TsunamiTeacher

United Nations Educational,
Scientific and Cultural Organization

TsunamiTeacher

Resource Kit

www.unesco.org

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Introduction

"Tsunami disasters pose a major threat to the coastal populations of the Pacific and other world oceans and seas. They have been responsible for the loss of thousands of lives and great damage to property."

"Although understanding of the tsunami phenomenon has increased in the past four decades and early warning systems have been established, these advances have been partially offset by population growth and extensive development of coastal zones."

"Therefore the tsunami risk and vulnerability of people living in coastal areas will continue to increase in the future."

– Intergovernmental Oceanographic Commission, UNESCO

Listen to the BBC's *Audio gallery: Tsunami disaster* for a reminder of the shocking events of 26 December 2004:

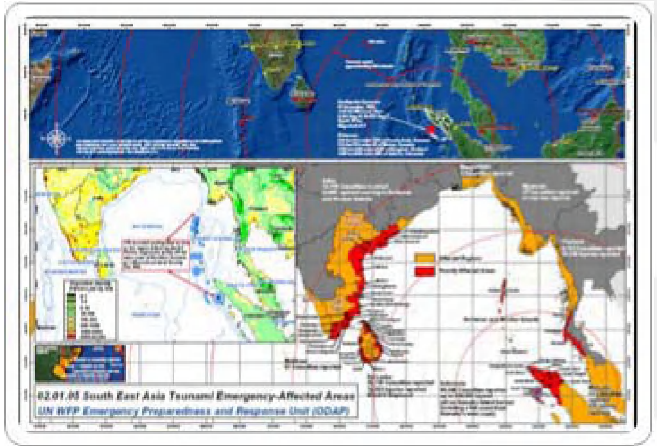
http://news.bbc.co.uk/1/hi/world/asia-pacific/4156329.stm

The Indian Ocean tsunami of 26 December 2004 claimed the lives of 231,452 people, the highest toll in recorded history.

In just a few hours, stunning the world with its destructive power, the tsunami struck every country in the Indian Ocean, wreaking massive damage along coasts and causing deaths in 11 countries. Indonesia, Sri Lanka, and southeast India were the worst hit.

The tsunami was largely to blame for a surge in the death toll from natural disasters in 2004, to 250,000 globally – three times higher than in 2003, 10 times more than in 2002 and three times the annual average for the decade 1994 to 2003 – according to the *World Disasters Report 2005* of the International Federation of Red Cross and Red Crescent Societies.

A tsunami is an unstoppable natural hazard, but the 2004 event made it tragically clear that countries were poorly prepared for the phenomenon. The goals now are to raise the ability of people to recognize an approaching tsunami, to grow the capacity of nations to respond rapidly and effectively to tsunami warnings when they are issued, and to mitigate the impacts when tsunamis occur.



Map of affected areas, courtesy United Nations World Food Programme, Preparedness and Response Unit.

In the aftermath of the 2004 tsunami, national authorities across the Indian Ocean region were charged, among other things, with developing tsunami information, awareness, education and resource materials for the media, schools, decision-makers and the public.

A wealth of information on tsunamis already exists, gathered down the decades on individual events and responses to them, and enriched by research and scientific advances. Many organizations and countries have also produced, or are developing, locally and regionally relevant materials on tsunamis.

But until now there has been no single, reliable and verified resource that has pulled these materials together at the global level and made them widely accessible to people, groups and governments around the world who might learn and benefit from them.

That is the task of UNESCO's *TsunamiTeacher,* an information and training kit that also aims to build global capacity to respond to and mitigate tsunamis. The kit is supported by a website – www.tsunamiteacher.org – that will be updated with new tsunami materials as they are developed.

A Tsunami Awareness Kit, developed for Pacific island countries, is one of many hazard awareness efforts currently underway in the global community to help protect lives and property from future catastrophes. (Source: Pacific Disaster Center)

TsunamiTeacher content

The content of *TsunamiTeacher* is divided into four main sections. It is recommended that all users read carefully through "2 – Getting Started" before proceeding to the training module relevant to them in "3 - Training Modules".

The "2 - Getting Started" and "4 - Workshops and Evaluation" are common to all users and can be accessed at any point by clicking on the appropriate link button. Training modules for different *TsunamiTeacher* audiences are in "3 - Training Modules".

There are three other sections, always readily accessible as buttons on the screen – "Glossary", "Resource Collection" and "Links and Contacts".

Aims and Outcomes

Aims

The overall aim of *TsunamiTeacher* is to help build the capacity of people and governments to respond effectively to tsunamis and mitigate their impacts, especially in regions most vulnerable to the natural hazard but also among all coastal communities.

Access to a consolidated global source of quality tsunami awareness and response information, as well as training modules aimed at stakeholder groups affected by or responsible for mitigating the multiple impacts of tsunamis, could greatly support ongoing capacity-building efforts at all levels across all regions.

Outcomes

The intended outcomes of *TsunamiTeacher* are to have enabled people, groups and governments in at-risk regions to:

- Share the valuable body of information gathered, and research and good practice undertaken on, tsunamis.
- Adapt high quality generic materials appropriately to local contexts.
- Grow stakeholder and public awareness of and preparedness for tsunamis.
- Develop responses that have the potential to save lives and mitigate the impacts of tsunamis.

Tsunamis should be addressed in a "multi-hazard" framework. Despite potentially disastrous consequences, because they occur infrequently tsunamis tend to drop off the public agenda. Effective responses to tsunamis are therefore only likely to be sustainable if they are plugged into national disaster frameworks.

TsunamiTeacher will help to keep tsunamis in the public eye, and will encourage authorities to integrate tsunami responses into broader national disaster strategies.

> Visit the United Nations News Centre's tsunami website:
> *http://www.un.org/apps/news/infocusRel.asp?infocusID=102&Body=tsunami&Body1*

The publishers

TsunamiTeacher is a product of UNESCO's Intergovernmental Oceanographic Commission (UNESCO-IOC) based in Paris, France, and its International Tsunami Information Centre (IOC-ITIC) in Honolulu, Hawaii.

The kit draws extensively on IOC and ITIC resources, and on materials produced and made available by many governments, organizations and international agencies. The *TsunamiTeacher* website is hosted and administered by the IOC's International Oceanographic Data and Information Exchange project office in Oostende, Belgium.

Logos

Intergovernmental Oceanographic Commission (UNESCO-IOC)

Intergovernmental Oceanographic Commission (UNESCO-IOC)

UNESCO's Intergovernmental Oceanographic Commission is a United Nations mechanism for promoting global cooperation between Member States in ocean study. It helps countries to resolve their own and mutual oceanographic and coastal problems through the sharing of knowledge, data and technology, and the coordination of national programmes.

The IOC has seven focus areas of study, monitoring and activity – marine environmental protection; fisheries and ecosystems; climate change; ocean observing and monitoring; coastal area management; data and information management; and disaster mitigation.

UNESCO-IOC is also the United Nations body mandated by its Member States to coordinate tsunami warning and mitigation efforts at the international level.

For the past four decades the IOC, through its Intergovernmental Coordination Group (ICG), has been responsible for harmonizing the efforts of countries involved in the Pacific Tsunami Warning and Mitigation System (PTWS). It is now leading the establishment of several other regional tsunami warning and mitigation systems at a global level.

For more information on UNESCO-IOC go to:

http://ioc.unesco.org/iocweb/index.php

International Tsunami Information Centre (IOC-ITIC)

International Tsunami Information Centre (IOC-ITIC)

The mission of UNESCO-IOC's International Tsunami Information Centre in Hawaii is to mitigate the hazards associated with tsunamis by improving tsunami preparedness – especially in the Pacific Ocean, where 85 percent of observed tsunamis have occurred.

Among its primary functions are to assist in setting up or improving international and national tsunami warming systems, and to disseminate information about warning system activities. The Centre is assisting UNESCO-IOC to set up a global tsunami warning system.

The ITIC is also charged with gathering and distributing knowledge on tsunamis, fostering tsunami research and its application, making records on tsunamis available, and developing and supporting post-tsunami surveys.

IOC-ITIC has an extensive tsunami database and long experience in developing print and visual resources on tsunamis, which it has widely shared with national authorities in affected regions.

It is the "home" of *TsunamiTeacher*, holding much of the content featured in the kit and on the website. IOC-ITIC has been responsible for compiling and verifying the quality and reliability of the information contained in the kit's Resource Collection.

For more information on IOC-ITIC go to:

http://www.tsunamiwave.info

The concept

Information is of limited use on its own, without context. The purpose of *TsunamiTeacher* is not only to pull together and widely disseminate – a critical mass of quality information and material about tsunamis, but also to add value by directing different audiences to materials that are relevant and important to them.

TsunamiTeacher is modeled on UNESCO-IOC's web-based distance learning *OceanTeacher* programme, which provides a highly effective and publicly accessible platform for delivering quality oceanographic information and educational modules.

Like *OceanTeacher*, but published both on CD-Rom and on the internet, *TsunamiTeacher* is a flexible value-added binary resource comprising:

- Modules that target different audiences
- A Resource Collection of quality tsunami-related information and materials

The Training Modules

The Modules contain specific, relevant information and materials from the Resource Collection, and are aimed at building awareness and understanding of, and the capacity of stakeholders to prepare for and mitigate the impacts of tsunamis. There is also a section containing workshop frameworks and evaluation forms, to assist trainers.

The Resource Collection

The Resource Collection includes media articles, film clips, brochures, website links, documents, research reports, multi-media and curricula materials, and resources on tsunami science, occurrences, preparedness, strategies, responses and mitigation.

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
2. Getting Started

Target audiences

The primary audiences for the *TsunamiTeacher* kit are:

- The media
- Schools
- The public and private sectors governments, businesses and community groups

Each of these stakeholder audiences have key informational and educational roles to play in promoting greater public awareness and understanding of tsunamis, and in developing responses that could save lives during a tsunami and mitigate the impacts of the great waves.

The dissemination of *TsunamiTeacher* among these audiences, especially in regions most affected by tsunamis, is also intended to encourage sharing of the rich international bank of quality information on tsunamis, its adaptation to local contexts, and the development by countries of effective strategies to prepare for and respond to tsunamis.

IOC-ISDR Japan Study Tour, Tokyo, Japan, July 2005.

ITIC Director being interviewed by media, Waikiki, Hawaii, December 2005.

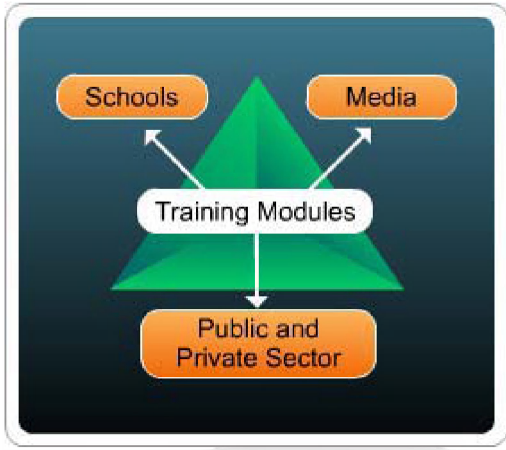
Users Guide

The *TsunamiTeacher* is designed to be both a resource and a training kit.

It is advisable for all users to work through the entire kit, to become fully familiar with the content, but *TsunamiTeacher* is also designed to be used as a resource on which people can draw, in the longer term.

For example, journalists can look for information and graphics for stories or programmes that they might work on, in future. Teachers can return to the school curriculum materials each year. And authorities, community groups and companies can use the kit's materials at any point to assist emergency planning efforts.

To enable quick and easy access to the *TsunamiTeacher's* wealth of content, a hierarchical organization comprising of sections, sub-sections and pages has been utilized. Clicking on a section header will reveal sub-section headers and pages of related information, making it easy to locate, and go directly to, specific content.



After completing this "2 - Getting Started" section, all first-time *TsunamiTeacher* users should proceed to "3 - Training modules". There are training modules targeting each of the target audiences – Media; Schools; and Public and Private Sectors (governments, businesses and community groups).

The modules can be used as the basis for workshops, or for self-learning.

Each module is designed to suit the perceived needs of its target audience, has its own set of objectives and intended outcomes, and contains storylines and links to resources on the internet and to selected materials in the parallel Resource Collection.

None of the modules use all of the materials in the Resource Collection, but all of the audiences will use some of the materials.

So, for example, journalists and teachers will be directed to information about tsunamis and visual materials that can illustrate articles or lessons, while governments, community groups and businesses can focus on disaster planning and emergency responses. All audiences will be interested in how people might seek safety during a tsunami.

TsunamiTeacher is a global resource that can be adapted to make it locally relevant.
For instance, a journalist or teacher or community leader can apply general tsunami safety rules to local factors such as topographical features and population concentrations.
Or Communities may use the *Tsunami – The Great Waves* brochure, translate it into local languages and replace or add more meaningful photographs to accompany the text.

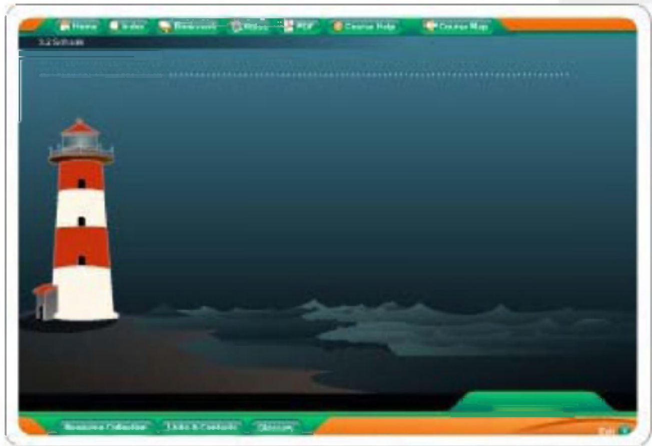
Finally, *TsunamiTeacher* is designed for easy use by trainers and participants in workshops. Section “4 – Workshops and Evaluation” contains notes for trainers, workshop frameworks, and questionnaires for evaluating workshops and the *TsunamiTeacher* kit.

Training modules can also be created from scratch anywhere in the world by drawing on “Resource Collection”, which is where all the kit’s background materials reside, and which can be used as a library for further research on tsunamis and as a source of materials for educational use.

There are two further sections – “Glossary” and “Links and Contacts”. “Resource Collection”, “Glossary” and “Links and Contacts” are on permanent display as buttons on the screen.

The glossary features a link to the IOC-ITIC illustrated Glossary, a list of tsunami terms, and a list of acronyms of tsunami-related organizations and systems. Definitions of terms, which may be encountered when learning about tsunamis can be accessed by first clicking the “Glossary” button and then clicking on the relevant term.

The “Links and Contacts” button contains contact details for tsunami organizations, specialists and research centres, as well as links to tsunami internet resources and media and photographic websites.



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TsunamiTeacher
2. Getting Started

Tsunami film footage and safety clips

Before proceeding to “3 - Training Modules”, users might wish to view film footage generously made available to *TsunamiTeacher* by the Asia-Pacific Broadcasting Union (ABU) and the Japan Broadcasting Corporation (NHK).

The film footage is featured in the kit’s second “Additional resources” CD-Rom, because of the substantial disk space that film takes up, and thus requires users to exit this *TsunamiTeacher* training CD-Rom. After viewing the materials, users should return to this CD-Rom, go directly to “3 - Training Modules”, and click through to the appropriate module.

The footage may be used for educational, not-for-profit purposes only. Commercial usage needs to be negotiated directly with the ABU and NHK Japan.

The Japan Broadcasting corporation (NHK) is a media outlet involved in broadcasting domestically and internationally, and has been producing short programmes about natural disasters and prevention measures for more than 30 years.

Asian Tsunami: Disaster of the Century

Asian Tsunami: Disaster of the Century is a 30-minute compilation of film materials on the 2004 Indian Ocean tsunami, gathered from ABU members throughout the Indian Ocean region. It is the most comprehensive visual account available about the disaster. The programme may only be used for educational purposes, and as a complete package.

