusual or unique situations, if needed ☐
  - Earthquake parameters (hypocentre, magnitude, geographic name location) ☐
  - Estimated Tsunami Arrival Times (ETAs) ☐
- Send Message ☐
- Read Message on telephone hotline (voice alert) ☐

Check that all messages transmitted and resend if necessary:

- GTS ☐
- SMS / RSS ☐
- Fax ☐
- Web site ☐
- Email ☐
- EMWIN ☐

- Call persons on Telephone Call Down List ☐

Continuing activities

Call closest affected provinces / communities:

- Confirm message received ☐
- Ask if they have any eyewitness reports ☐

- Display marigrams and monitor nearest sea-level gauges for tsunamis ☐
  (Tide Tool, IOC SL Monitoring Site, other national sources) ☐
- Measure tsunami wave amplitudes and arrival time on sea-level gauges ☐
  (Tide Tool, other national sources) ☐
- Run Tsunami Forecast Model software or look up in Tsunami Scenario Database ☐
- Review historical information ☐
- Check for Tsunami or Slow Earthquake (Mw vs Ms, Theta) ☐
- Monitor for updated EQ parameters and CMTs, or compute CMTs (email, other) ☐
- Appoint and deploy a tsunami advisor to the EMA ☐

A.2.5 MESSAGE TEMPLATES

NTWC Text Messages should include basic important information on the tsunami threat so that customers know who is the source, what information is being given, what action should be taken, and when. Messages should include a standard set of information, and follow a standard format. Message templates should be used to enable immediate and efficient creation.

The following are examples of Information, Warning, and Cancellation Message Templates. Countries may choose to issue shorter messages contain only the most important information. If delegated the responsibility, some NTWC Tsunami Warning messages may instruct include evacuation instructions.

Example of NTWC Information Message (no tsunami threat)

Date and Time of Message Issuance
Header

< *insert country message header* >

TSUNAMI INFORMATION STATEMENT

EVALUATION

An earthquake has occurred…but there is no tsunami threat from this earthquake to < *insert country* > based on available data at this time.

PRELIMINARY EARTHQUAKE PARAMETERS

An earthquake has occurred with the following preliminary parameters reported by the Pacific Tsunami Warning Center *[or National or other Tsunami Service Provider]*

Origin Time (in local time)
Coordinates –
Depth –
Location –
Magnitude –

RECOMMENDED ACTIONS

No action is required.

NEXT UPDATE AND ADDITIONAL INFORMATION

- This will be the only statement issued for this event.
- Authoritative information about this event can be found at XXX <web site>

Example of NTWC Tsunami Warning Message (tsunami threat, dangerous waves)

Date and Time of Message Issuance
Header

< *insert country message header* >

TSUNAMI THREAT MESSAGE

A TSUNAMI WARNING IS IN EFFECT FOR xxxxxx < *insert country name and section of country if appropriate* >

Repeat

A TSUNAMI WARNING IS IN EFFECT FOR xxxxxx < *insert country name and section of country if appropriate* >

PRELIMINARY EARTHQUAKE PARAMETERS

An earthquake has occurred with the following preliminary parameters reported by the Pacific Tsunami Warning Center. *[or National or other TSP]*

Origin Time (in local time)
Coordinates –
Depth –
Location –
Magnitude –

EVALUATION

A major earthquake has generated a tsunami that could be destructive to coasts in <country>. The earliest estimated time that the first impacts may occur is <earliest ETA for your country, converted to local time>. Authorities should take appropriate action to save lives and reduce property damage for this threat.

TSUNAMI THREAT FORECAST

< copy PTWC [or National or other TSP] sections applicable to a country's coastal tsunami amplitude wave forecasts in meters above the tide level. >

ESTIMATED TIMES OF ARRIVAL

Estimated times of arrival (ETA) of the initial tsunami wave for points within threatened regions are given below. Actual arrival times may differ and the initial wave may not be the largest.

Location Region Coordinates ETA (local time)
< copy PTWC [or National or other TSP] wave arrival time sections applicable to a country's coastline. Convert UTC time to local time. >

RECOMMENDED ACTIONS

- This message is intended to trigger appropriate actions by <agencies responsible for carrying out evacuations, etc.> in accordance with their tsunami warning standard operating procedures.
- Persons located in or near threatened coasts should stay alert for instructions from national and local authorities.

POTENTIAL IMPACTS

- A tsunami is a series of waves and the time between wave crests can vary between five minutes to one hour. The hazard may persist for many hours after initial wave arrival.
- The first wave may not be the largest.
- A coastal tsunami of only 1-meter amplitude above tide level can cause strong currents in a harbor, be dangerous to swimmers in the water and be hazardous to persons along inland waterways.
- Flooding impacts can vary significantly from one section of coast to the next due to local bathymetry and the shape and elevation of the shoreline.

TSUNAMI OBSERVATIONS *<if waves have been measured>*
The following are tsunami wave observations from coastal and/or deep-ocean sea level gauges at the indicated locations. The maximum tsunami amplitude is measured with respect to normal tide level.

Gauge Location Coordinates Time of Measure Max Tsunami Ampl Wave Period
< copy PTWC [or National or other TSP] tsunami observation section. >

NEXT UPDATE AND ADDITIONAL INFORMATION

- The next message will be issued hourly or sooner if the situation warrants.
- The Tsunami Warning will remain in effect until further notice.
- Authoritative information about this event can be found at XXX <web site>

Example of NTWC Tsunami Warning Cancellation Message (dangerous waves have ceased)

Date and Time of Message Issuance
Header

< *insert country message header* >

TSUNAMI WARNING CANCELLATION MESSAGE

THE TSUNAMI WARNING IS CANCELLED FOR xxxxxx < *insert country name and section of country if appropriate* >

Repeat

THE TSUNAMI WARNING IS CANCELLED FOR xxxxxx < *insert country name and section of country if appropriate* >

PRELIMINARY EARTHQUAKE PARAMETERS

An earthquake has occurred with the following preliminary parameters reported by the Pacific Tsunami Warning Center. *[or National or other Tsunami Service Provider]*

Origin Time (in local time)
Coordinates –
Depth –
Location –
Magnitude –

EVALUATION

[after destructive tsunami waves]

Based on all available data, the destructive tsunami waves from this earthquake have now passed and there is no further threat. However, some coasts may still experience small sea level fluctuations lasting for several more hours.