The copyright contact details for the ABU are:

Director, Programme Department

Address: Asia-Pacific Broadcasting Union, PO Box 1164, 59700 Kuala Lumpur, Malaysia

Tel: +60 3 2282 2480
Fax: +60 3 2282 5292

Website: www.abu.org.my

Disaster Broadcast: An In-house Training Guide

Disaster Broadcast: An In-house Training Guide is an NHK Japan production, and contains six video clips featuring footage of earthquakes and what happens next in Japan regarding tsunami warnings.

Notes on Disaster Prevention: Surviving a Tsunami

Also produced by NHK Japan, *Notes on Disaster Prevention: Surviving a Tsunami* contains three 30-second clips relating specifically to the 2004 Indian Ocean tsunami. The clips have already been distributed to members of the ABU.

The copyright contact details for NHK Japan are:

Address: 2-2-1 Jinnan, Shibuya-ku, Tokyo 150-8001, Japan

Tel: +81 3 3465 1111

Website: http://www.nhk.or.jp/english/

Asian Tsunami, Disaster of the Century, ABU, 2005.

The purpose of *TsunamiTeacher's* Media Module is to help media professionals report on tsunami events and issues, and to provide the media with materials they might draw on for tsunami coverage, commentary or analysis.

The Module is aimed at media professionals across all media types – print, radio, television and the Internet – and more specifically at:

- Media professionals who would cover tsunamis, such as reporters and producers.
- Media professionals who make content decisions, such as news-editors.
- Editors and managers who are in overall charge of editorial content and resources.
- Media trainers who might find *TsunamiTeacher's* resources useful for teaching.

The module can form the basis of workshops for media professionals, it can be used for self-training, or it can be employed primarily as a source of media material.

Media professionals provide the vital link between politicians, experts and communities. The media can help save lives and protect communities: it can play a critical role in reporting on tsunamis that threaten – or have struck – countries and regions.

The media can – but in many countries has yet to – play a key role in informing members of the public about how to prepare for tsunamis. For instance, the media can point out areas that experts consider safe for people to flee to after a tsunami warning, or can inform parents about responses they might plan to maximize family safety during a tsunami.

Reporters can usefully question local and national authorities about tsunami and other emergency strategies, and businesses about systems they have in place to warn clients and prepare staff for a tsunami occurrence. The media can also investigate disaster relief and reconstruction plans that the public and private sectors might (or might not) have developed.

A UNTV cameraman in Mullaitivu, a town in Northeastern Sri Lanka ravaged by the tsunami of 26 December 2004.

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media - 3.1.1 Introduction - 3.1.1.2 Tsunamis - The media's roles

The media is crucial to the rapid dissemination of tsunami warnings. News media can provide effective communication channels after a disaster has struck, and can assist in rapidly providing a picture of how a tsunami has affected areas it has hit – and thus help to direct aid and rescue efforts to survivors.

The media ought to keep the public up-to-date on information about and research into tsunamis, and has a key role to play in monitoring relief efforts and the performance of authorities in rebuilding areas that tsunamis have devastated.

December 26, 2004 tsunami, Banda Aceh, Indonesia. Source: Eksklusif, Metro TV, Asian Broadcasting Union.

Go to this Reuters story about the 2005 *World Disasters Report* of the International Federation of Red Cross and Red Crescent Societies, which argues that information is as valuable to people as food, water or shelter after disaster has struck:

http://www.alertnet.org/thefacts/reliefresources/112849785964.htm

Get a glimpse of the immense range of internet articles available by viewing *AsiaToday's* web page on the Indian Ocean tsunami:

http://www.asiasource.org/news/at_mp_02.cfm?newsid=122888

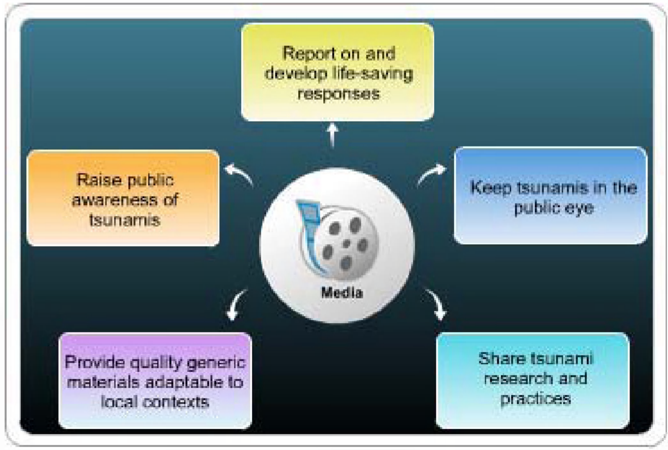
3.1 Media - 3.1.1 Introduction - 3.1.1.3 Aims and Objectives

The over-arching aim of the *TsunamiTeacher* Media Module is to provide accurate, verified information to media professionals to improve their knowledge of tsunamis and help them to produce quality articles and programmes that promote public awareness and understanding of – and preparedness for – tsunami events.

More specifically, the media objectives of *TsunamiTeacher* are to:

- Develop the interest, knowledge and skills of media professionals in raising public awareness and understanding of tsunamis
- Build the capacity of the media to report on, and help to develop, responses that have the potential to save lives and mitigate the impact of future tsunamis
- Encourage the media to keep tsunamis in the public eye, despite their infrequent occurrence, and to monitor the integration of tsunami responses into broader national disaster strategies
- Share the valuable body of existing tsunami research and sound practices undertaken by many governments and groups, including United Nations agencies
- Provide high quality generic materials that the media can adapt appropriately to local contexts

It is hoped that the availability of quality materials and the improved ability of the media to impart information on tsunamis will bolster ongoing capacity building activities around the world, especially in high-risk tsunami regions and among coastal communities everywhere.



3.1 Media - 3.1.1 Introduction - 3.1.1.4 Intended kit outcomes

After working through *TsunamiTeacher*, media professionals should:

- Have better understanding of how tsunamis affect their area, country and world
- Have strong understanding of the news and public interest roles of the media in helping communities and countries to prepare for and mitigate impacts of tsunamis
- Be able to accurately and comprehensively report on tsunamis and their aftermath
- Take interest in keeping the tsunami phenomenon on the public agenda, particularly within the context of more general local and national disaster strategies
- Have enhanced research skills and access to a wide range of tsunami information
- Have been introduced to a range of institutional and website information resources

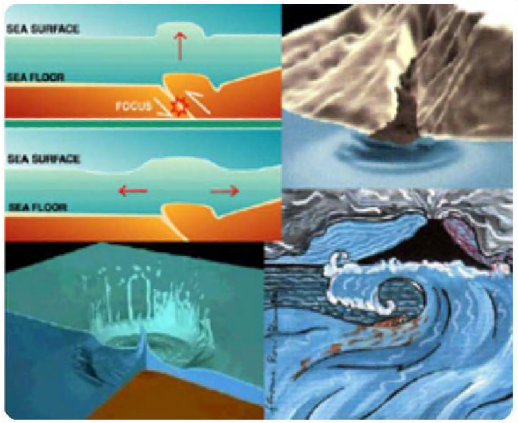
3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

The phenomenon called tsunami is a series of traveling ocean waves of great length that are generated primarily by earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis.

Tsunamis are usually caused by earthquakes, less commonly by submarine landslides, infrequently by submarine volcanic eruptions – though they have the potential to produce awesome tsunami waves – and very rarely by large meteorite impacts in the ocean.

When there is a sudden displacement of a huge volume of water, or an earthquake raises or drops the sea floor, forces of gravity can form big tsunami waves that radiate out of the area of origin and can be extremely dangerous and damaging when they reach coasts.

Refer [3.1.2 - 01 of 11] to learn moreon the Great Waves in the CD - ROM



A tsunami can be caused by, clockwise from top left, earthquakes, landslides, volcanic eruptions, and in theory, meteorites.

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

The word tsunami (pronounced soo-NAH-mee) is composed of the Japanese words “tsu” (harbour) and “nami” (wave). Often the terms seismic or tidal waves are used to describe the same phenomenon, but they are misleading because tsunami waves can be generated by non-seismic disturbances and have physical characteristics different to tidal waves.

Tsunami waves are unrelated to astronomical tides (regular ocean waves), which are caused by the extraterrestrial, gravitational influences of the moon, sun and planets. Tsunami has been internationally adopted as the correct term because it covers all forms of impulsive wave generation.

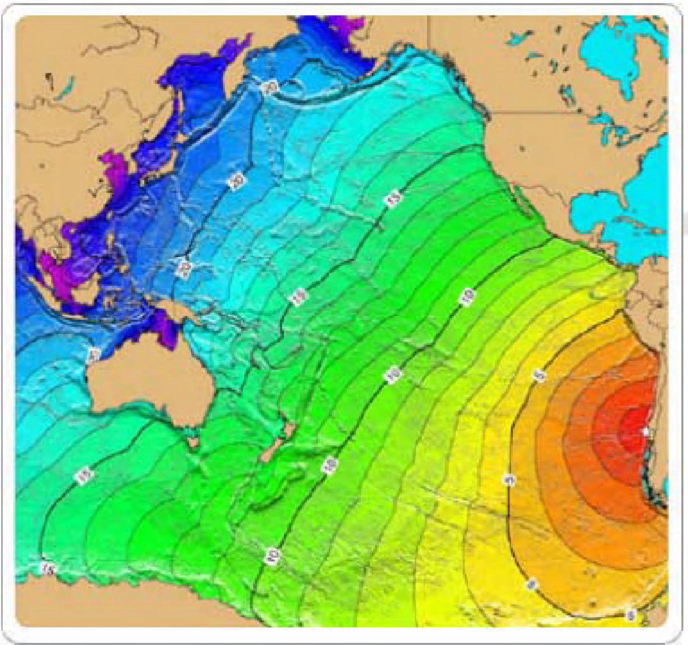
Banda Aceh, Sumatra, Indonesia. The tsunami of December 26, 2004 completely razed coastal towns and villages, leaving behind only sand, mud, and water.

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

Tsunamis on the move

All ocean regions of the world can experience tsunamis. But large, destructive tsunamis occur most frequently in the Pacific Ocean and its marginal seas because of that ocean's immense size and many severe earthquakes.

Tsunami waves are distinguished from ordinary ocean waves by the great length between wave crests, often exceeding 100 kilometres (over 60 miles) in the deep ocean, and by the time between the crests, which ranges from 10 minutes to an hour.



On May 22, 1960 a Magnitude 9.5 Mw earthquake, the largest earthquake ever instrumentally recorded, occurred in southern Chile. The series of earthquakes that followed ravaged southern Chile and ruptured over a period of days a 1,000 km section of the fault. Tsunami travel time contours are shown in hours.

Before proceeding to a formal description of tsunamis and their causes, read through this gripping and informative National Geographic account of the 2004 Indian Ocean tsunami.

http://news.nationalgeographic.com/news/2004/12/1227_041226_tsunami.html

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media

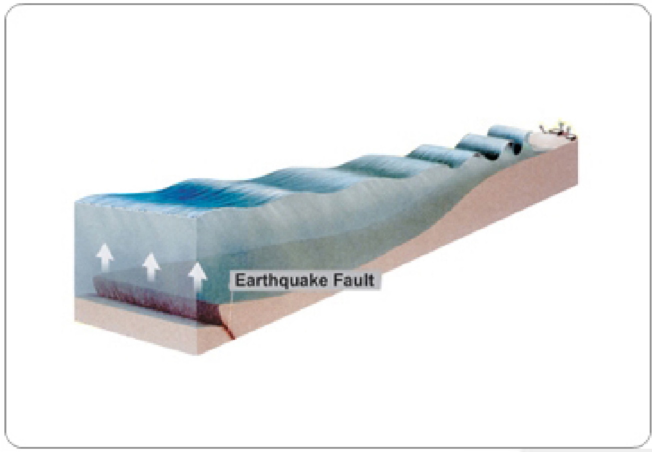
3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

Tsunamis on the move

Wave crests can also be hundreds of kilometres long, radiating out from an impulsive occurrence such as an earthquake like the ripples caused by throwing a rock in a pond.

Where the ocean is over 6,000 metres (20,000 feet) deep, tsunami waves can travel at speeds of over 800 kilometres (500 miles) per hour – as fast as a commercial jet – at a wave height of only a few tens of centimetres.

A tsunami can move from one side of an ocean to the other in less than a day, where its low amplitude and long wavelengths go unnoticed by ships at sea and cannot be seen from the air.



A sudden vertical displacement of the seafloor caused by earthquake faulting can generate a tsunami, which grows in height as the water shallows toward the coast.

3.1 Media

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

How tsunami waves grow

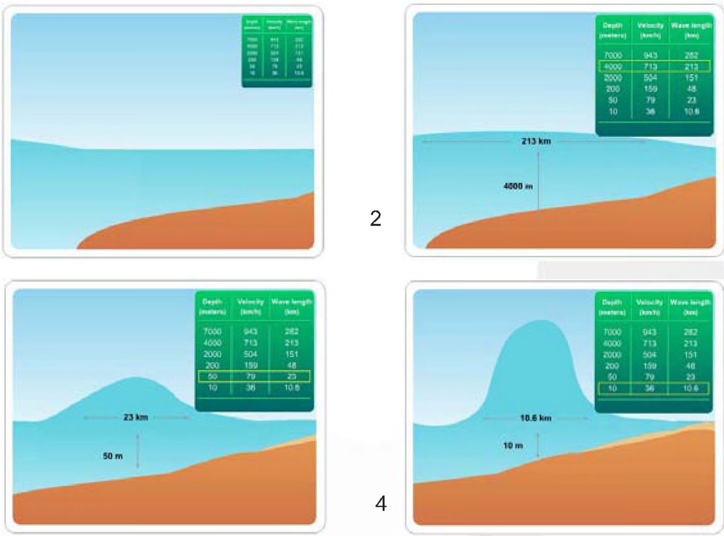
Tsunami wave energy extends from the bottom to the surface of the ocean in even the deepest waters. Tsunami waves arrive at a coastline as a series of successive crests (high water levels) and troughs (low water levels), usually 10 to 45 minutes apart.

Tsunami Speed is reduced in **shallow water** as wave height increases rapidly. In the open ocean a tsunami is less than a few tens of centimeters (1ft) high at the surface, but wave height increases rapidly in shallow water.

Tsunami wave energy extends from the surface to the bottom in even the deepest waters.

As the tsunami reaches the shallow waters of coasts, the waves slow down to between 45 to 60 kilometres (28 to 38 miles) an hour and become compressed.

As the tsunami attacks the coastline, the wave energy is compressed into a much shorter distance and a much shallower depth, creating destructive, life-threatening waves.



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3.1 Media
3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot
How tsunami waves grow

The maximum height a tsunami reaches on shore is called the run-up. It is the vertical distance between the maximum height reached by the tsunami water on shore and the usual sea level surface. Any tsunami run-up of over a metre is dangerous. Flooding by each wave lasts from 10 minutes to half-an-hour, so the danger period for successive waves can last for hours. Wave energy is directed upward and water can pile up into a wall of destruction tens of metres (30 feet) or more high.

In extreme cases, water levels have risen to more than 15 metres (50 feet) for tsunamis of distant origin and over 30 metres (100 feet) for tsunami waves generated near the epicentre of an earthquake. Even a tsunami three to six metres (10 to 20 feet) high can be highly destructive, causing many deaths and injuries.

Runup is the elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, or sea level at the time of the tsunami attack, and measured ideally at a point that is the local maximum of the horizontal inundation.

Runup can often be inferred from the vertical extent of dead vegetation, from debris normally found at ground level that are observed stuck on electric wires, in trees, or at other heights, and from water line marks left on building walls. In extreme cases, cars, boats, and other heavy objects have been lifted and deposited atop buildings. Banda Aceh, Indonesia, 26 December 2004. Photo courtesy of C. Courtney, Tetra Tech EMI.

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

The influences of coastlines

The height and impact of tsunami waves can depend on offshore and coastal features, as well as on how the energy is focused and the travel path of the waves.

Reefs, bays, river mouths, undersea features and the slope of a beach all modify a tsunami as it attacks the coastline. The effect can be amplified if a bay, harbour or lagoon funnels the wave as it moves inland.