[or, if cancelled before wave arrival]

Based on the analysis of additional data it has now been determined that there is no tsunami threat to <country> and a warning is no longer warranted. However, some coasts may still experience small sea level changes beginning around <earliest ETA> and continuing for several hours.

[or, if cancelled because the waves arrived and were too small]

Based on measurements of the tsunami waves now impacting the coasts of <country> a tsunami warning is no longer warranted. However, some coasts may continue to experience small sea level changes for several more hours.

RECOMMENDED ACTIONS

- This message is issued as guidance to government agencies responsible for public safety alerts.
- Persons located in threatened coasts should stay alert for instructions from national and local authorities.

POTENTIAL IMPACTS

- A tsunami is a series of waves and the time between wave crests can vary between five minutes to one hour. The hazard may persist for many hours after initial wave arrival.
- The first wave may not be the largest.
- A coastal tsunami of only 1-meter amplitude above tide level can cause strong currents in a harbor, be dangerous to swimmers in the water and be hazardous to persons along inland waterways.
- Flooding impacts can vary significantly from one section of coast to the next due to local bathymetry and the shape and elevation of the shoreline.

TSUNAMI OBSERVATIONS

The following are tsunami wave observations from coastal and/or deep-ocean sea level gauges at the indicated locations. The maximum tsunami amplitude is measured with respect to normal tide level.

Gauge Location Coordinates Time of Measure Max Tsunami Ampl Wave Period
< copy PTWC [or National or other TSP] tsunami observation section. >

NEXT UPDATE AND ADDITIONAL INFORMATION

- This will be the final NTWC message.
- Authoritative information about this event can be found at XXX <web site>

Annex B GUIDELINES FOR EMA TSUNAMI EMERGENCY RESPONSE PLANS AND SOPs

B.1 Tsunami Emergency Response Plans: Format and Design

A response plan is effective when emergency managers understand it, are comfortable with it, and are able to locate the information they need from it. The following must be considered when designing a response plan:

- Structure: The document must be structured so that it is easy to reference. Single subdivisions will support this, while it also enables revisions of particular sections without the requirement to rewrite the entire plan.
- Progression: The subdivisions and content should follow a logical sequence, yet avoiding unnecessary duplication. If a topic does not fit into the sequence, it may fit better in a separate plan.
- Consistency: Terms and concepts must be used consistently throughout the whole plan, and are best supported by a glossary or explanation at the front or end of the plan.
- Adaptability: Plans are developed based on the anticipated cause of an event, supported by experience of previous responses. However no future response can be anticipated with 100% certainty. Emergency managers must therefore be ready to adapt the framework they provide, as appropriate.
- Compatibility: The plan must recognise and align with other plans (including those of other agencies) to support coordination. Those other plans must be referenced.

B.2 Guidance on TER Plans for Public Awareness

The guidance below provides a general overview on activities that can be undertaken towards public awareness of the tsunami hazard, and how to respond in tsunami events. There is no one best method or practice, and, besides some very basic key information that can be conveyed in many different ways, there is no single best awareness publication or education text book.

The following are important considerations in developing an awareness plan:

- Local or traditional knowledge: This can be a powerful tool to support scientific knowledge in community preparedness. Although it may be the most effective means in a more traditional or remote community, in general, local traditional knowledge alone will not be enough to ensure an effective response. Additional information on warning systems, evacuation arrangements and return is required.
- Community needs: To be effective, awareness activities and material should be tailored to the country or area-specific community needs. Factors such as the frequency of tsunamis, geography, demographics, language, cultural, religious and social orientations should influence the awareness approach. They will present both strengths and opportunities.
- A multi-faceted approach: The awareness programme should target a variety of formal and informal education, awareness-building and preparedness activities, or programmes. Approaches and material should anticipate and answer the obvious questions of the target audience simply and clearly.
- Coordination and collaboration: Working together and coordination between the different agencies involved is essential. Involvement and commitment by all stakeholders will support sustainability.
- Public policy: A formal tsunami education and awareness programme that is able to sustain itself over generations can be highly effective, and may be the only feasible (funded) mitigation for localities where the occurrence of tsunamis is infrequent.

Awareness and education materials generally include the basic topics of:

- Basic information about the tsunami hazards, with specific reference to the specific country or area. This is best supported by information on historical tsunami events and

their impacts, including local and/or traditional knowledge of past events.
- The country's tsunami warning system – where will warnings come from, how and when will they be communicated and what information will they contain (and not contain)
- Tsunami evacuation arrangements – what the evacuation zones and routes are, how the instruction to evacuate will be issued, what to take with, where the safe areas are, and where to listen or look for the all-clear
- Understanding natural warning signs and how to respond to them (self-evacuations)
- Tsunami safety rules (for people on land, in the water and in small boats).

B.2.1 Education formats and methods

Awareness education formats and channels must be appropriate to the assessed levels of risk to the communities and to the capacities of those communities at risk. In high-risk areas, short-term campaigns that are repeated regularly may be appropriate. These may include posters and leaflets, as well as publications in conventional media – newspapers, magazines and the Internet. Where the tsunami hazard is less prevalent, long-term awareness of tsunami, along with other natural hazards, is best achieved by inclusion as part of the formal educational school curricula and capitalizing on the actuality of the topic when tsunami events occur elsewhere.

Formats for awareness education materials include books and booklets; advertising, public maps and sign boards, leaflets; flyers; newsletters; comics; toys and games; video, CDRom/DVD; posters; stickers.

Methods of awareness education include face-to-face teaching; train- the-trainers; community events and "Awareness Days"; memorials, special meetings; drills and exercises; focus events for special needs communities; specific interest group activities.

Mobile and electronic technologies have become a commonplace medium for quickly and widely sharing information. Social media networks, such as Facebook and Twitter, and video sharing through YouTube, are popular and accepted around the world. As such, governments and practitioners need to develop ways to communicate through these mechanisms. In these cases, vital safety information should be short, concise, actionable, and visually interesting.

B.2.2 Additional resources:

Tsunami Preparedness Materials: http://itic.ioc-unesco.org

B.3 Guidance on TER Plans for Public Notifications

Plans for public notifications should contain three parts:

- Receipt of warnings (from the NTWC and others), threat assessment and decision making
- Public alerting responsibilities (NTWC or EMA, subject to national protocols)
- Public alerting arrangements
- Media arrangements

B.3.1 Receipt of warnings

The notification plan must first establish the arrangements for the receipt of warnings form the NTWC and others, the assessment process and criteria to assist decision-making. Considerations are:

- How are the NTWC notifications received by the EMA (process and systems)?
- What is assessment and decision making process?
- Who will decide what action to take?
- Who will execute the action?
- Which stakeholders will have an interest and must be informed?

B.3.2 Public alerting

All public notification plans should incorporate some kind of alert system. When planning for the public alerting system, considerations are:

- How will the alerting system be activated?
- What communication channels will be used to alert agencies and the public respectively?

- Who are responsible for the respective communication channels and how will the EMA communicate with them?
- How will people with disabilities and with special needs be notified?
- Are specific considerations for tourists required?
- What message content will be used?
- Are different messages required for different scenarios?

Alerts should be audible and recognisable (e.g. a system of amplifiers, loudspeakers, radios, and microphones, church or school bells, foghorns, PA speakers, etc.), and as far a possible include instructions on what do. Bespoke alert systems should be supplemented by conventional communication means, in particular websites and social media.

B.3.3 Media

The public notification plan must also state the arrangements of the NTWC and/or EMA with the media to support the communication of warnings and instructions with the public. The media plan may be a separate (individual) plan, but must align closely with the public notification plan. The following elements should be covered:

- Establishment of a formal partnership and understanding with key news media and NTWC as part of preparedness activities
- Arrangements to support the media understanding the science, the warning process, and the roles of various agencies and organizations in the tsunami warning process
- Arrangements to communicate warnings with the news media, and to keep them informed during a warning situation
- Templates for communication with the media, including public advice and core messages
- Protocols for the broadcasting of official warnings by the news media
- Points of contact at the various news media
- Arrangements to keep the media aware of their responsibilities
- Identification and preparation of official spokespersons and others with specific expertise, e.g. scientists.

Public advice – Marine Threat

- A tsunami advisory/warning is in effect
- Information about location of the earthquake
- There is a threat to beach, immediate foreshore areas, harbour, estuary and small boat activities
- There is unlikely to be wide-scale inundation of low-lying coastal areas
- Stay out of the water (sea, rivers and estuaries)
- Stay off beaches and shore areas
- Do not go sightseeing
- Depending on wave arrival time, boat owners tied up in harbours or shoreline must pre-determine if they have sufficient time to deploy their vessel to safer deep water. If there is little time, secure your boat and/or move away from the coastline.
- Vessels already at sea should stay in deep water and remain there until further advised
- Share this information with family, neighbours and friends
- Listen to the radio and/or TV for updates
- Follow instructions of local emergency management authorities

Public advice – Marine and Land Threat (evacuations)

- A tsunami warning is in effect
- Information about location of the earthquake
- The Emergency Management Agency has ordered/advises the evacuation of low-lying parts of coastal towns and villages depicted in tsunami evacuation maps and/or in the following coastal zones: [insert list]
- This evacuation order is issued under [insert relevant national legislation]
- Take only small, essential items that you can carry including important papers, family photographs, and medical needs
- If there are no tsunami evacuation zones established, general guidance is to go to higher ground at least ten metres above sea level, or, if possible, move at least 1 km away from beaches, harbours and estuaries
- It will be in your own interests to walk to safety if possible, to avoid traffic jams
- If you cannot leave the area, take shelter in highest floor or roof of a multi-story structural steel or reinforced concrete multi-storey building
- Depending on wave arrival time, boat owners tied up in harbours or shoreline must pre-determine if they have sufficient time to deploy their vessel to safer deep water. If there is little time, secure your boat and/or move away from the coastline

Box B.3-4 Example for advice to the general public on how to respond in the event of an advisory or warning

B.4 Guidance on TER Plans for Evacuations

Evacuation planning is a fundamental component of emergency planning for tsunami. It requires two core foundation blocks:

- Identification of inundation areas: The areas affected by inundation should be identified and used to map evacuation zones that cover all areas up to the maximum expected inundation limit. Where appropriate, different zones can be established for distant and local source tsunamis. It is important to note that wave activity in areas such as harbours or narrow bays may be amplified by harbour resonance. Critical Infrastructure and/or facilities that may produce hazardous effects, affected by tsunamis should also be included in maps.
- Understanding the time required to evacuate the evacuation zones: The amount of time required to execute an evacuation should be analysed, and must then form the basis for planning evacuation routes, identification of appropriate safe places, and determining the resources required to support the evacuations.

B.4.1 Defining evacuation zones

A key consideration for tsunami emergency response planning is the number of evacuation zones used for evacuation management, and the ways in which hazard information is communicated to the public. Use of a single tsunami evacuation zone has the advantage of simplicity for planning and public awareness and understanding. However, because a single evacuation zone must accommodate the very wide range of risk scenarios that may exist, this can result in regular 'over-evacuation' of the entire zone for more regular small scale events.

Recurring over-evacuation is likely to result in decreasing levels of community trust in emergency response arrangements. Use of more than three or four evacuation zones may more accurately reflect the range of local tsunami risk scenarios. However, such differentiation requires far greater resources and a higher degree of coordination for planning and response, and the complexity of information may cause confusion. Therefore the use of at least two and a maximum of three evacuation zones appears to be the best approach.