One coastal community may experience no damaging wave activity while another community nearby may be devastated by large and violent waves. Flooding can extend inland by 300 metres (1,000 feet) or more, covering large expanses of land with water and debris.

Reefs, bays, river mouths, undersea features and the slope of a beach all modify a tsunami as it attacks the coastline.

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

The influences of coastlines

Small islands with steep slopes usually experience little run-up – wave heights may be only slightly greater than on the open ocean. Thus, islands with steep-sided fringing or barrier reefs are only at moderate risk from tsunamis.

This is not the case for islands such as the Hawaiian or Marquesas chains, which do not have extensive barrier reefs and have broad bays exposed to the open ocean. For example, Hilo Bay at Hawaii and Tahauku Bay at Hiva Oa in the Marquesas are especially vulnerable.

Any gap in a reef puts the adjacent shoreline at risk. In Fiji, the local tsunami from the Suva earthquake of 1953 did little damage because of extensive offshore reefs. But two villages on the island of Viti Levu, near gaps in the reef, were damaged and five people drowned.

Tsunamis are a series of waves and later arriving waves will likely be turbulent and full of floating debris, sand, and mud. Everyone should be aware of other conditions which may add to the severity of the waves hitting the coast.

Hotels along vulnerable coasts should have tsunami emergency response plans in place. Coral Coast, Viti Levu, Fiji.

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

A destructive force

Tsunamis have three main means of destruction – inundation, erosion and wave impact on structures.

Inundation is the distance inland that a tsunami wave floods. The greater the inundation, the greater the destructive force of a tsunami is likely to be.

Strong tsunami-induced currents lead to the erosion of foundations and the collapse of bridges and seawalls.

Flotation and drag forces rip houses apart and overturn vehicles and train carriages. Considerable damage is caused by floating debris, including boats and cars that become dangerous projectiles that can crash into buildings, break power lines and start fires.

Fires from damaged ships in port, or ruptured oil storage tanks and refineries can cause destruction greater than that inflicted directly by the tsunami. Of growing concern, is the potential of receding waters uncovering the cooling water intakes of a nuclear power plant.

1993 Okushiri, Japan tsunami.

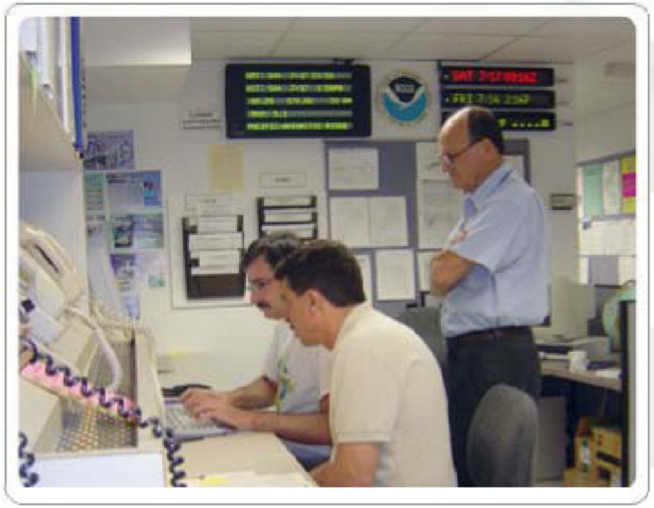
3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

Predicting tsunamis

Since scientists cannot predict when earthquakes will occur, they cannot determine exactly when a tsunami will be generated.

However, a tsunami early warning system detects potentially dangerous earthquakes and provides immediate early warning to countries that might be hit. Coordination of these global warning systems is being undertaken by UNESCO's Intergovernmental Oceanographic Commission (IOC) supported by its International Tsunami Information Centre. Building upon its experience in the Pacific, the IOC is currently helping to establish tsunami warning capabilities in the Indian Ocean, Caribbean, Atlantic, and Mediterranean.

Also, by looking at past tsunamis, scientists know where tsunamis are most likely to be generated. Past tsunami height measurements are useful in predicting future tsunami impact and flooding limits in specific coastal locations and communities.



PTWC analysts responding to tsunami alarm.

3.1.2 The Great Waves - 3.1.2.1 Tsunamis: A snapshot

Predicting tsunamis

During each of the last five centuries, there were three to four Pacific-wide tsunamis, most of them generated off the Chilean coast.

The Indian Ocean tsunami of 26 December 2004, which claimed 231,452 lives and wreaked vast damage to the coastlines of 12 countries, was the first known basin-wide destructive tsunami in the Indian Ocean. Nobody predicted it.

Following the north-west Sumatra earthquake, the Indian Ocean tsunami of 2004, approaches Hat Rai Lay Beach, Krabi, southern Thailand. After venturing out when the water first receded, foreign tourists scramble for safety in advance of the first of six tsunami waves.
Credit: AFP, Getty Images

To recap, read the *National Geographic* article "Tsunamis: Facts about killer waves"

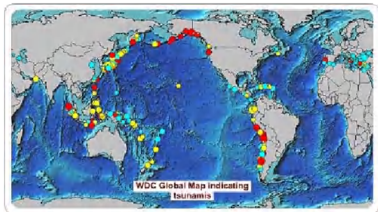
http://news.nationalgeographic.com/news/2004/12/1228_041228_tsunami.htm

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Each part of the world appears to have its own cycle of frequency and pattern in generating tsunamis that range in size from small to large and highly destructive events.

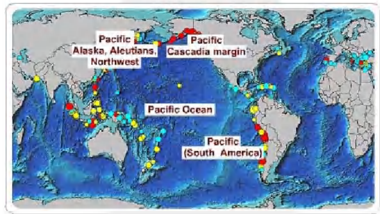
The geographical location of an ocean affects the tsunami.

WDC Global Map indicating tsunamis



Historical tsunamis with red circles showing events of greatest intensity, and blue circles of lowest intensity. The larger the size of the circle, the larger the magnitude of the earthquake that generated the tsunami.

According to a 2005 compilation by the World Data Center for Solid Earth Geophysics – Tsunamis that are hosted by the US National Geophysical Data Center, 82% of the 1106 verified tsunamis have occurred in the Pacific, 10% in the Mediterranean, Black, and Red Seas, and the northeastern Atlantic, 5% in the Caribbean and southwest Atlantic, and 1% in the Indian Ocean, and 1% in the southeast Atlantic. Altogether, about 500,000 deaths have been reported with 470,000 of these caused by 23 major tsunamis. Of these, nearly 50% (230,000) resulted from 2004 Indian Ocean tsunami, clearly demonstrating that tsunamis can happen anywhere and at any time. Before 2004, the Indian Ocean had observed only a very few tsunamis compared to the rest of the world.



Pacific Ocean Rollover
909 tsunamis have occurred in the Pacific, with Japan being the most active source region, followed by Indonesia. The majority of tsunamis are categorized as local or regional tsunamis meaning that damage, if any, has been confined to generally within a few 100 or 1000 km of the tsunami source.

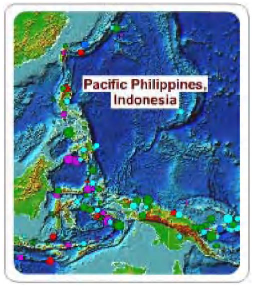
PacificOcean-South America
Large, shallow, offshore earthquakes associated with the subduction of the Nazca and Pacific tectonic plates beneath South America have caused destructive teletsunamis, including the M9.5 22 May 1960 Chile tsunami which killed 61 people in Hawaii 15 hours afterward, and in 122 in Japan 22 hours later. The 1960 Pacific-wide tsunami, which was generated by the largest earthquake measured in modern times, provided the motivation for the creation of the Pacific Tsunami Warning System in 1965.

Pacific – Cascadia margin
Paleoseismic and tsunami research in the last 10 years have pieced to together evidence for a M9+ earthquake off the Pacific northwest on 26 January 1700 that generated a teletsunamis that was recorded in northern Japan. Scientists postulate that another great earthquake associated with the Cascadia Subduction Zone may be overdue, causing US and Canada government officials to increase their tsunami preparedness activities along northwestern North America.

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

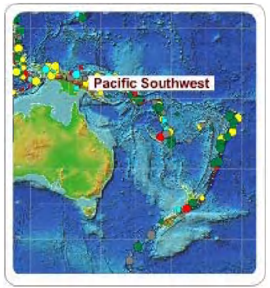
Pacific – Alaska, Aleutians, Northwest

The northwest Pacific, including northern Japan, Kamchatka, and the Kuriles, and the Aleutian islands and Gulf of Alaska have been the source regions for destructive teletsunamis. During the periods between 1946 and 1964, Hawaii was hit by five teletsunamis from this region. Because of the frequency of tsunamis, and at the request of countries in the region, Japan began the Northwest Pacific Tsunami Advisory Center in 2005 to provide timely tsunami warning advisories.



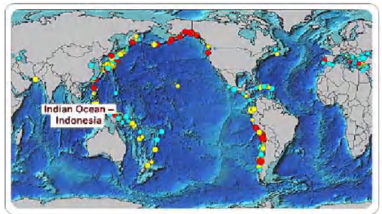
Pacific – Philippines, Indonesia

The western Pacific marginal basins and seas extending from the Philippines south to Indonesia is a complex tectonic region where a large number of local tsunamis have occurred. Altogether, 187 tsunamis have been observed, including a number that have caused thousands of deaths from local tsunami.



Pacific – Southwest

The southwest Pacific, including New Guinea, New Caledonia, the Solomons, and Vanuatu have observed a total of 87 local tsunamis. The 1998 Aitape, Papua New Guinea tsunami, which was generated by a M7.1 earthquake that triggered a landslide tsunami, killed about 2200 people.

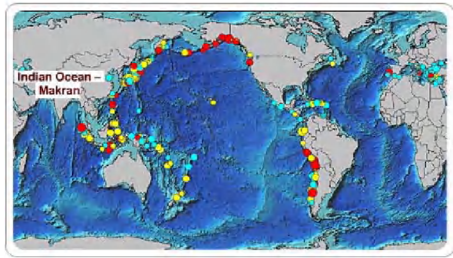


Indian Ocean – Indonesia, Andaman, and Nicobar Islands.

Although only 1% of historical tsunami have occurred in this region, the most deadly tsunami occurred off western Sumatra on 26 December 2004. This region, has however, had a history of large earthquakes. The event instantly created global awareness of the hazard and has motivated the development of the Indian Ocean Tsunami Warning and Mitigation System.

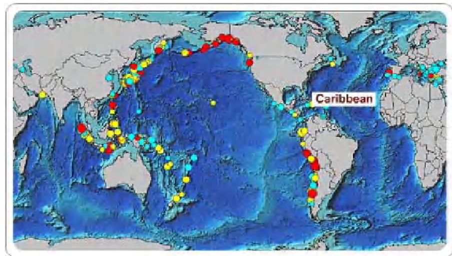
3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Indian Ocean – Makran off Iran and Pakistan



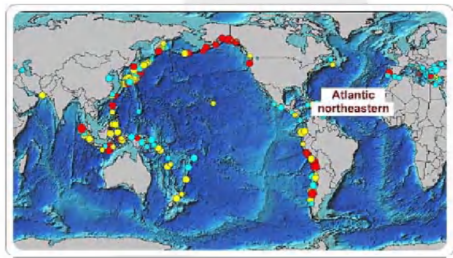
An M8.3 earthquake off Oman and south of Iran on 21 November 1945 is reported to have killed 4000 and generated 13-m waves in Pasni, Pakistan. If a tsunami were generated in the Makran region, waves would hit Oman in an hour, Yemen in two hours, Somalia in three hours, and the Seychelles in about five hours.

Caribbean



Tsunamis have been observed in the Caribbean and adjacent seas since the 16th century with several significant paleotsunamis suggested in the Netherlands Antilles as many as 3500 ybp. Additionally, the Caribbean Plate boundary is marked by active sub-aerial and submarine volcanoes, steep underwater slopes and numerous earthquakes which can generate submarine landslides and tsunamis. Both local and teletsunamis have affected this region at the rate of one or more severe occurrences per century. Increases in population density, combined with its transient population of visitors relaxing on its many beaches and cruise ships porting in island harbors, make this region especially vulnerable.

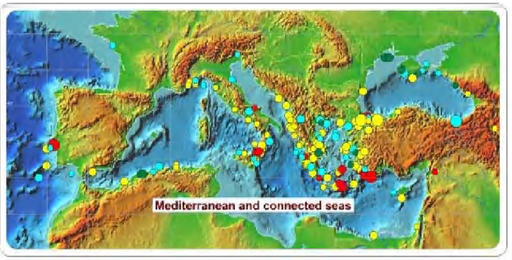
Atlantic northeastern



The great Lisbon earthquake of 1 November 1755 , which killed about 10,000, generated a teletsunami with 7-m high waves in the Caribbean Lesser Antilles and waves in the West Indies. Locally and regionally, waves of more than 15m were reported in Portugal, Spain, and Morocco, arriving within an hour to the coast of Portugal and continuing in some places for more than eight hours. Entire bays were emptied by receding waters, ships overturned and buildings shattered by the flooding black waters.

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Mediterranean and connected seas



The region includes the Mediterranean, Black and Red Seas, and is the second most common tsunami source region after the Pacific with 98 observed tsunamis. Tsunami warning systems in this region must mitigate against local tsunamis that will hit coasts within 10s of minutes. Perhaps the most famous tsunami, though not well verified, involved the disappearance of the island of Santorini in 1400 BC that is estimated to have caused 100,000 deaths.

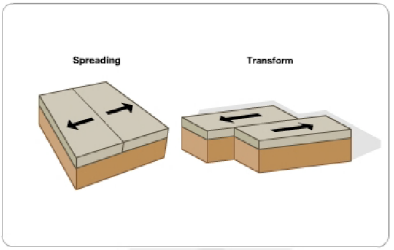
3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Earthquakes are the primary cause of tsunamis. Thus, in seeking to understand tsunamis, it is useful briefly to investigate causes of earthquakes.

Plate tectonic theory

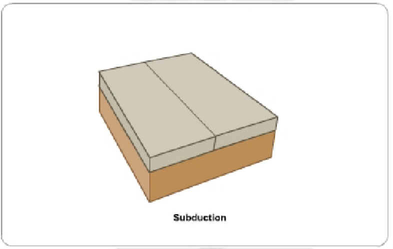
According to plate tectonic theory, the Earth is encased in a small number of lithospheric plates, between 70 and 250 kilometres (44 to 156 miles) thick, which float on a viscous under-layer called the as thenosphere. The plates cover the entire surface of the Earth – the continents and sea floor – and move relative to each other by up to 10 centimetres (four inches) a year.

An earthquake can be caused by volcanic activity, but most are generated by movements along the fault zones of plate boundaries.



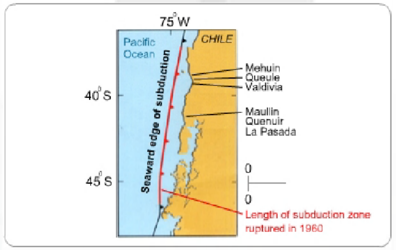
Where two plates come into contact is called a plate boundary, and the way plates move relative to each other determines the type of boundary:

- Spreading: where the two plates move away from each other.
- Transform: where two plates slide horizontally past each other.



Most strong earthquakes – 80 percent of the total energy released worldwide by earthquakes – occur in subduction zones where an oceanic plate slides under a continental plate or another younger oceanic plate.

Subduction is where two plates move toward each other and one slides beneath the other.



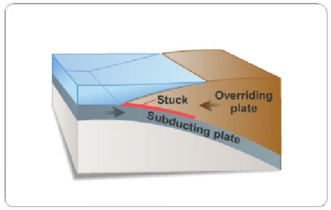
The 1960 Chilean tsunami radiated outward from a subduction zone along the coast of Chile. This tsunami was a result of the largest earthquake ever measured. (magnitude 9.5). Its waves reached Hawaii in 15 hours and Japan in 22 hours.
Source-Surviving tsunamis-Lessons from Chile, Hawaii and *Japan*

Refer [3.1.2 - 02 of 06] to view Surviving tsunamis Lessons from Chile, Hawaii and Japanin the CD - ROM

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

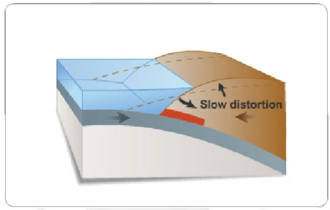
Vertical Slice Through a Subduction Zone

One of the many tectonic plates that make up the Earth's outer shell descends, or "subducts," under an adjacent plate. Within the subduction zone, when the plates move suddenly in an area where they are usually stuck, an earthquake happens.



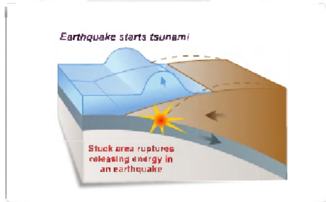
Between Earthquakes

Stuck to the subducting plate, the overriding plate gets squeezed. Its leading edge is dragged down, while an area behind bulges upward. This movement goes on for decades or centuries, slowly building up stress.



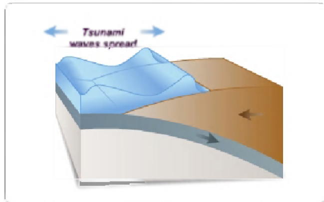
During an Earthquake

An earthquake along a subduction zone happens when the leading edge of overriding plate breaks free and springs seawards, raising the sea floor and the water above it. This uplift starts a tsunami.

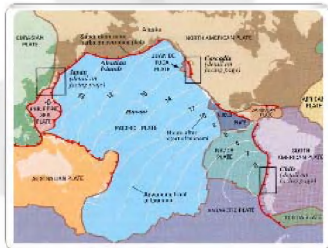


Minutes Later

Part of the tsunami races towards nearby land, growing taller as it comes in to shore. Another part heads across the ocean towards distant shores.



Subduction zones are characterized bydeep ocean trenches. The volcanic mountain chains that comprise the **Ring of Fire** are strewn across the Pacific's many subduction zones.



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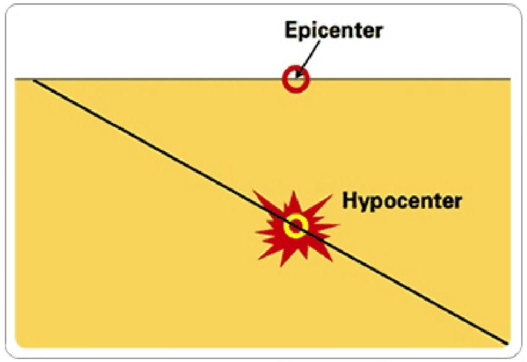
3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Plate tectonic theory

Some earthquake terms

The following are some terms commonly associated with earthquakes. Click on each one for its definition.



Credit: US Geological Survey.

Magnitude

This is a measure of the relative size of an earthquake. A number of different magnitude scales exist besides the Richter scale, including the moment magnitude, which measures the energy released and gives the most reliable estimate for large earthquakes. Because the scale is logarithmic, an increase in one unit of magnitude corresponds to a 10-fold increase in seismic wave amplitude and a 30-fold increase in released energy. And a change of 0.3 units equals a three-fold increase in intensity.
In other words, the 9.3 Sumatra earthquake that generated the 2004 Indian Ocean tsunami was three times more powerful than the 9.0 earthquake it was originally thought to be.
Moment magnitude is measurable almost immediately thanks to the advent of modern seismometres, digital recording and real-time communication links. It allows warning centres to provide initial tsunami advisories within minutes of an earthquake occurrence. In Japan, an earthquake warning is broadcast to the public within 30 seconds of an occurrence.

Hypocenter-Focus

This is the point on the earth where a rupture first occurs and where the first seismic waves originate.

Epicentre

This is the point on the earth's surface directly above the focus. The hypocenter, also commonly called the focus, is the point within the earth where an earthquake rupture starts. Source:USGS.

The BBC website's graphic description of tectonic plate movement and the Sumatra earthquake that generated the 2004 Indian Ocean tsunami:

http://news.bbc.co.uk/1/hi/in_depth/4136289.stm

The Earthquake Hazards Programme of the United States Geological Survey publishes an up-to-date website atlas of Recent Earthquake Activity in the World. Take a look at:

http://earthquake.usgs.gov/recenteqsww/index.html

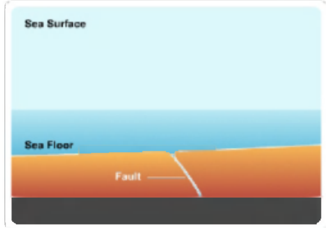
3.1 Media

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Usually, it takes an earthquake with a Richter scale magnitude exceeding 7.5 to produce a destructive tsunami.

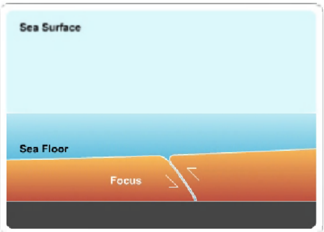
Step1

Not all earthquakes generate tsunamis. For that to happen, the fault where the earthquake occurs (subduction zone) must be underneath or near the ocean.



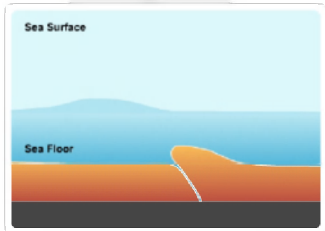
Step2

When the earthquake occurs, it causes a vertical movement of the sea floor (up to several metres) over a large area (up to 100,000 square kilometres).



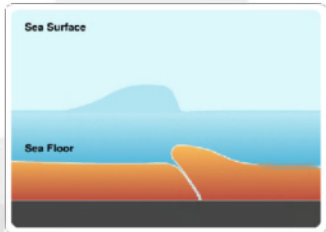
Step3

As the land mass shifts, the waves become broader and move outwards. The most destructive tsunamis are generated by large, shallow earthquakes that have an epicentre or fault line near or on the ocean floor usually along subduction boundaries where tectonic plates collide in regions of high seismic activity.



Step4

The amount of vertical and horizontal motion of the sea floor, the area over which it occurs, the simultaneous occurrence of slumping of underwater sediments due to the shaking, and the efficiency with which energy is transferred from the earth's crust to the ocean water to create destructive waves, are all part of the tsunami generation mechanism



3.1 Media

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

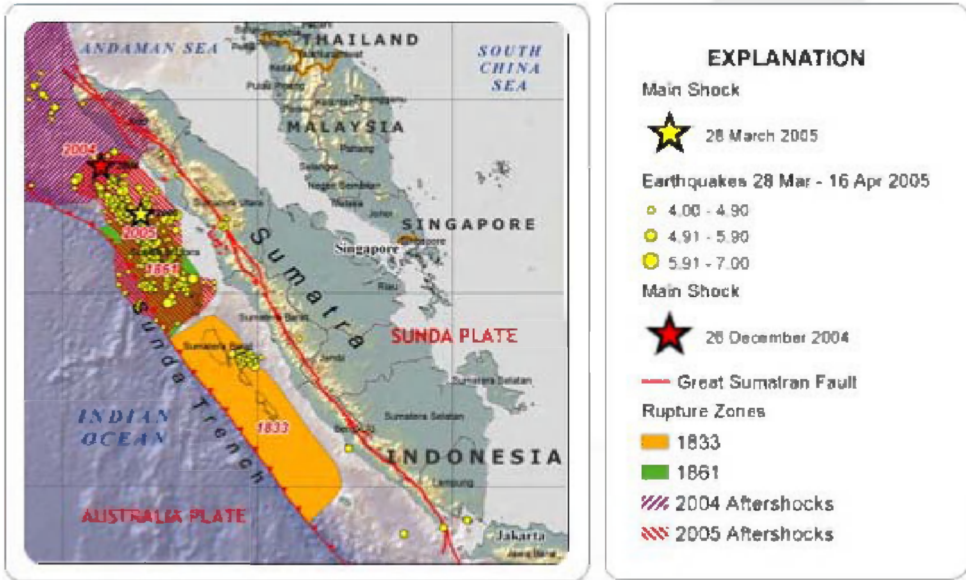
Earthquakes and tsunamis

The 2004 Indian Ocean tsunami was caused by a massive north-west Sumatra earthquake of a magnitude of 9.3.

Indonesia is an area of great seismic activity and will continue to experience big earthquakes and volcanic eruptions in the centuries to come, some of which could generate tsunamis. In addition, along the Sumatra fault two sections of rock are sliding past each other, cutting through the island. Earthquakes occur along both the trench and the fault.

The Sunda trench, a 5,500 kilometre (3,440 mile) subduction zone stretching from Myanmar towards West Australia, where the Indian and Australian tectonic plate is colliding with part of the Eurasian plate, runs parallel to western Sumatra about 200 kilometres (125 miles) offshore.

Read *National Geographic's* article on the subject: "Tsunami-battered Sumatra ripe for more disasters" at:
http://news.nationalgeographic.com/news/2005/01/0107_050107_tsunami_quake.html



3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Volcanic eruptions

Although relatively infrequent, violent volcanic eruptions are also impulsive disturbances that can displace a great volume of water and create extremely destructive tsunami waves in the immediate source area.

Waves are generated by the sudden displacement of water, caused by a volcano's slope failure or, more likely, by a phreatomagmatic explosion – an explosive volcanic eruption resulting from the interaction of water and magma – and the collapse of a volcano's magmatic chambers.

One of the largest and most destructive tsunamis ever recorded was on 26 August 1883, after the explosion and collapse of the volcano of Krakatoa (Krakatau) in Indonesia.

The explosion generated waves that reached 42 metres (nearly 130 feet) high, destroyed coastal towns and villages along the Sunda Straits on the islands of Java and Sumatra, and killed 36,417 people.

Landslides, rock falls and slumps

Less frequently, tsunami waves can be generated by displacements of water resulting from rock falls, icefalls and sudden submarine landslides or slumps.

Such events can be caused impulsively from the instability and sudden failure of submarine slopes. For example in the 1980s, earth moving and construction work on an airport runway along the coast of southern France, triggered an underwater landslide that generated destructive tsunami waves in the harbour of Thebes.

Major earthquakes are suspected to cause many underwater landslides, which may contribute significantly to tsunami generation. Many scientists believe that the 1998 tsunami, that killed thousands of people and destroyed villages on the northern coast of Papua New Guinea, was powered by an underwater slump of sediments triggered by an earthquake.

In general, the energy of tsunami waves generated from landslides or rock falls is rapidly dissipated as they travel away from the source and across the ocean, or in a body of water like a lake or fjord. But it should be noted that one of the biggest tsunami waves ever observed was caused by a rock fall in Lituya Bay, Alaska, on 9 July 1958. The wave reached a height of 520 metres (about 1,600 feet) and wiped out a forest.

3.1.2 The Great Waves - 3.1.2.2 Causes of Tsunamis

Asteroids, meteorites and explosions

Fortunately it is very rare for a meteorite or an asteroid to reach the Earth. No Asteroid has hit the planet, and no asteroid or meteorite has been documented to have generated a tsunami in recorded history.

However, large meteorites have struck in the distant past, evidenced by craters found in different parts of the earth. It is also possible that an asteroid fell to earth in prehistoric times – the last one some 65 million years ago during the Cretaceous period.

Since evidence of the fall of meteorites and asteroids on Earth exists, we must conclude that some have landed in oceans and seas, since four-fifths of the planet is covered by water. Their fall into oceans has the potential to cause tsunamis of cataclysmic proportions.

In 1997, scientists discovered evidence of an asteroid with a four kilometre (2.5 mile) diameter that landed offshore of Chile approximately two million years ago, producing a huge tsunami that swept over portions of South America and Antarctica.

Scientists have concluded that the impact of a moderately large asteroid, five to six kilometres (three to four miles) in diameter, in the middle of a large ocean basin such as the Atlantic, would produce a tsunami that would travel all the way to the Appalachian Mountains in the upper two-thirds of the United States. Across the Atlantic, coastal cities would be washed out.

An asteroid that size falling between the Hawaiian islands and the west coast of North America would produce a tsunami that would attack cities on the west coasts of Canada, the United States and Mexico and would cover most of the inhabited coastal areas of the Hawaiian islands.

It has not happened, but conceivably tsunami waves could be generated by very large nuclear explosions.

In 2002 *Newswise* and *Science News* reported on a prehistoric asteroid that scientists believe created a giant tsunami that swept around the Earth several times:
http://news.nationalgeographic.com/news/2002/08/0823_020823_asteroid.html

Before proceeding to the next section, view the excellent US National Science Foundation multi-media special report, "After the tsunami":
http://www.nsf.gov/news/special_reports/tsunami/index_high.jsp

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

This section provides an historical overview of tsunamis, and details major local, regional, and Pacific-wide events starting with the destruction of Lisbon in 1755, moving through the centuries to the 1990s and culminating with a description of the 2004 Indian Ocean tsunami.

The intention is to portray the havoc that tsunamis have wreaked through history and the ongoing threat to humankind, and to provide materials that can be used to grow public awareness and understanding of tsunamis.

The Wave. Painting by Lucas Rawah of Aitape, done to commemorate the 17 July 1998 Papua New Guinea tsunami. A magnitude 7.1 earthquake is thought to have triggered a submarine landslide, generating a tsunami that destroyed entire villages along the Aitape coast. Credit: ITIC.

Read the Newsweek story titled "The Tsunami Threat" here:

http://www.msnbc.msn.com/id/6777713/site/newsweek/

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

Although they occur relatively infrequently, tsunamis rank among the most life-threatening of natural disasters. In the past century-and-a-half, tsunamis have claimed hundreds of thousands of lives and wreaked billions of dollars worth of damage to coasts and structures.

Since scientists cannot predict when earthquakes will occur, they cannot determine exactly when a tsunami will happen.

But by studying geology, oceanography and historical events, scientists know where tsunamis are most likely to be generated. Past tsunami height measurements are useful in predicting future tsunami impact and flooding limits at specific coastal locations.

Paleotsunami research, in which scientists study sediments deposited by giant tsunamis, is helping to extend the documented historical tsunami record further back in time. As more events are found, better estimates of how often tsunamis occur in a region are obtained.

1 April 1946. People flee as a tsunami attacks downtown Hilo, Hawaii. Credit: Bishop Museum Archives.

View the biggest Tsunami Countdown website which details the world's five biggest tsunamis:

http://fohn.net/biggest-tsunami/

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

In *2004 Science Year*, *The World Book Annual Science Supplement*, Dr Laura Kong, the director of UNESCO-IOC's International Tsunami Information Centre in Hawaii, described the significant contributions tsunami research has made to human understanding of the phenomenon.

Let us read through these research contributions chronologically from the 1980's to the late 20th century for a better understanding.

The Past Century

In the past century many tsunamis have been extensively documented, especially in Japan and the Mediterranean. According to the National Oceanic and Atmospheric Administration (NOAA) in the United States:

"Since 1900 (the beginning of instrumentally located earthquakes), most tsunamis have been generated in Japan, Peru, Chile, New Guinea and the Solomon Islands. However, the only regions that have generated remote-source tsunamis affecting the entire Pacific Basin are the Kamchatka Peninsula, the Aleutian Islands, the Gulf of Alaska and the coast of South America. Hawaii, because of its location in the center of the Pacific Basin, has experienced tsunamis generated in all parts of the Pacific."

"The Mediterranean and Caribbean Seas both have small subduction zones, and have histories of locally destructive tsunamis."

"Only a few tsunamis have been generated in the Atlantic and Indian Oceans. In the Atlantic Ocean, there are no subduction zones at the edges of plate boundaries to spawn such waves except small subduction zones under the Caribbean and Scotia arcs. In the Indian Ocean, however, the Indo-Australian plate is being subducted beneath the Eurasian plate at its east margin. Therefore, most tsunamis generated in this area are propagated toward the southwest shores of Java and Sumatra, rather than into the Indian Ocean."

The 2004 Indian Ocean tsunami was a devastating exception.

The Last Half of 20th Century

In the **last half of the 20th Century**, Pacific-wide destructive tsunamis struck in 1946, 1952, 1957, 1960, and 1964. Many more destructive local or regional tsunamis occurred in inland seas on the Pacific Rim, killing thousands of people.