Where more than one zone is used, people should evacuate all the zones in "natural" warnings. In official warnings, people are expected to evacuate the zone(s) stated in the warning message.

Evacuation zone boundaries can be determined using a variety of hazard models. Zones ideally need to represent an envelope around all possible inundations from all known tsunami sources, taking into account all of the ways each of those sources may generate a tsunami. The high degree of uncertainty in tsunami source models, and the time consuming and resource intensive nature of modelling make this comprehensive approach to tsunami risk assessment challenging and often impractical. The recommended approach to developing tsunami evacuation zones is therefore to 'map now' using the best available knowledge, and progressively refine the accuracy of boundaries as the science improves over time.

B.4.2 Evacuation maps

Maps of evacuation zones and routes are critical for communicating tsunami risk and emergency response information to the public, and for providing a common platform for integrated evacuation planning. As a general rule, communities should be engaged early and often in the development of evacuation maps, with opportunities provided for the community to lead local evacuation plans.

In addition to the number and appearance of evacuation zones on maps, the basic legend, instruction messages and supporting information on maps should be nationally consistent. To ensure common understanding across a country, maps should use the same or closely similar colours, the same names for evacuation zones, and common symbols. A balance is required between oversimplification and excessive detail.

B.4.3 Signage

Signage is an integral part of practical tsunami risk management. Signage depicting evacuation zones and routes raises public awareness of local tsunami risk and provides information to increase the efficiency and effectiveness of an evacuation. Well placed evacuation signage is the critical link between the evacuation plan and an actual event.

B.4.4 Evacuation routes

Evacuation should be on foot (or bicycle) wherever possible. Realistically, however, the public will instinctively drive vehicles during evacuations. Planners should consider this when identifying optimum evacuation routes. Narrow and heavily used routes in densely populated areas should be avoided to prevent bottlenecks in traffic.

Vertical evacuation (e.g. evacuation upstairs in/on buildings or structures) options also need to be considered, and where planned for should be indicated on tsunami evacuation maps and supported with signage.

Special planning considerations must also be made to address the portion of the public sector that is willing, yet incapable of evacuating inundation zones.

Once areas have been evacuated, roadblocks, barricades, and/or a system of patrols should be set in place to keep the public from wandering into evacuation zones.

B.4.5 Self-evacuation

In “natural warnings” where there is no time for official warnings and evacuation instructions, the communities within evacuation zones must evacuate instantly. Emergency managers should therefore promote public awareness in at-risk areas, prepare communities to recognize natural tsunami warning signs, and to self-evacuate, without any official warning.

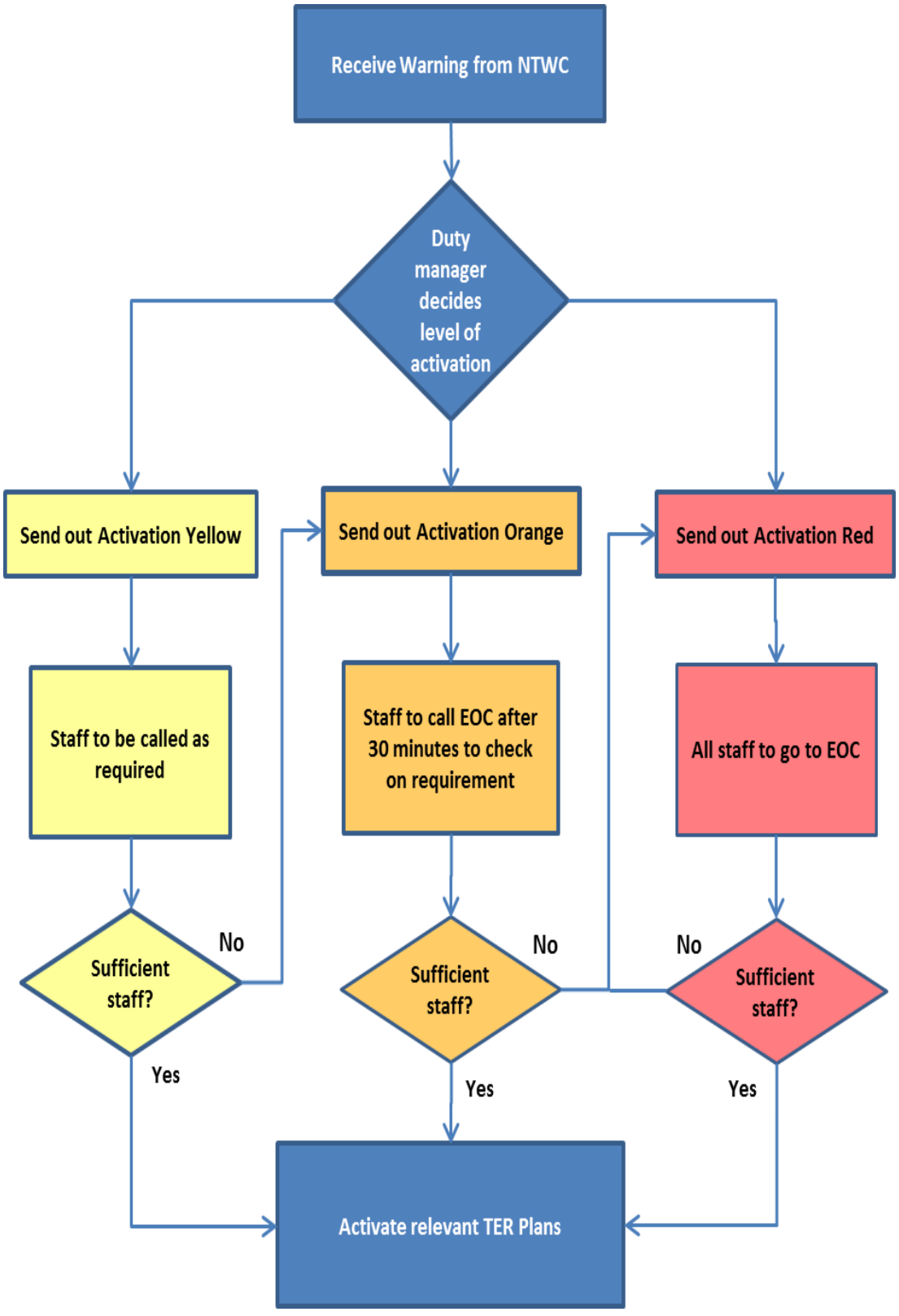
B.4.6 All Clear

The NTWC will inform the EMA when the tsunami threat is over, and the decision to allow re-entry after evacuations must be made by the appropriate local emergency management officials. As far as practicable, residents should re-enter through control points to ensure that account can be taken for evacuees and so that safety information can be conveyed.