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

Although not as frequently, tsunamis have also attacked coastlines in other areas, including the Indian and Atlantic oceans, Mediterranean and Caribbean seas, and smaller bodies of water.

During the 1990s alone there were 17 regional or local tsunamis. More than 4,000 people were killed by tsunamis during the decade, including 1,000 in the 1992 tsunami in the Flores region of Indonesia, and 2,200 in the 1998 Papua New Guinea tsunami.

The Late 1980s

In the **late 1980s** two teams of scientists began to build databases on tsunamis. One team was lead by geophysicist James F Lander of the US National Geophysical Data Center in Colorado, and the other by geophysicist Viacheslav K Gusiakov of the Tsunami Laboratory in Novosibirsk, Russia. While 80 percent of all tsunamis occur in the Pacific Ocean's Ring of Fire:

"The databases enabled researchers to more clearly see that tsunamis threaten coastlines around all oceans of the world, as well as the shores of the Mediterranean and Caribbean seas…

"Lander's and Gusiakov's databases indicate that tsunamis have been devastating communities around the Ring of Fire for thousands of years. Chinese accounts of tsunamis began 4,000 years ago, and Japanese accounts date back about 1,300 years. However, detailed information is available only for tsunamis that occurred in the past 500 years or so."

The 1990s

During the 1990s other scientists studied conditions that contributed to the generation of tsunamis in the past and compared them with current conditions in various parts of the world, wrote Dr. Costas Synolakis and Dr. Emile Okal.

Hydrodynamic engineer Costas Synolakis, of the University of Southern California in Los Angeles, intensively investigated the site of the 1998 Papua New Guinea tsunami and concluded that the moderate earthquake that occurred at the time could not have been its sole cause, and that a landslide triggered by the earthquake contributed to the violent tsunami.

His research was pooled with that of seismologist Emile Okal of Northwestern University in Illinois, who studied Seismic and hydroacoustic (underwater sound) data recorded on the day of the earthquake.

Using a computer programme that mathematically described the events of the day, physical process they were able to show that an underwater landslide could have generated the tsunami.

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

The Early 21st Century

In the early part of this century, paleotsunamis (prehistoric tsunamis) captured the interest of the scientific community. The goal of this relatively new science, in which geologists examine uncharacteristic sediments found in different areas, is to discover how they got there.

"For example, a scientist who is working inland might discover a kind of sand and or gravel that is normally found only on an ocean coast. By studying the material and the surrounding area, the scientist might determine that a tsunami carried the material inland. Perhaps he or she could even learn when and where the tsunami struck and how much land the waves covered."

Starting in the 1980s Brian F Atwater of the US Geological Survey and other geologists began mapping deposits found in the Pacific Northwest of the United States. In 2001, the researchers reported that sand and gravel at over 50 inland sites in north California, Oregon, Washington and Vancouver Island, Canada, had been deposited by a tsunami that struck in about 1700.

In some places deposits extended as far as 10 kilometres (over six miles) inland, and in others waves bearing the sediment had poured over coastal barriers eight metres (21 feet) high. Some sediments were about 3,500 years old. According to Dr Kong:

"Researchers had proved that tsunamis had struck the area in the past and had found evidence of how far inland the waters had flowed. As a result, they had shown that damaging tsunamis may occur in the area again and that such waves would affect many currently populated areas."

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

The International Tsunami Information Centre has drawn up historical lists of teletsunamis – those that originate from a distant source, generally over 1,000 kilometres (625 miles) away – and of regional and local tsunamis. The first details teletsunamis that have occurred during the past three-and-a-half centuries.

Teletsunamis recorded since 1650

Date	Source location	Estimated dead or missing
20 October 1687	Peru	500
7 June 1692	Jamaica	*3,000
26 January 1700	Cascadia, Northeast Pacific	N/A
8 July 1730	Chile	0
25 May 1751	Chile	30
1 November 1755	Lisbon, Portugal	*10,000
24 April 1771	Ryukyuu Islands	12,000
2 February 1835	Chile	3
7 November 1837	Chile	62
24 December 1854	Japan	3,000
13 August 1868	Chile	*26,000
10 May 1877	Chile	500
31 December 1881	Bay of Bengal	N/A
27 August 1883	Krakatau, Indonesia	*30,000
15 June 1896	Sanriku, Japan	*22,000
31 January 1906	Colombia-Ecuador	500
17 August 1906	Chile	N/A
7 September 1918	Kuril Islands	47
11 November 1922	Chile	100
3 February 1923	Kamchatka, Russia	2
1 September 1923	Kanto, Japan	2,144
2 March 1933	Sanriku, Japan	3,000
7 December 1944	Tonankai, Japan	1,038
1 April 1946	Aleutian Islands, U.S.A	179
20 December 1946	Nankaido, Japan	1,997
4 March 1952	Hokkaido, Japan	33
4 November 1952	Russia	N/A
9 March 1957	Aleutian Islands, U.S.A	5
22 May 1960	Chile	2,000*
28 March 1964	Alaska, U.S.A	132
4 February 1965	Aleutian Islands, U.S.A	0
16 May 1968	Honshu, Japan	52
4 October 1994	Shikotan Island, Russia	11
21 February 1996	Peru	15
26 December 2004	Northern Sumatra	*250,000

*May include earthquake casualties. N/A; Numbers not available

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

The International Tsunami Information Centre has also compiled lists of regional and local tsunamis. The list below details regional and local tsunamis measured since 1975.

Regional tsunamis are capable of destruction in a particular geographic region, according to the ITIC, generally within about 1,000 kilometres (625 miles) of its source, and occasionally can have very limited effects outside the region.

Local tsunamis strike from a nearby source and their destructive effects are confined to coasts within 100 kilometres (62.5 miles) of the source.

Regional and local tsunamis measured since 1975.

Date	Source location	Estimated dead or missing
29 November 1975	Hawai, U.S.A	2
17 August 1976	Moro Bay, Philippines	*4,000
19 August 1977	Sumbawa, Indonesia	189
18 July 1979	Lembata IS, Indonesia	187
16 October 1979	French Riviera	6
12 December 1979	Narino, Colombia	500
11 May 1981	South Africa	0
26 May 1983	Sea of Japan	100
3 March 1985	Chile	*377
22 April 1991	Atlantic Ocean (Central America)	2
25 April 1992	California, United States	0
2 September 1992	Nicaragua	168
12 December 1992	Flores Island, Indonesia	*1,000
12 July 1993	Sea of Japan	*330
3 June 1994	Java, Indonesia	222
3 November 1994	Skagway, Alaska, United States	1
14 November 1994	Verde Island Passage, Philippines	*74
15 June 1995	Gulf of Corinthos, Greece	0
30 July 1995	Chile	3
9 October 1995	Manzanillo, Mexico	1
1 January 1996	Sulawesi, Indonesia	9
17 February 1996	Irian Jaya, Indonesia	110
17 July 1998	Papua New Guinea	2,200
17 August 1999	Izmit, Turkey	0
23 June 2001	Peru	26
3 January 2002	Vanuatu	0
30 December 2002	Stromboli, Italy	0
21 May 2003	Algeria	0
25 September 2003	Hokkaido, Japan	2

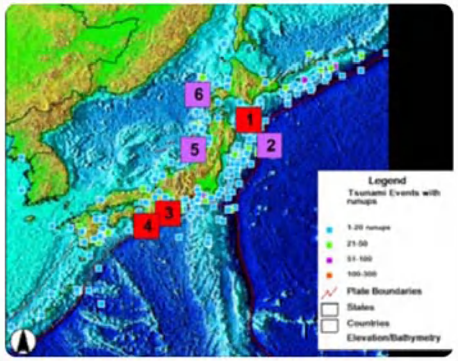
*May include earthquake casualties.

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

In the past century, many tsunamis have been extensively documented, especially in Japan and the Mediterranean.

Japan

According to the World Data Centre, almost 25% of the world's observed and verified tsunamis have occurred in Japan. Detailed observations dating back to 600 A.D. has been compiled to produce the most complete tsunami record in the world. Japan's greatest tsunami hazard is from locally-generated, large earthquakes occurring off Japan's eastern coasts where the Pacific Plate subducts along the Japan Trench in the north, and the Philippine Plate subducts along the Nankai Trench in the south where the Philippine plate. Local tsunamis also occur within the back-arc basin of the Japan Sea west of Japan. Japan has been struck by regional tsunamis occurring to the north off of the Kurile Islands and Kamchatka, and distant tsunamis such at the 1700 Cascadia tsunami and 1960 Chile tsunami that crossed the entire Pacific Ocean.



Major Tsunami Disaster in Japan

Pyroclastic flows impacting the sea at Stromboli volcano have generated small local tsunamis.

Major Tsunami Disasters In Japan

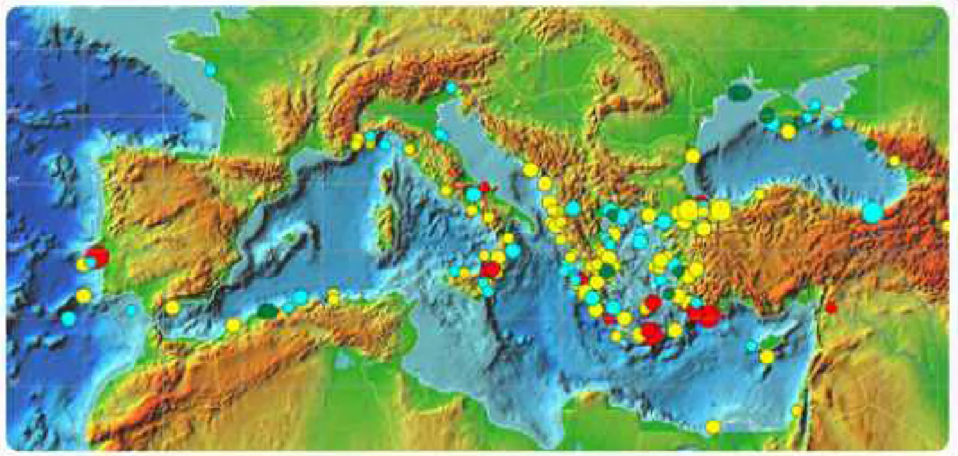
Date	RunupHeight, m	Dead, Missing
1896/06/15	24.4	22,000 #
1933/03/03	23	3,064 #
1944/12/07	9	998 *
1946/12/21	6.5	1,330 *
1983/05/26	6.6	104 #
1993/07/12	29	230 #

* Mostly by Earthquake # Mostly by Tsunami

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

Mediterranean

The World Data Centre reports that nearly 9% of the world's tsunamis, with the 60% of these occurring in primarily the Eastern Mediterranean and connected seas (South Italy, Corinth Gulf, Aegean Sea, Levantine Sea, Marmara Sea, Black Sea). Locally-destructive tsunami have been reported dating back several thousand years. Landslide and volcanically-generated tsunamis are also causes; the greatest example being the pre-historic Storegga submarine landslide off Norway 8000 year ago, and most recently the eruptions of Stromboli volcano and a local damaging tsunami in 2002. The region, especially in the eastern portion is tectonically complex with many microplates. In the western Mediterranean and into the eastern Atlantic, tsunamis are the result of the interactions between the Eurasian and African Plates. In the Euro-Mediterranean seas, the distances are small so that tsunami attack typically within about 40-50 minutes. Updates to the GITEC-TWO European Tsunami Catalogue are undertaken cooperatively.



Earthquakes generating tsunamis in the Mediterranean and connected seas. Circle color indicates extent of tsunami damage (greatest is red, followed by yellow, blue, and green). The size of the circle is scaled to the magnitude of the earthquake. Source: ITDB, 2005.

Take a look at NOAA's world map of earthquake tsunami events:

http://map.ngdc.noaa.gov/website/seg/hazards/viewer.htm

3.1.3 Tsunamis down the years - 3.1.3.1 A Short history

How common are tsunamis?

Cataclysmic tsunamis go down in history, and tsunamis are known to be relatively infrequent although they hold the potential to claim massive death tolls. But tsunamis might well be more common occurrences than is generally understood in the public mind.

The ITIC lists show that 23 teletsunamis and regional and local tsunamis have been measured since 1990, and that one to three tsunamis are measured almost every year, indicating that they are more common than most people realize.

In the aftermath of the tsunami of 26 December 2004. Galle bus station

Tsunami of 26 December 2004. Bamboo poles shipped from the mainland at the village being reconstructed on Ko Surin.

For more detail on local or regional tsunamis since 1992, and on Pacific-wide tsunamis, go to the ITIC website. A list of dates leads to information of some individual tsunamis. 'Follow the links from Tsunami Events.'

http://www.tsunamiwave.info/

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

The 2004 Indian Ocean tsunami killed more people than any other tsunami in recorded history. But other events have claimed tens of thousands of lives, and some have generated higher waves and have been just as destructive when they struck coastlines.

One of the reasons for the 2004 disaster's enormous death toll was the increased population concentration in coastal areas. In Banda Aceh, for example, there were far more people living along the coastline than there would have been 200, 100, or even 30 years ago.

Where large numbers of people have been killed in the past, it has been because a tsunami attacked an area of high population density, such as Lisbon in 1755 when an estimated 10,000 people died, or when a tsunami has been particularly destructive, such as Krakatau in 1883, which generated waves 42 metres (nearly 130 feet) high and killed up to 30,000 people.

Tsunami deposit from 1883 Krakatau tsunami. Anyer, Indonesia. Credit: ITIC

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

The following pages provide brief descriptions of several of the world's worst tsunamis. Some are rated such because of their devastating death tolls, others because of the extreme height of their waves, or the spread of their destruction.

Much of this material is drawn from the UNESCO-IOC International Tsunami Information Centre and the World Data Centre for Solid Earth Geophysics – Tsunami hosted by NOAA.

Sri Lanka southern coast, after the tsunami of 26 December 2004.

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

Knowledge of tsunamis down the years is useful to scientists who are researching how tsunamis impact on different coastlines, to experts and authorities who are working to improve the preparedness of coastal communities, especially in high risk regions – and to journalists in search of interesting information.

Let us go through the descriptions of some of the worst tsunamis in history and update our knowledge.

1692: The Port Royal tsunami

On 7 June 1692 a devastating earthquake hit the town of Port Royal, near Kingston in Jamaica. The sand-spit on which the town was built began to liquefy and flow out into Kingston Harbour, and a tsunami further eroded the sand, sinking the town below water.

The tsunami is reported to have lifted a large English sailing vessel from the harbour on one side of the peninsula on which the town was located, carried it over the two-storey buildings in the town, and deposited it in the sea on the other side of the peninsula.

It is told that some frantic residents managed to grab the ship's cables and rigging and climb aboard to safety as it swept by. About 3,000 people were killed either by the earthquake or by the tsunami – half of the town's population.

1755: The Lisbon earthquake and tsunami

On 1 November 1755 an earthquake occurred off the coast of Lisbon in Portugal, believed to measure 9.0 on the Richter scale. It shook and cracked the city for up to six minutes.

The earthquake spawned three tsunami waves. The first wave engulfed the harbour and downtown city. Fires broke out in areas not swamped by the waves and raged for five days. Eighty five percent of Lisbon's buildings were reportedly destroyed.

Initially the earthquake and tsunami together killed up to 90,000 people – a third of the Lisbon population – with about 30,000 of the deaths attributed to the tsunami. Recently, the number of casualties had been revised after more research to about 10,000.

The great waves also wreaked destruction throughout southern Portugal and parts of Spain, the English south coast and the west coast of Ireland.

Tsunami waves up to 20 metres high struck the coast of North Africa, claiming a further 10,000 lives, and waves crossed the Atlantic to attack Martinique and Barbados.

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

Other Atlantic tsunamis

Also in the Atlantic, a moderate tsunami hit the northwest coast of Puerto Rico in 1918, following an offshore earthquake along the North Atlantic and Caribbean Plate boundary. And on 18 November 1929, an earthquake in the Grand Banks of Newfoundland catalyzed a tsunami that claimed lives and caused damage at Placentia Bay, Newfoundland.

For more information on the Lisbon tsunami, go to Wikipedia at:

http://en.wikipedia.org/wiki/1755_Lisbon_earthquake

1883: The Krakatau tsunami

May 1883 marked the beginning of months of spectacular eruptions of Krakatau (Krakatoa) volcano in Indonesia, and they were watched with fascination by people on passing ships and the inhabitants of nearby Java and Sumatra

A series of cataclysmic explosions started on 26 August 1883 and ended the following day, when the northern two-thirds of the island collapsed and generated a series of massive tsunami waves – one of the largest and most destructive tsunamis ever recorded.

Waves reached 42 metres (up to 130 feet) as they struck shore, killing an estimated 30,000 people and demolishing 295 coastal towns and villages along the Sunda Strait on the islands of Java and Sumatra.

US scientists who studied unusual pumice-enriched deposits from the inundation of coasts by the Krakatau tsunami, have argued that recognition of such deposits on coasts in areas of active volcanoes could provide an extra criterion with which to assess volcanic hazards.

(Another devastating volcano-generated tsunami was the explosion or collapse of Santorin in the Aegean Sea in 1490 BC. It is thought to have destroyed Greece's Minoan civilization.)

Take a look at this interesting account of the Krakatau explosions and tsunami on the website of the Department of Geological Sciences at San Diego State University:

http://www.geology.sdsu.edu/how_volcanoes_work/Krakatau.html

1896: The Great Sanriku tsunami

The most devastating tsunami in Japanese history happened on 15 June 1896, and was caused by an earthquake. The Great Sanriku tsunami generated waves of 25 metres (nearly 80 feet) that reached the coast of Japan in 35 minutes, killed over 22,000 people and destroyed the port of Sanriku and villages along 275 kilometres (172 miles) of coastline.

Across the Pacific Ocean in Hawaii, wharves were demolished and houses swept away. Waves three metres (over nine feet) high were observed in California. The disaster provided the catalyst for tsunami research in Japan.

One hundred years later to the day, the Geophysical Research Letters of the American Geophysical Union published research explaining why the tsunami was much larger than would have been expected from an earthquake of 7.2 on the Richter scale.

Two US scientists had developed a computer simulation model to describe conditions that produced the unusual tsunami. Their results indicated that the source of the earthquake was very close to the Japan trench – unlike other quakes in the region whose sources were closer to the coast – and that it ruptured in a relatively shallow area.

If a substantial earthquake occurs in the same area in the future, a resulting tsunami could be unusually large, like the 1896 event. This is a good example of how research into historical tsunamis can assist in the prediction of destructive tsunamis in the future.

Refer [3.1.3 - 03of 03] to view a historical account of the 1896 GreatSanriku earthquake and tsunami from the Japan Science and Technology Agency (JST) Knowledge Failure Database [PDF] in the CD - ROM

For more information about the American Geophysical Union's research, visit:

http://www.agu.org/sci_soc/sanriku.html

1908: The Sicily tsunami

On 28 December 1908 the most destructive earthquake in recorded European history struck the Straits of Messina in southern Italy, flattening the cities of Messina in Sicily and Reggio di Calabria in Italy.

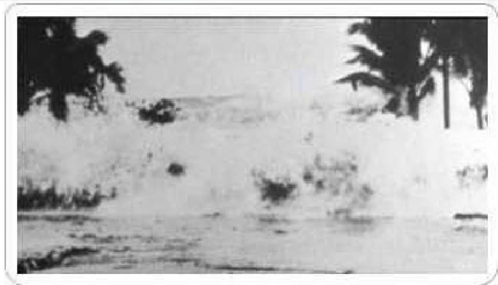
The quake measured about 7.5 on the Richter scale and generated a tsunami with waves of over 12 metres (nearly 40 feet) that swamped towns and cities in the area, which is known as "la terra ballerina" (the dancing land) for its periodic seismic activity.

Together the earthquake and tsunami killed an estimated 58,000 people. Stretches of coastline sank into the sea. Hundreds of smaller tremors in the following days destroyed remaining buildings and more people died.

1946: The Aleutian tsunami

One of the most destructive Pacific-wide tsunamis of the 20th Century occurred on 1 April 1946, and it led to the United States establishing a Pacific Tsunami Warning Center in Hawaii in 1949.

The Aleutian tsunami was generated by a magnitude 7.8 earthquake (with a moment magnitude of 8.6) near Unimak in Alaska's Aleutian Island Chain. A 35 metre (nearly 110 feet) high wave destroyed the reinforced concrete US Coast Guard's Scotch Cap lighthouse on Unimak, which stood about 30 metres (90 feet) above sea level, and claimed the lives of all its five occupants.



The tsunami generated by the earthquake of April 1, 1946, in the Aleutian Islands, Alaska striking the beachfront area at the Puumaile Tuberculosis Hospital on the Island of Hawaii, about 3,800 km from the generating area. In this area east of Hilo, Hawaii, waves were 6.1 m high overtopping the breakwater and causing minor flooding at the hospital. These catastrophic waves engulfed the Hawaiian Islands suddenly and unexpectedly. The maximum rise of water was almost 8 m in Hilo and as much as 12 m in other areas on the island of Hawaii.
Photograph Credit: Mrs. Harry A. Simms, Sr.

Destructive tsunami waves reached the Hawaiian Islands five hours later, completely obliterating Hilo's waterfront on the island of Hawaii. The tsunami claimed a total of 161 lives, including children attending school at Hawaii's Laupahoehoe Point, where waves reached up to eight metres (25 feet). A hospital was also destroyed.

The tsunami wreaked destruction along the coasts of Alaska (where some waves reached over 12 metres, or nearly 40 feet), British Columbia, Washington, Oregon and California, where one person drowned.

The Pacific Tsunami Warning Center in Hawaii served as headquarters for a United States national tsunami warning system, and in 1965 it was integrated with other national warning systems to become the Pacific Tsunami Warning System. As a result of this event, the Seismic Sea Wave Warning System (now the PTWC) was started in 1949 to provide early warnings against tsunamis.

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

Wreckage of the political party club-house, Kamehameha Avenue, Hilo, Hawaii after the tsunami generated by an earthquake in the Aleutian Islands, Alaska struck April 1, 1946. Every house on the main street facing Hilo Bay was washed across the street and smashed against the buildings on the other side. Houses were overturned, railroads ripped from their roadbeds, coastal highways buried, and beaches washed away. The waters off the island were dotted with floating houses, debris, and people. Property damage in Hawaii was $26 million (1946 dollars). Photo-graph Credit: U.S. Army Corps of Engineers.

1958: The Alaska tsunami

The largest tsunami wave ever observed anywhere was caused by a rock fall in Lituya Bay, Alaska, on 9 July 1958.

Following an earthquake along the Fairweather fault, an approximately 40 million cubic metre rock-fall at the head of the bay generated a wave that grew to the amazing height of 520 metres (nearly 1,600 feet) on the opposite side of the inlet.

A huge solitary wave sped at about 160 kilometres (100 miles) per hour across the long and narrow bay, stripping trees from the opposite headland, destroying three fishing boats and killing two people.

The tsunami's energy and height diminished rapidly away from the source and out in the open ocean it was hardly picked up by tide gauge stations.

Two survivors of the tsunami, Bill and Vivian Swanson, who were in their boat on the bay, later described an amazing "wild ride" on top of the wave that surfed them above trees on the shore and "rocks as big as houses".

Short excerpts from these and another eye-witness accounts, published on the NOAA website, make gripping reading:

http://wcatwc.arh.noaa.gov/web_tsus/19580710/narrative1.htm

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

1960: The Chilean tsunami

The largest earthquake of the 20th Century, measuring 9.5 on the Richter scale, occurred on 22 May 1960 off the coast of south-central Chile. It generated one of the most destructive Pacific-wide tsunamis ever.

The total number of fatalities from both the earthquake and tsunami was never accurately established, but estimates are that the tsunami claimed about 2,000 lives.

Both the earthquake and the tsunami were highly destructive near the point of origin, and particularly along the coast extending from Concepcion to the southern end of Isla Chiloe, which was closest to the epicentre at Valdivia, 700 kilometres (438 miles) south of Santiago.

Tsunami waves 25 metres (nearly 80 feet) high struck Isla Chiloe within 10 to 15 minutes, killing at least 200 people, sinking all boats and inundating half a kilometre (a third of a mile) inland. There was extensive damage to and loss of life in the industrial city of Concepcion.

Around 130,000 houses in the earthquake zone were destroyed – one in three – and around two million people were left homeless.

The tsunami was destructive throughout the Pacific Ocean but especially in the Hawaiian Islands – 10,000 kilometres (6,250 miles) away – and in Japan, where there was extensive loss of life and damage. At Hilo Bay in Hawaii the waterfront was completely destroyed and 61 people died.

Tsunami waves and run-up were also experienced along the western coast of the United States, and at Crescent City in California waves reached 1.7 metres (over five feet) and caused minor damage.

You can find out more about this massive disaster on the US Geological Survey Earthquake Hazards Programme website at:

http://neic.usgs.gov/neis/eq_depot/world/1960_05_22_articles.html

Aerial view of the coastal area on Isla Chiloe, Chile, showing tsunami damage and wave extent. Two hundred deaths were reported here from the tsunami generated just off Chile's coast by a magnitude 8.6 earthquake on May 22, 1960. The inhabitants, fearing the earthquake, took to small boats to escape the shaking. The trough of the tsunami arrived 10 to 15 minutes after the earthquake. Upon the return of the sea in a thunderous breaker, all boats were lost. The total property damage from the combined effects of the earthquake and tsunami in Chile was $417 million (1960 dollars). Over 1,000 people were killed, most of them by the tsunami. Photograph Credit: Unknown.

Aftermath of the 1960 tsunami in Hilo, HI generated by the earthquake of May 22, 1960, off the coast of Chile. Parking meters were bent by the force of the debris-filled waves. The earthquake-generated tsunami affected the entire Pacific Basin. One of the most seriously affected areas was Hilo, Hawaii, where 61 deaths and $23 million in damage occurred. In the area of maximum destruction, only buildings of reinforced concrete or structural steel, and a few others sheltered by these buildings, re-mained standing. Photograph Credit: U.S. Navy.

1964: The Alaska earthquake and tsunami

The northern hemisphere's biggest earthquake of the 20th Century, with a magnitude of 9.5, occurred on 28 March 1964 and struck an area in Alaska 1,600 kilometres (1,000 miles) long and 300 kilometres (188 miles) wide, from Valdez to the Trinity Islands in the Gulf of Alaska.

The earthquake caused some areas to be lifted by as much as 15 metres (nearly 50 feet), while many other areas subsided.

According to the ITIC, in addition to local tsunamis in the Prince William Sound, a Pacific-wide tsunami was generated by vertical crustal displacements averaging 1.8 metres (six feet) over an area of about 300,000 square kilometres (188,000 square miles) across the Gulf of Alaska's continental shelf.

In all, the tsunami killed 132 people and caused $106 million in damage, making it the costliest ever to strike the western United States and Canada.

It was very destructive in south-eastern Alaska, Vancouver Island in Canada and in the US states of Washington, California and Hawaii.

Five of Alaska's seven largest communities were devastated by the earthquake and tsunami. Alaska's fishing industry and most seaport facilities were all but destroyed. At Kodiak Island waves washed away 158 buildings and swept fishing boats inland.

The waves affected the entire California coastline, but hardest hit was Crescent City where waves of up to six metres (nearly 20 feet) destroyed half of the waterfront business district and many people died. There was also extensive damage at San Francisco Bay, in Marin County and in the Noyo, Los Angeles and Long Beach harbours, and some damage reported at Santa Cruz harbour.

Survivors in California of the 1964 tsunami relived their experiences in this *National Geo-graphic* article:

http://news.nationalgeographic.com/news/2005/01/0121_050121_1964_tsunami.html

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

A tsunami surge wave produced by the March 27, 1964 earthquake in Prince William Sound, Alaska left a 2 x 12 in. (5.2 x 31 cm) plank in a truck tire at Whittier, Alaska. Whittier incurred $10 million in property damage (1964 dollars). The tsunami that struck Whittier was generated by one of the largest shocks (magnitude 8.4) ever recorded on the North American Continent and the most destructive in Alaska's history. Photograph Credit: U.S. Geological Survey.

Damage resulting from a tsunami generated by an earthquake March 27, 1964 in the Prince William Sound, Alaska. View of the north end of Resurrection Bay at Seward, Alaska, about 75 km from the epicenter. An overturned ship, a demolished Texaco chemical truck, and a torn-up dock strewn with logs and scrap metal are visible. Photograph Credit: U.S. Department of the Interior.

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Tsunami Teacher
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3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

1993: Okushiri Island earthquake and tsunami

July 12, 1993 – Okushiri Island, off the Southwest Coast of Hokkaido, Japan

An earthquake of magnitude 7.8 on July 12, 1993 in the Japan Sea generated a tsunami with a maximum run-up height of 30 meters on Okushiri Island, a small island off southwest of Hokkaido. Thetsunami struck the island within four minutes after the earthquake and overtopped the seawalls surrounding the small peninsula town of Aonae at the south end of Okushiri. Hundreds of houses were crushed and washed away, mudslides triggered and fires burned, and 230 people were killed. Afterward, this area was designated as a park and memorial so that no tsunami waves would ever damage this area again. Elsewhere on the Japanese coastline seawalls, some as much as 4.5 meters high, lessened the destruction caused by the tsunami. The tsunami was mainly confined to the Japan Sea, but also caused some destruction in Korea and Russia. The 1993 tsunami occurred 10 years after a M7.7 Japan Sea earthquake that also generated a tsunami so that Okushiri townspeople still had remembered the safety measures when the 1993 tsunami struck.

Click here to view an abstract of the scientist's paper.

http://www.agu.org/sci_soc/sanriku.html

Refer [3.1.3 - 03of 03] to view a historical account of the 1993 Okushiri earthquake and tsunami from the Japan Science and Technology Agency (JST) Knowledge Failure Database. in the CD - ROM

3.1.3 Tsunamis down the years - 3.1.3.2 Amazing tsunamis

1998: Papua New Guinea

One of the most destructive and deadly tsunamis in recent years was on 17 July 1998. It was generated by an earthquake off the northern coast of Papua New Guinea that measured 7.1 on the Richter scale and apparently triggered a large underwater landslide.

Minutes after the earthquake shook the region, and in the darkness of the early night, three tsunami waves attacked a 30 kilometre (19 mile) stretch of coastline in West Sepik province. The largest wave was estimated to be 10 metres (over 30 feet) high.

The ITIC reports survivors feeling their homes tremble as the earthquake shook the seabed. About a minute later they heard a roar “like a jet fighter landing”, and about 18 minutes later the sea was quiet again.

Some 2,200 people were killed, most of them children, primarily in the villages of Sissano, Warupu, Arop and Malol along the shores of Sissano lagoon. Another 1,000 people were injured and more than 10,000 were left homeless. Two of the villages were completely swept away, and palm and coconut trees were ripped out of the ground.

Northern Papua New Guinea is a very active seismic region involving complex interactions and movements of tectonic plates. It is where the smaller Caroline tectonic plate subducts the larger Australian tectonic plate. According to the ITIC:

“.... many and bitter. Today, Papua New Guinea has joined the ICG/PTWS in an effort to work together in the region to build tsunami preparedness against local and regional tsunamis.”

The sand spit where the two Arop villages once stood. In the foreground are remains of a septic tank. The wave removed almost all other traces of the several hundred houses that stood on the sand spit. (Photo credit: Hugh Davies, University of PNG.)