B.5 SUPPORT TOOLS FOR TER SOPs: EXAMPLES

B.5.1 FLOW CHARTS

Example of a flow chart for the activation of an EOC



B.5.2 CRITERIA TABLES

Example of a criteria table

TSP Message	Earthquake Parameters	Maximum Tsunami Wave Amplitude Indicated	Threatened Coast	Time left to Initial Wave Arrival	NTWC Alert Level for Threatened Coast	Emergency Response Action
Tsunami Threat	Magnitude 7.1 or greater, undersea or very near the sea, and < 100 km depth	**≥ 1 m**	Sections of coast with forecast amplitudes ≥ 1 m	**< 3 hrs**	WARNING	Evacuate xxx zones
				3 to 6 hrs	WATCH	Standby, Prepare to evacuate
				> 6 hrs	INFORMATION	Monitor for subsequent forecasts
		0.3 to 1 m	Sections of coast with forecast amplitudes 0.3 to 1 m	**< 3 hrs**	ADVISORY	Evacuate beaches and harbours
				3-6 hrs	WATCH	Standby, Prepare to evacuate
				> 6 hrs	INFORMATION	Monitor for subsequent forecasts
		< 0.3 m	None		INFORMATION	Monitor for subsequent forecasts

Notes: *The 3-hour time criteria is based on the amount of time required for a country to safely complete a coastal evacuation. The 3-hr threshold that was used by PTWC through 2014 for the Pacific is considered a conservative, but reasonable time criteria. Historically, the value is from a requirement from USA Hawaii State Emergency Management Agency as the time required to safely evacuate all coasts of the State of Hawaii. Each country should consider their situation.*

Compared to A.2.2, this adds another NTWC alert level; the Advisory corresponds to a lower level of Warning, and calls for evacuating the beaches and harbours only. Laboratory studies complementing empirical structural damage and casualty data collected from recent tsunamis show that tsunami inundation or flow depths of less than one meter, and as small as tens of centimeters, can be dangerous and destructive (e.g., Arikawa et al., 2006; Suppasri et al., 2013). The response would be for people to avoid beaches and low-lying coastal areas, and for vessels in harbors and waterways to take precaution against unusually strong water currents. This lower level of warning (Advisory) is used in the United States. In an Advisory status, a full scale land evacuation is not necessary.

Finally, note that some of the above information may not be available in the first message received from a TSP or NTWC, but only in subsequent messages. For local source events, decisions will likely have to be based on the earthquake information alone, and if available, quick look-up in database of pre-computed scenarios.

B.5.3 TIMELINES

Example of a Timeline for EMA tsunami response (distant source event, simplified)

EMA TIMELINE: DISTANT SOURCE TSUNAMI WARNING			
STEP	TIME since EQ*	ACTIVITY	ACTION AND PROCEDURES
1	15-30 min	Receive 1st Warning from NTWC	Consult with NTWC Assess threat Decide response
2	35 min	Public alerting	Prepare applicable alert/message Sign-off Send alert
3	35-50 min	Evacuation	(If applicable): Activate Evacuation Plan
4	35-50 min	Public Info Mgmt	Activate Media arrangement Info on website Info on social media
5	35-50 min	Activate NEOC	Request agency representatives Connect with Local EMAs Prepare communication
6	50 min>	Manage evacuations	(If applicable): Provide shelter/welfare support On-going communication
7	60-80 min	2nd message from NTWC	Consult with NTWC Re-assess Communicate update
etc.	etc.	etc.	etc.

B.5.4 CHECKLISTS

Example of a Checklist (simplified)

EMA Checklist – Tsunami Warning	
	✓
Duty Team notified	□
NTWC consulted	□
Response decided	□
Alert sent	□
Evacuation Plan activated	□
Media arrangement activated	□
Website updated	□
Social media updated	□
NEOC activated	□
Local EMAs informed	□
etc.	

Annex C CASE STUDIES

This Annex provides synopses of published and unpublished examples of plans and SOPs. Full versions of the documents are available from ITIC. These and additional documents were used in the UNESCO-IOC SOP Strengthening Project Workshop Course Manual and have been used in subsequent SOP Strengthening Trainings by the ITIC and IOC.

C.1 National Tsunami Warning and Emergency Response Plan

New Zealand, MCDEM, 2009. Tsunami Advisory and Warning Plan, Supporting Plan [SP 01/09], revised October 2014. ISBN 978-0-478-43503-0

http://www.civildefence.govt.nz/This plan outlines the national arrangements for tsunami warning and response in New Zealand. It describes the arrangements to receive and assess tsunami information at the national level, and the dissemination of national official notifications via the National Warning System. Sections include responsibilities of stakeholders, thresholds and the process of notifications, and the types of notifications issued.

The plan does not address the detailed actions to be taken by the stakeholders. Instead it expects agency-specific SOPs to deal with that detail, while matters such as local public alerting systems, possible areas of inundation and evacuation arrangements must be incorporated into local plans.

The plan also does not address the response arrangements after a tsunami has struck. Generic response arrangements are detailed in the *National Civil Defence Emergency Management (CDEM) Plan (2015, http://www.civildefence.govt.nz/ (Accessed 4 July 2016))* that takes an all-hazards approach. The CDEM Plan sets out the arrangements, roles, and responsibilities of agencies for the national management, or support to local management, of emergencies, responding to and recovering from emergencies. This includes central and local government, lifeline utilities, emergency services and non-government organizations.