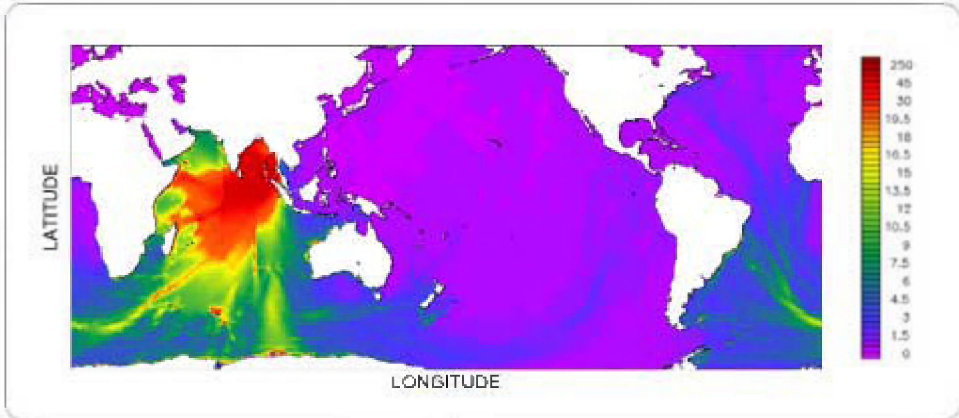
The 76-year-old church at Sissano Mission, photographed in 1990 (top). The bottom frame shows all that remained after the tsunami. A collapsed two-story classroom building can be seen on the far right of the photo. A classroom building that was only slightly damaged is on the left of the photograph (in the background). It was almost 400 m from the shoreline. (Photo credits: Father Eugene McKinnon, OFM; Hugh Davies, University of PNG.)

A two-story wooden school building that stood near the church at Sissano Mission was carried 65 m by the wave until caught by a grove of coconut palms. The lower floor of the building collapsed, but the upper floor class rooms were preserved. Schoolwork was still hanging on the wall. (Photo credit: Hugh Davies, University of PNG.)

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

On 26 December 2004 a massive earthquake off Sumatra generated a tsunami that quickly and violently struck Indonesia before radiating out to hit the Andaman islands (half-an-hour), Thailand (90 minutes), Sri Lanka and India (after two hours), the Maldives and finally, seven hours later, the east coast of Africa.

The Sumatra earthquake turned out to be more powerful than initially believed. Research by United States seismologists put it at 9.3 and not M8.0 as initially measured in the first few minutes by the geophysical and tsunami centres, or 9.0 an hour later after the earthquake had stopped rupturing – second only to the 9.5 magnitude quake recorded in Chile in 1960.

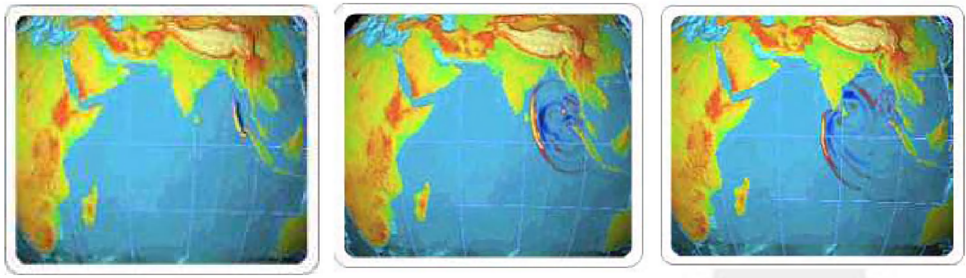


Maximum calculated global wave heights (cm) from the 26 December 2004 Indian Ocean tsunami. Observed waves were recorded on sea level gauges in Antarctica, and along the coasts of South and North America and Canada in both the Pacific and Atlantic Oceans (NOAA PMEL).

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Additionally, after seeing the tsunami's destructive trail firsthand, scientists reported that the waves were much larger than first estimated through numerical modeling.

A research team, led by Yoshinobu Tsuji of the University of Tokyo, found evidence that the wave height along a section of the shoreline south of Banda Aceh in Indonesia averaged over 24 metres (about 75 feet), with run-ups on island slopes often reaching over 30 metres (90 feet), and that the tsunami's average speed on the shore was 13.72 metres (42 feet) per second.



Computer simulation of the tsunami from the Sumatra earthquake as it progressed across the Indian Ocean. Source, NOAA PMEL

Read the *New Scientist* story on the power of the Sumatra earthquake at:

http://www.newscientist.com/article.ns?id=dn6991

Read the full *Seattle Post-Intelligencer* article at:

http://seattlepi.nwsource.com/local/211012_tsunamiscience07.html

View the illustrations of the Sumatra earthquake featured in a Science Magazine special edition, contained on the Incorporated Research Institutions for Seismology (IRIS) website at:

http://www.iris.iris.edu/sumatra/

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The tragedy

The tsunami destructively struck 12 countries – Indonesia, Sri Lanka, India, Thailand, Maldives, Malaysia, Myanmar, Bangladesh and, in Africa, Somalia, Kenya, Tanzania and the Seychelles – causing unprecedented destruction in terms of scale and geographical distribution.

Most of the coasts the tsunami swamped were home to poor coastal communities, and it destroyed basic services, critical infrastructure, administrative capacity and livelihoods.

Most shocking was the Indian Ocean tsunami's death toll, which was by far the highest in recorded history. Worst hit was Indonesia, followed by Sri Lanka and India. Only major earthquakes and diseases and wars have claimed more human lives.

The vast destruction of Moratuwa, a coastal town in the Southwest of Sri Lanka, caused by the tsunami of 26 December 2004.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The US Geological Survey recorded the toll as 283,1000 killed – about a third of them children – 14,100 missing and 1,126,000 people displaced. The United Nations figure, is 231,452 people killed.

The tsunami had multiple and different impacts on many countries, and not only those where the waves struck.

Up to 9,000 foreign tourists died alongside local people, and so the tsunami reached into the lives of people around the world. Sweden was the western country worst hit by the tsunami – 550 Swedes were killed and 1,500 injured.

Mosque left standing after 2004 Indian Ocean tsunami, Sumatra, Indonesia, Credit: Y. Nishimura, Hokkaido University.

Only bare ground was left after the tsunami swept through Sumatra, Indonesia. Credit: Y. Nishimura, Hokkaido University.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean tsunami

The tsunami and the media

The 2004 Indian Ocean tsunami was not only the worst tsunami catastrophe in recorded history and the first known basin-wide destructive tsunami in the Indian Ocean, it was also the most reported tsunami ever.

Global television began giving the event blanket coverage within hours of the earthquake in northern Sumatra and the first waves striking land, drawing on amateur footage of tsunami waves flooding coasts and wreaking havoc, sweeping up people and objects and leaving massive destruction in its wake.

Within days hundreds of journalists from around the world descended on affected countries and began reporting on the devastating aftermath, for international and national media.

December 26, 2004 tsunami, Banda Aceh, Indonesia.
Source: Eksklusif, Metro TV, Asian Broadcasting Union.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean tsunami

The causes and science and history of tsunamis were explained at length to the public, and alongside unfolding stories of human tragedy on a huge scale were extraordinary reports of animals sensing the impending waves, of lucky escapes and of people (including children) who had learned about tsunamis saving hundreds of lives through their warnings – a compelling argument for greater public understanding of tsunamis.

It was clear from the start that the 2004 tsunami had claimed tens of thousands of lives. The pictures told us that. But it took months of heartbreaking searching and research before it was established that 231,452 people had died.

Urak Lawoi children attending the preparations of a ceremony to appease the souls of those lost in the tsunami of 26 December 2004.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The Tsunami and the media

Thanks to the existence of pervasive media, the 2004 tsunami was possibly the most effective global lesson on the threat that this natural disaster poses to human life.

The Japanese word tsunami, unheard of in many parts of the world, joined the vocabulary of all languages and most people around the world gained understanding of tsunamis that they did not possess before.

Given that the news media is news-driven, however, coverage of the 2004 Indian Ocean tsunami did not provide enough of the kind of information that the public needs to respond appropriately to tsunamis in future.

UNDAC and UNESCO Bangkok teams visiting Baan Khem (Phang Nga province), a village which was very seriously hit by the tsunami of 26 December 2004.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Saturation coverage of rotting corpses and devastated towns hammered in the dangers that tsunamis present, their warning signs – such as earthquakes and rapidly receding tides – and the need to immediately head for higher ground, all potentially life-saving knowledge.

But messages of the tsunami threat need to be comprehensive and kept alive in the public mind everywhere: the 2004 event highlighted the fact that tsunami disasters do not only strike in the high-risk Pacific region.

And with the assistance of the media, schools, local and national authorities, businesses and community groups – and as part of broader multi-hazard disaster planning – coastal communities around the world need to examine the threats that tsunamis pose to their areas and draw up response plans.

Baan Khem (Phang Nga province), a village which was very seriously hit by the tsunami of 26 December 2004.

Refer [3.1.3 - 08 of 34] to view the ITIC Safety Flyer [PDF] in the CD - ROM

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The 2004 tsunami swept the internet to the fore as a tool to help response efforts following major disasters.

One example encapsulates a new role for the new media. In response to the unfolding calamity, three bloggers based in India – Peter Griffin, Rohit Gupta and Dina Mehta – set up a blog – the popular word for "web log" – which they linked to the Google page dedicated to the tsunami.

It rapidly attracted information, comments, personal accounts, requests for help from people searching for missing relatives, and floods of visitors. Within eight days over 200 people around the world had offered their help to the blog, which was called TsunamiHelp.

Journalists from mainstream media used the blog to gather information, and along with many volunteers helped to ferret out what was important amidst the data deluge. A collaboratively edited web page provided a home for the information generated.

Although it was not the only tsunami blog, TsunamiHelp became the most complete non-mainstream media account of the tsunami.

The 2004 tsunami swept the internet to the fore as a tool to help response efforts following major disasters.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The international Webby Awards, which honour excellence on the internet, named the 2004 tsunami one of the "10 web moments that changed the world". But there was even more to it than that in journalistic terms. In the words of *The Guardian*:

"It marked the coming of age of citizen media, when 'ordinary people armed only with digital cameras and internet access' provided firsthand accounts of the disaster that couldn't be matched by the mainstream media in terms of their immediacy or impact."

"The blog also turned on its head the stereotype that all web innovations trickle down from the US to the rest of the world. Although the team of volunteers who staffed the blog were from everywhere you can think of, its three founders were all based in India."

An Internet café on the main street in Louang Prabang, Laos PDR.

"As journalist Ashok Malik put it, the traditional pattern was reversed: 'An Indian media product, if that be the word, was the prototype for an American one'."

"Perhaps most importantly of all, the TsunamiHelp blog has left a lasting legacy. The model of communication it forged has set the standard for web coverage of subsequent disasters, including Hurricane Katrina and the Pakistan earthquake, and many of the TsunamiHelp bloggers have used their expertise to launch similar projects on other disasters. And NGOs and academics are interested in using the TsunamiHelp model as a template for communication during future disasters."

The full article in *The Guardian*, "The coming of age of citizen media", is at:

http://blogs.guardian.co.uk/news/archives/2005/12/26/the_coming_of_age_of_citizen_media.html

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The story of the 26 December 2004 tsunami is most eloquently told by the media. What follows is a sprinkling of the wealth of articles and programmes that are available on the world wide web.

Please bear in mind that web addresses can change. Where addresses no longer lead to where they used to, it should still be possible to track down the relevant articles or resource by going to the organization's home page and conducting a search.

The next several pages focus on different aspects of the 2004 tsunami, including a description of the event, survivor accounts, the aftermath, impacts, and aid efforts, the first anniversary, and the circumstances of affected areas a year later.

UNDAC and UNESCO Bangkok teams visiting Baan Khem (Phang Nga province), a village which was very seriously hit by the tsunami of 26 December 2004

Before proceeding to the media articles, look at the Asian tsunami's page in Wikipedia, a free encyclopedia. It contains just about everything anybody would want or need to know about the tsunami:

http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The tsunami

All media sectors covered the tsunami comprehensively, not only reporting on how the disaster unfolded and its immediate aftermath but also providing comprehensive background information about tsunamis, their causes, past events and future prospects.

Newsweek's 10 January 2005 cover story "Tide of Grief" tells both a physical and the very human story of the tsunami. In its words: "The Earth shrugged, and more than 140,000 died. A story of unimaginable tragedy and heroism":

http://www.msnbc.msn.com/id/6786340/site/newsweek/

Take a look at *National Geographic's* physical description of what happened on 26 December 2004, titled "The deadliest tsunami in history?":

http://news.nationalgeographic.com/news/2004/12/1227_041226_tsunami.html

The BBC's "Tsunami: Anatomy of a Disaster" tells the story of 26 December 2004, why the waves were so devastating and what scientists are doing to improve warning systems. This is the background text to a television programme:

http://news.bbc.co.uk/1/hi/sci/tech/4381395.stm

There are BBC maps showing in detail what areas were hit by the tsunami, by country – Indonesia, Thailand, Sri Lanka, India, and Andaman and Nicobar:

http://news.bbc.co.uk/1/shared/spl/hi/world/04/asia_quake/quake_maps/html/1.stm

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Survivors' tales

In "Eye witnesses recount tsunami terror", CNN published a selection of survivor stories about the tsunami at:

http://edition.cnn.com/2004/WORLD/asiapcf/12/26/asia.quake.eyewitness/

Survivors of a horror rail accident in Sri Lanka, in which a train was swept off the tracks by the tsunami, killing at least 802 people, told the BBC of their experiences:

http://news.bbc.co.uk/1/hi/world/south_asia/4132247.stm

Swedish tourist Karin Svaerd, who was shown bravely running into the tsunami to save her children, in pictures that were published around the world, told her story to the BBC:

http://news.bbc.co.uk/1/hi/world/europe/4141733.stm

This BBC report describes a Swedish toddler who was reunited with his father after being found abandoned next to a road on the island of Phuket, Thailand:

http://news.bbc.co.uk/1/hi/world/europe/4133751.stm

At the Phuket resort town of Patong, Thailand, Australian Les Boardman survived by clinging onto a pole His wife Dianne also lived to tell the tsunami tale. Visit CNN at:

http://edition.cnn.com/2004/WORLD/asiapcf/12/26/asia.quake.moro/

A young Indonesian woman – along with her unborn child – survived for five days in the Indian Ocean by clinging onto a palm tree trunk and eating its fruit and bark, but lost her husband. This story is on the BBC at:

http://news.bbc.co.uk/1/hi/world/asia-pacific/4151059.stm

An Indonesian man swept out to sea by the tsunami was rescued two weeks later. Ari Afrizal lived on makeshift rafts and a damaged fishing boat before being rescued by an Arab container ship.
The BBC story:

http://news.bbc.co.uk/1/hi/world/asia-pacific/4163587.stm

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The aftermath

In the days and weeks following 26 December 2004, attention focused on the tsunami's devastating destruction – the mounting death toll, the health threats to survivors and the damage to coastal environments and habitats, among other things.

The BBC's "At-a-glance: Countries hit" web page provides a map of the region that the tsunami hit, and snapshots of countries affected, each with a summary of the tsunami's impact, the (at the time) death and missing tolls, and aid action taken:

http://news.bbc.co.uk/1/hi/world/asia-pacific/4126019.stm

CNN reported that as of 22 February 2005, government agencies and the United Nations put the death toll at 169,752 and 127,294 people were listed as missing. The story also provides breakdowns by country:

http://www.cnn.com/2004/WORLD/asiapcf/12/28/tsunami.deaths/

The Indonesian coast, between Banda Aceh and Meulaboh, after the earthquake and the tsunami of 26 December 2004.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The aftermath

The worst-hit countries declared states of emergency. Soldiers worked alongside civilians for over a month to find and remove corpses and restore some semblance of normalcy to devastated coasts.

In Indonesia's Banda Aceh, the worst-hit area of all, the death toll was staggering. *The Telegraph* reported that between 400,000 and 700,000 people had been displaced, and weeks were spent trying to reunite fractured families:

http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2005/01/24/wtsun24.xml&sSheet=/news/2005/01/24/ixworld.html

National Geographic photographer Chris Rainer provided an eyewitness account of the devastation of Banda Aceh, and described the city as looking like "Hiroshima after the atom bomb". His story is at:

http://news.nationalgeographic.com/news/2005/01/0111_050111_tsunami_sumatra.html

The Guardian reported on damage done to the Sri Lankan village of Mavadicheanai, in a Tamil area where 20 years of civil war had so damaged the infrastructure that people were less able than those in other affected areas to recover from the disaster and receive aid:

http://www.guardian.co.uk/comment/story/0,3604,1383142,00.html

In the aftermath of the tsunami of 26 December 2004. Al Madeena Hotel in Galle.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The aftermath

Channel News Asia compiled a one-month chronology of events following the tsunami, providing an unfolding picture of events in the disaster's wake including the mounting death toll and the world's massive response.