C.2 NTWC SOP

Example TSP and NTWC Operations manuals

The documents are examples of operations manuals used by NTWC and TSPs. The manuals include descriptions of the role and responsibilities, operations, and product and services of the centre. It includes 24x7 duty staffing arrangements, seismic and sea-level data detection and analysis, alert level assessment, warning decision-making criteria, message and graphics product creation, warning dissemination, and routine office duties. The documents contain examples of support tools such as decision-making flow charts, event processing checklists, criteria tables listing actions, timelines of activities, and pre-scripted or sample message templates.

TSP and NTWC operations manuals:

USA: National Oceanic and Atmospheric Administration (NOAA), Pacific Tsunami Warning Center (PTWC) Operation Manual, v1.3.5, 2011

India: Indian National Centre for Ocean Information Services (INCOIS), Indian Tsunami Early Warning Centre User Guide, 2014

C.3 TER SOPs

Distant-generated Tsunami, and Locally-generated Tsunami and Earthquake SOPs

Hawaii Emergency Management Agency (HI-EMA, formerly Hawaii State Civil Defense), 2016. Distant and Local Tsunami Emergency Response SOP Checklist Examples (2016).

These documents state the procedures for responding to a Distant Tsunami Advisory, Watch or Warning, and an Urgent Tsunami Warning, or Local Tsunami issued by the Pacific Tsunami Warning Center (PTWC) for the Hawaiian Islands. The document gives the checklist of procedures and action steps followed by HI-EMA Emergency Operating Center duty staff. HI-EMA is the State emergency agency for Hawaii, and serves a coordinating role to the Counties.

Oahu Department of Emergency Management (DEM), 2014, Tsunami Standard Operating Guidelines, 2014

This document states the guidelines for responding to a distant and local tsunami as followed by the Oahu DEM. DEM is the county emergency agency covering Oahu and the City and County of Honolulu, and is responsible for tsunami evacuation. Checklists cover the different bulletins issued by the PTWC, including Information, Advisory, Watch, Warning, and Cancellation.

Plans and Planning Template

Hawaii Emergency Management Agency (HI-EMA, formerly Hawaii State Civil Defense). Tsunami Planning Template (2008, rev 2016)

The document, based on Hawaii plans, assists in basic tsunami response planning for local communities. Response plans will be written specifically for the evacuation of populations living in coastal areas and inland waterways. The document focuses on a timeline from the receipt of a tsunami warning to the completion of the evacuation. Response plans should focus on saving and protecting the welfare of the general public, protecting critical infrastructure and key resources, and lessen the impacts to individuals, communities, and the environment.

California Local Plans and Planning Guidance

Local Planning Guidance on Tsunami Response, A Supplement to Emergency Planning Guidance for Local Governments (California Office of Emergency Services, now Emergency Management Agency, 2nd Edition, 2005). Appendix 3 (Tsunami Planning) covers considerations for a wide range of topics in the plan.

Tsunami Evacuation SOP (within Emergency Operations Plan)

City and County of Honolulu, Hawaii Emergency Operations Plan and Functional Annexes for specific hazards, threats, or incidents, 2008, 2014.

The Emergency Operations Plan comprehensively describes functions and responsibilities, and the functional annexes describe the operational procedures for responding to natural and man-made hazards. Tsunami is included in Warning and Notification (Annex C), Emergency Announcements (pre-scripted messages, Annex F), and Evacuation and Sheltering (Annex T). Checklists and the inter-agency Oahu Emergency Alert System Agreement between Oahu Civil Defense Agency, Oahu

Operational Area Communications Committee, State Civil Defense, Honolulu Forecast Office, National Weather Service, and the Pacific Tsunami Warning Center are also included. (1991).

Marin County, California, Sheriff Office of Emergency Services, Tsunami Annex (Draft), Marin Operational Area Emergency Operations Plan, 2015

ACRONYMS AND ABBREVIATIONS

CARIBE-EWS	Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions
CBDRM	Community-based Disaster Risk Management
CFZ	Coastal Forecast Zone
CMT	Centroid Moment Tensor
EMA	Emergency Management Agency
EOC	Emergency Operations Centre
ETA	Estimated Time of Arrival
GIS	Geographical Information System
GTS	Global Telecommunications System (of WMO)
ICAM	Integrated Coastal Area Management
ICG	Intergovernmental Coordination Group (for Tsunami Warning and Mitigation Systems)
IOC	Intergovernmental Oceanographic Commission (UNESCO)
IOTIC	Indian Ocean Tsunami Information Centre (formerly JTIC)
IOTWMS	Indian Ocean Tsunami Warning and Mitigation System
ITIC	International Tsunami Information Center
JCOMM	WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology
JMA	Japanese Meteorological Agency
JTIC	Jakarta Tsunami Information Centre (now IOTIC)
MCDEM	Ministry of Civil Defence & Emergency Management, New Zealand
NEAMTWS	North-Eastern Atlantic, Mediterranean and Connected Seas Tsunami Early Warning and Mitigation System
NOAA	National Oceanic and Atmospheric Administration (United States Government)
NOAA NWS	NOAA National Weather Service
NTWC	National Tsunami Warning Centre

NWPTAC	North-West Pacific Tsunami Advisory Centre (administered by JMA)
PPEW	Platform for the Promotion of Early Warning
PTWC	Pacific Tsunami Warning Center
PTWS	Pacific Tsunami Warning and Mitigation System
TIC	Tsunami Information Centre
TSP	Tsunami Service Provider
SOP	Standard Operating Procedure
TCC	Tsunami Coordination Committee
TER	Tsunami Emergency Response
TNC	Tsunami National Contact
TWC	Tsunami Warning Centre
TWFP	Tsunami Warning Focal Point
UNISDR	United Nations Office for Disaster Risk Reduction
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational Scientific and Cultural Organisation
US NTWC	US National Tsunami Warning Center (formerly West Coast / Alaska Tsunami Warning Centre
UTC	Coordinated Universal Time
WMO	World Meteorological Organisation

IOC Manuals and Guides

No.	Title
1 rev. 2	Guide to IGOSS Data Archives and Exchange (BATHY and TESAC). 1993. 27 pp. (English, French, Spanish, Russian)
2	International Catalogue of Ocean Data Station. 1976. *(Out of stock)*
3 rev. 3	Guide to Operational Procedures for the Collection and Exchange of JCOMM Oceanographic Data. Third Revised Edition, 1999. 38 pp. (English, French, Spanish, Russian)
4	Guide to Oceanographic and Marine Meteorological Instruments and Observing Practices. 1975. 54 pp. (English)
5 rev. 2	Guide for Establishing a National Oceanographic Data Centre. Second Revised Edition, 2008. 27 pp. (English) *(Electronic only)*
6 rev.	Wave Reporting Procedures for Tide Observers in the Tsunami Warning System. 1968. 30 pp. (English)
7	Guide to Operational Procedures for the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring. 1976. 50 pp. (French, Spanish)
8	*(Superseded by IOC Manuals and Guides No. 16)*
9 rev.	Manual on International Oceanographic Data Exchange. (Fifth Edition). 1991. 82 pp. (French, Spanish, Russian)
9 Annex I	*(Superseded by IOC Manuals and Guides No. 17)*
9 Annex II	Guide for Responsible National Oceanographic Data Centres. 1982. 29 pp. (English, French, Spanish, Russian)
10	*(Superseded by IOC Manuals and Guides No. 16)*
11	The Determination of Petroleum Hydrocarbons in Sediments. 1982. 38 pp. (French, Spanish, Russian)
12	Chemical Methods for Use in Marine Environment Monitoring. 1983. 53 pp. (English)
13	Manual for Monitoring Oil and Dissolved/Dispersed Petroleum Hydrocarbons in Marine Waters and on Beaches. 1984. 35 pp. (English, French, Spanish, Russian)
14	Manual on Sea-Level Measurements and Interpretation. (English, French, Spanish, Russian)
	Vol. I: Basic Procedure. 1985. 83 pp. (English)
	Vol. II: Emerging Technologies. 1994. 72 pp. (English)
	Vol. III: Reappraisals and Recommendations as of the year 2000. 2002. 55 pp. (English)
	Vol. IV: An Update to 2006. 2006. 78 pp. (English)
	Vol. V: Radar Gauges. 2016. 100 pp. and Supplement: Practical Experiences. 100 pp. (English, French,, Spanish)
15	Operational Procedures for Sampling the Sea-Surface Microlayer. 1985. 15 pp. (English)
16	Marine Environmental Data Information Referral Catalogue. Third Edition. 1993. 157 pp. (Composite English/French/Spanish/Russian)
17	GF3: A General Formatting System for Geo-referenced Data
	Vol. 1: Introductory Guide to the GF3 Formatting System. 1993. 35 pp. (English, French, Spanish, Russian)
	Vol. 2: Technical Description of the GF3 Format and Code Tables. 1987. 111 pp. (English, French, Spanish, Russian)
	Vol. 3: Standard Subsets of GF3. 1996. 67 pp. (English)
	Vol. 4: User Guide to the GF3-Proc Software. 1989. 23 pp. (English, French, Spanish, Russian)

No.	Title
	Vol. 5: Reference Manual for the GF3-Proc Software. 1992. 67 pp. (English, French, Spanish, Russian)
	Vol. 6: Quick Reference Sheets for GF3 and GF3-Proc. 1989. 22 pp. (English, French, Spanish, Russian)
18	User Guide for the Exchange of Measured Wave Data. 1987. 81 pp. (English, French, Spanish, Russian)
19	Guide to IGOSS Specialized Oceanographic Centres (SOCs). 1988. 17 pp. (English, French, Spanish, Russian)
20	Guide to Drifting Data Buoys. 1988. 71 pp. (English, French, Spanish, Russian)
21	*(Superseded by IOC Manuals and Guides No. 25)*
22 rev.	GTSPP Real-time Quality Control Manual, First revised edition. 2010. 145 pp. (English)
23	Marine Information Centre Development: An Introductory Manual. 1991. 32 pp. (English, French, Spanish, Russian)
24	Guide to Satellite Remote Sensing of the Marine Environment. 1992. 178 pp. (English)
25	Standard and Reference Materials for Marine Science. Revised Edition. 1993. 577 pp. (English)
26	Manual of Quality Control Procedures for Validation of Oceanographic Data. 1993. 436 pp. (English)
27	Chlorinated Biphenyls in Open Ocean Waters: Sampling, Extraction, Clean-up and Instrumental Determination. 1993. 36 pp. (English)
28	Nutrient Analysis in Tropical Marine Waters. 1993. 24 pp. (English)
29	Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. 1994. 178 pp . (English)
30	MIM Publication Series:
	Vol. 1: Report on Diagnostic Procedures and a Definition of Minimum Requirements for Providing Information Services on a National and/or Regional Level. 1994. 6 pp. (English)
	Vol. 2: Information Networking: The Development of National or Regional Scientific Information Exchange. 1994. 22 pp. (English)
	Vol. 3: Standard Directory Record Structure for Organizations, Individuals and their Research Interests. 1994. 33 pp. (English)
31	HAB Publication Series:
	Vol. 1: Amnesic Shellfish Poisoning. 1995. 18 pp. (English)
32	Oceanographic Survey Techniques and Living Resources Assessment Methods. 1996. 34 pp. (English)
33	Manual on Harmful Marine Microalgae. 1995. (English) [superseded by a sale publication in 2003, 92-3-103871-0. UNESCO Publishing]
34	Environmental Design and Analysis in Marine Environmental Sampling. 1996. 86 pp. (English)
35	IUGG/IOC Time Project. Numerical Method of Tsunami Simulation with the Leap-Frog Scheme. 1997. 122 pp. (English)
36	Methodological Guide to Integrated Coastal Zone Management. 1997. 47 pp. (French, English)
37	International Tsunami Survey Team (ITST) Post-Tsunami Survey Field Guide. 2nd Edition. 2014. 120 pp. (English)
38	Guidelines for Vulnerability Mapping of Coastal Zones in the Indian Ocean. 2000. 40 pp. (French, English)
39	Manual on Aquatic Cyanobacteria – A photo guide and a synopsis of their toxicology. 2006. 106 pp. (English)
40	Guidelines for the Study of Shoreline Change in the Western Indian Ocean Region. 2000. 73 pp. (English)

No.	Title
41	Potentially Harmful Marine Microalgae of the Western Indian Ocean Microalgues potentiellement nuisibles de l'océan Indien occidental. 2001. 104 pp. (English/French)
42	Des outils et des hommes pour une gestion intégrée des zones côtières - Guide méthodologique, vol.II/ Steps and Tools Towards Integrated Coastal Area Management – Methodological Guide, Vol. II. 2001. 64 pp. (French, English; Spanish)
43	Black Sea Data Management Guide *(Cancelled)*
44	Submarine Groundwater Discharge in Coastal Areas – Management implications, measurements and effects. 2004. 35 pp. (English)
45	A Reference Guide on the Use of Indicators for Integrated Coastal Management. 2003. 127 pp. (English). *ICAM Dossier No. 1*
46	A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management. 2006. iv + 215 pp. (English). *ICAM Dossier No. 2*
47	TsunamiTeacher – An information and resource toolkit building capacity to respond to tsunamis and mitigate their effects. 2006. DVD (English, Bahasa Indonesia, Bangladesh Bangla, French, Spanish, and Thai)
48	Visions for a Sea Change. Report of the first international workshop on marine spatial planning. 2007. 83 pp. (English). *ICAM Dossier No. 4*
49	Tsunami preparedness. Information guide for disaster planners. 2008. (English, French, Spanish)
50	Hazard Awareness and Risk Mitigation in Integrated Coastal Area Management. 2009. 141 pp. (English). *ICAM Dossier No. 5*
51	IOC Strategic Plan for Oceanographic Data and Information Management (2008–2011). 2008. 46 pp. (English)
52	Tsunami risk assessment and mitigation for the Indian Ocean; knowing your tsunami risk – and what to do about it. 2009. 82 pp. (English)
53	Marine Spatial Planning. A Step-by-step Approach. 2009. 96 pp. (English; Spanish). *ICAM Dossier No. 6*
54	Ocean Data Standards Series: Vol. 1: Recommendation to Adopt ISO 3166-1 and 3166-3 Country Codes as the Standard for Identifying Countries in Oceanographic Data Exchange. 2010. 13 pp. (English) Vol. 2: Recommendation to adopt ISO 8601:2004 as the standard for the representation of date and time in oceanographic data exchange. 2011. 17 pp. (English)
55	Microscopic and Molecular Methods for Quantitative Phytoplankton Analysis. 2010. 114 pp. (English)
56	The International Thermodynamic Equation of Seawater—2010: Calculation and Use of Thermodynamic Properties. 2010. 190 pp. (English)
57	Reducing and managing the risk of tsunamis. Guidance for National Civil Protection Agencies and Disaster Management Offices as Part of the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connected Seas Region – NEAMTWS. 2011. 74 pp. (English)
58	How to Plan, Conduct, and Evaluate Tsunami Exercises / Directrices para planificar, realizar y evaluar ejercicios sobre tsunamis. 2012. 88 pp. *(*English, Spanish*)*
59	Guide for designing and implementing a plan to monitor toxin-producing microalgae. Second Edition. 2016. 63 pp. (English, Spanish)
60	Global Temperature and Salinity Profile Programme (GTSPP) — Data user's manual, 1st Edition 2012. 2011. 48 pp. (English)
61	Coastal Management Approaches for Sea-level related Hazards: Case-studies and Good Practices. 2012. 45 pp. (English)

No.	Title
62	Guide sur les options d'adaptation en zone côtières à l'attention des décideurs locaux – Aide à la prise de décision pour faire face aux changements côtiers en Afrique de l'Ouest / A Guide on adaptation options for local decision-makers: guidance for decision making to cope with coastal changes in West Africa / Guia de opções de adaptação a atenção dos decisores locais: guia para tomada de decisões de forma a lidar com as mudanças costeiras na Africa Ocidental. 2012. 52 pp. (French, English, Portuguese). *ICAM Dossier No. 7*.
63	The IHO-IOC General Bathymetric Chart of the Oceans (GEBCO) Cook Book. 2012. 221 pp. (English). *Also IHO Publication B-11*
64	Ocean Data Publication Cookbook. 2013. 41 pp. (English)
65	Tsunami Preparedness Civil Protection: Good Practices Guide. 2013. 57 pp. (English)
66	IOC Strategic Plan for Oceanographic data and Information Management (2013-2016). 2013. 54 pp. (English/French/Spanish/Russian)
67	IODE Quality Management Framework for National Oceanographic Data Centres (in preparation)
68	An Inventory of Toxic and Harmful Microalgae of the World Ocean (in preparation)
69	A Guide to Tsunamis for Hotels: Tsunami Evacuation Procedures (in preparation)
70	A guide to evaluating marine spatial plans. 2014. 96 pp. (English)
71	IOC Communication Strategy for Marine Information Management (2015-2017). 2015
72	How to reduce coastal hazard risk in your community – A step-by-step approach. 2016
73	Guidelines for a Data Management Plan. 2016
74	Tsunami Ready Guidelines for the Caribbean and Adjacent Regions. 2016. (English/French/Spanish)
75	ICAN (International Coastal Atlas Network) - best practice guide to engage your CWA (Coastal Web Atlas) user community. 2016
76	Plans and Procedures for Tsunami Warning and Emergency Management – Guidance for countries in strengthening tsunami warning and emergency response through the development of Plans and Standard Operating Procedures for their warning and emergency management authorities. 2017
77	IOC Strategic Plan for Oceanographic Data and Information Management (2017-2021). 2017

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