ReliefWeb, a global website that publishes critical information on emergencies and natural disasters – administered by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) – compiled a list of shocking facts about the tsunami's devastation.

Sources: UN office of the Special Envoy for Tsunami Recovery; Oxfam International; Reuters Alertnet. Date published by ReliefNet: 23 December 2005.

Read through the Channel News Asia chronology at:

http://www.channelnewsasia.com/killerwaves/chronology_1month.htm

Destruction	Figure
People killed	231,452
Ratio of women and children killed to men	3:1
Number of people displaced	2,089,883
Number of people who lost their livelihood	1,500,000
Number of houses reduced to rubble	392,544
Number of boats destroyed	103,829
Total damage cost	$10.73 billion
Rebuilding cost	$10.375 billion

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The children

The tsunami claimed the lives of more women and children than men – the ratio was three to one. Children especially were vulnerable during and after the event: smaller, weaker and less able to survive the waves, and more susceptible to hunger and disease afterwards.

Charles J Lyons, president of the United States Fund for the United Nations Children's Fund, told CNN that children likely made up over a third of the death toll. While a third or more children in the developing countries that were struck are under 18, he said, beyond that:

"Children are much less able to run away, fight the water, hold onto or climb a tree. Adults that were stronger were more likely to survive; the youngest were simply unable to."

Children are also more prone to dehydration, under-nourishment, and the diseases that plague the unhygienic conditions of refugee camps.

The tsunami claimed the lives of more women and children than men – the ratio was three to one.

Experts warned that young survivors could suffer post-traumatic stress disorder. Among other things, relief efforts aimed at children focused on returning life to normalcy, providing opportunities for play, reopening schools, and counseling. Images of tsunami destruction could also have impacted on children elsewhere, undermining their sense of security.

UNICEF warned that children would be vulnerable to exploitation and human trafficking. In Indonesia, where 13,000 children were believed to have been orphaned, the authorities barred people from leaving hard-hit Aceh province with children under 16.

Moken children watching goods being unloaded on Ko Surin, in the aftermath of the tsunami of 26 December 2004.

Read the CNN story, "The most vulnerable victims, at:

http://edition.cnn.com/2005/WORLD/asiapcf/01/05/overview.children/

This CNN article, "Treating children's emotional wounds", is at:

http://edition.cnn.com/2005/WORLD/asiapcf/01/05/tsunami.children.cope/index.html

Take a look at this CNN story, "Traffickers threaten Aceh orphans":

http://edition.cnn.com/2005/WORLD/asiapcf/01/04/indonesia.children/index.html/

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean tsunami

The environment

The tsunami impacted on the environment in many ways, from the death of marine life to the destruction of livestock, plant life and the impact on geological features. There were reports of damage to mangroves, coral reefs and vegetation.

National Geographic described the tsunami's "terrifying" merging of land and ocean, with people and trees swept out to sea and stingrays, sharks and dolphins left stranded on land. Of great concern were damage to marine habitats and the impacts on coastal towns that are intertwined with fragile marine systems.

Baan Khem (Phang Nga province), a village which was very seriously hit by the tsunami of 26 December 2004.

On 3 February 2005 the United Nations Environmental Programme's rapidly-established Asian Tsunami Disaster Task Force, set up to assist efforts by countries to repair damage to environments, reported "varying degrees of similar tsunami-induced environmental problems".

These problems included:

- Ground water contamination.
- Damage to coral reefs, sea grass beds and mangrove ecosystems.
- Salinisation of soils and damage to vegetation and crops.
- Tsunami-generated waste and debris.
- Impacts on sewage collection and treatment systems.
- Damage to protected areas.
- Coastline erosion and inundation.
- Changes in river hydrology.
- Loss of livelihoods based on natural resources or ecosystem services.

Communities already deeply traumatized by the tsunami and the lives it claimed, were further devastated by the obliteration of habitats and livelihoods – those extraordinary UN figures of over two million people displaced, nearly 400,000 houses reduced to rubble, and 1.5 million lost livelihoods

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean tsunami

The environment

But it was not all bad news. The Global Coral Reef Monitoring Network has revealed that most coral reefs escaped "serious damage" from the tsunami and should recover in less than 10 years – so long as local governments protect marine ecosystems.

According to a Network report, published on 20 February 2006, reefs in Indonesia, Sri Lanka, India and Thailand were hardest hit, with up to 30 percent of coral reefs damaged in some places.

However, human stresses such as illegal fishing and climate change pose a greater risk to the survival of Indian Ocean coral reefs and mangrove forests, and "stronger conservation and protection of coral reefs and other coastal resources" is essential.

The following articles provide a limited picture of the environmental effects of the disaster.

Read *National Geographic's* "Tsunami clouds future of marine animals" at:

http://news.nationalgeographic.com/news/2005/01/0117_050119_tsunami_marine.html

***National Geographic* reports that the tsunami "rearranged geographic features of the Indian Ocean on a gargantuan scale – above and below the water's surface". Read the article, "Tsunami redraws Indian Ocean maps" at:**

http://news.nationalgeographic.com/news/2005/01/12_050112_tv_tsunami_map.html

***The Observer* reports on growing concerns about the long term impact of the tsunami disaster on the environment, and an aid project to protect the tropical forests and mangroves of Aceh.**

http://www.guardian.co.uk/tsunami/story/0,15671,1676115,00.html

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

A year later

The Indian Ocean tsunami burst back into the news on its first anniversary, 26 December 2005, with media reports of memorials in the affected countries and updates on progress being made towards the reconstruction of devastated areas.

Tsunami memorial at Laupahoehoe, Hawaii to remember school teachers and children who perished in the 1946 Aleutian Island tsunami that struck Hawaii about five hours after the earthquake. The Pacific Seismic Sea Wave tsunami warning system was started in 1949 to provide early warnings.

On the first anniversary of the tsunami, coastal communities across the Indian Ocean gathered to remember those who had died. Also there were thousands of foreigners, including survivors, relatives of those who perished, and aid workers involved in the world's largest ever recovery and reconstruction operation, reports *The Guardian*:

http://www.guardian.co.uk/tsunami/story/0,15671,1673994,00.html

Parts of Banda Aceh in Indonesia were totally destroyed by the tsunami. A year later, the first replacement house had just been built in Lampulo district. But, *The Guardian reports*, people's grumbles about the slow pace of reconstruction masks the far greater pain of grief for the dead and missing:

http://www.guardian.co.uk/tsunami/story/0,15671,1673294,00.html

Somalia, the African country worst hit by the tsunami, lost nearly 300 people and suffered major wave damage, including to the livelihoods of thousands of people in one of the region's poorest and most under-developed nations, reports the BBC:

http://news.bbc.co.uk/1/hi/world/africa/4560246.stm

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Relief and reconstruction

The first task of local people and relief workers was to find, identify and bury the dead – a massive task in some parts, which took long and traumatic weeks to complete.

Most affected countries declared states of emergency and their militaries joined civilians and thousands of international aid workers – they became known as the "second tsunami" – in sifting through the devastation and delivering relief.

The World Health Organization warned that deaths from epidemics of communicable diseases that thrive in unhygienic conditions – cholera, diphtheria, dysentery and typhoid – could rival the tsunami toll. Thankfully, relief efforts ensured that that did not happen.

Mullaitivu, a town in the Northeastern Sri Lanka ravaged by the tsunami of 26 December 2004. As part of the international assistance efforts, relief workers clean up the debris.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The delivery and restoration of safe water was a priority, along with the sending of medical supplies and health care workers to over-burdened hospitals and clinics in affected areas, along with tents, clothing and food.

Wikipedia reports that while relief efforts were quick in India and Thailand, the people of Sri Lanka and Indonesia were "to some extent overwhelmed by the enormity of the catastrophe, especially in inaccessible areas".

Preparations for a religious Urak Lawoi ceremony. Food offering will be released at sea to appease the souls of those lost in the tsunami of 26 December 2004.

The threat to life posed by the tsunami did not end with the last of its waves. Survivors faced many dangers afterwards, including to their health. *Newsweek* looked at some of the health hazards:

http://www.msnbc.msn.com/id/6777638/site/newsweek/

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The Asian tsunami prompted the world's biggest-ever relief effort and generated a record amount of aid funding – more than enough to meet estimated needs.

There were pledges of US$ 6.7 billion for humanitarian aid, according to the United Nations, which coordinated the relief effort. Further donations were pledged for long term reconstruction, raising total support to $13.6 billion.

Indonesia, which suffered the highest death toll of all affected countries, was the largest recipient of aid: it secured financial pledges of $4.4 billion, according to the UN.

Food cargo arriving to Panadura on the Southwestern coast of Sri Lanka ravaged by the tsunami of 26 December 2004. A shipment of 13,5 tons of rice offered by Japan through the World Food Program (WFP).

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

At the governmental level, Japan had been the largest single donor by December 2005, contributing $500 million to the humanitarian effort. The United States Congress approved $900 million in long-term financial support for affected countries.

People and companies around the world responded with extraordinary generosity, donating $4 billion towards the relief effort – 67 percent of all the humanitarian aid.

The United Nations Children's Fund (UNICEF) received almost double what it had sought in donations, while the UN's World Health Organisation (WHO) and World Food Programme (WFP) secured 95 percent of targeted funding.

Food cargo arriving to Panadura on the Southwestern coast of Sri Lanka ravaged by the tsunami of 26 December 2004. A shipment of 13,5 tons of rice offered by Japan through the World Food Program (WFP).

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

All of the United Nation's 17 agencies were involved in tsunami relief efforts, under the stewardship of its Office for the Coordination of Humanitarian Affairs (OCHA).

A United Nations Foundation Tsunami Fund was established to raise money to support UN emergency relief, reconstruction and rehabilitation work in tsunami-affected countries.

The Fund focused first on urgent needs: rapid response by existing UN coordinators in Sri Lanka, Indonesia and Maldives to get aid and recovery moving before global aid arrived; and supporting the essential work of OCHA, UNICEF and the WFP.

After the tsunami of 26 December 2004 - Moken camped at Park Headquarters temporarily, while their new village was under construction.

Funds were also raised to finance a range of "second stage" rehabilitation needs, including:

- Stabilizing health delivery systems.
- Creating sustainable finance programmes for home and business reconstruction.
- Restoring water and sanitation in areas where they were damaged or destroyed.
- Strengthening UN communications capabilities.

View the OCHA website at:

http://ochaonline.un.org/

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

As coordinator of the "second tsunami", OCHA worked with an extraordinary "90 donor nations, 35 militaries, 17 UN agencies, hundreds of NGOs and scores of private companies," said UN under-secretary general for humanitarian affairs Jan Egeland.

OCHA negotiated with government officials, organized relief through coordinated working groups, created databases and websites to manage information, facilitated contributions to relief projects, and resolved logistical bottlenecks at major ports and hubs.

Four teams were deployed to worst-hit countries to liaise with governments, organize inter-agency assessments and establish baseline data on humanitarian needs. New offices were opened in Sri Lanka and the Maldives, and OCHA's presence in Indonesia was expanded.

According to OCHA's 2006 report, Humanitarian Information Centres were set up in Sri Lanka and Indonesia. Over 50 people were deployed to facilitate coordination in the field.

OCHA organized donor countries to provide support modules of equipment for camps for humanitarian workers, and was part of the environmental team that did rapid assessments to identify and alleviate life-threatening environmental issues.

After the tsunami of 26 December 2004 - Moken returning back to camp after another day's work building their new village.

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Information played a crucial role in relief efforts. United Nations websites such as ReliefWeb were used intensively for information gathering and distribution, and OCHA held media conferences and issued daily bulletins providing information critical to relief efforts.

Governments around the world that took part in tsunami relief and reconstruction, or that were affected by the disaster, did the same and information also poured out from companies and charitable organizations that got involved.

Tsunami meeting.from left to right : Mr. W. A. Abeysinghe, Chairman, NLDSB, Dr. Susanne Ornager, Adviser/CI, UNESCO New Delhi, 4th from left: Mr. Piyasena, District Secretary 5th from left: Mr. Chamal Rajapaksha, Deputy Minister

According to OCHA's 2006 report:

"In the first two months following the tsunami, ReliefWeb had published over 4,000 documents and 90 maps on the disaster, and during the peak of the response phase hits on the website averaged three million a day.

"OCHA also ensured a continuous flow of information to the world media on the tsunami's impact and the priority humanitarian needs. During the first two months following the disaster, OCHA provided over 1,000 interviews and responded to numerous press inquiries."

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

As news media focus drifted to other events and the immediate needs of tsunami survivors were met, OCHA and other aid organizations played a key role in keeping tsunami relief requirements in public and donor minds.

The media too helped keep tsunami relief in the news by returning to report on the disaster after three months, six months and a year.

One of the objectives of *TsunamiTeacher* is to encourage the media, schools, authorities, the private sector and communities to keep the tsunami threat alive in human consciousness in the longer term, through media coverage, school curricula and awareness campaigns.

Relief supplies being offloaded, 8 January 2005, Calang, Sumatra, Indonesia.

Take a look at ReliefWeb:

http://www.reliefweb.int/rw/dbc.nsf/doc100?OpenForm

The United Nations Integrated Regional Information Networks (IRIN) also provides a font of reliable information about emergencies and relief efforts:

http://www.irinnews.org/

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

While the tsunami relief and reconstruction effort was nothing short of extraordinary, it was of course not perfect and the media was quick to point out where it was lacking.

For example, almost a year after the tsunami there were still around a million people displaced, and while the UN estimated that 308,000 houses needed to be built to replace those destroyed by the tsunami, only 46,000 had been built or were under construction.

In October 2005, a report by the International Federation of Red Cross and Red Crescent Societies complained that many aid agencies had wasted money following the tsunami by failing to consult survivors, the UN or other relief groups.

It went on to say that within a month of the disaster there were at least 200 relief groups on the ground in Indonesia's Aceh province alone, but less than a quarter of them sent reports to OCHA. As a result of this

The Tsunami Evaluation Coalition Synthesis Report examines the successes and failures as well as the constraints within which the response occurred between the first eight and 11 months of the response to the 26 December 2004 tsunami. It does this by distilling the findings and learning not only from the TEC's thematic evaluations but from over 140 additional reports, including many TEC member agencies' real-time and ex-post evaluations as well as learning reviews.

Refer [3.1.3.3 - 30 of 34] to learn more on the Indian Ocean Surviving a Tsunami Synthesis Report in the CD - ROM

An article on Tsunami Evaluation Coalition Report can be found at:

http://www.tsunami-evaluation.org/home

An AlertNet article on the Red Cross and Red Crescent Societies can be found at:

http://www.alertnet.org/thefacts/reliefresources/112849687980.htm

A Reuters AlertNet report for the 2004 Indian Ocean Tsunami is at **:**

http://www.alertnet.org/db/crisisprofiles/SA_TID.htm

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

A year after the tsunami the United Nations announced that governments had yet to deliver about nine percent of $6.7 billion in humanitarian aid money pledged to support survivors.

The UN figures showed that the US had given just 38 percent of the aid it pledged, and other countries that had failed to fulfill their promises were Britain, France, Germany and Italy, China and Australia. The European Commission was short some $70 million.

Aid officials expressed doubt over whether some major donors would ever fully deliver on their promises. A UN official involved in the tsunami relief effort told the BBC:

"There are certainly substantial uncommitted humanitarian pledges out there. We hope that the agencies and the donors will nail these down because they are needed. In the majority of cases, there is still the hope and expectation that [the donors] will follow through."

A Moken woman with her child, while their village is under reconstruction after the tsunami of 26 December 2004.

The BBC relief funding story, "Unpaid money hurts tsunami effort", is at:

http://news.bbc.co.uk/1/hi/business/4521088.stm

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Despite relief glitches, an extraordinary amount was achieved by the world's biggest-ever relief and reconstruction effort. The following are but a few examples.

UNICEF immunized over a million young tsunami survivors against measles and provided Vitamin A supplements. It also provided sanitation facilities and clean drinking water to survivors. In Indonesia alone, UNICEF achieved the following:

Mobile health units and doctors immunized over a million young tsunami survivors against measles and provided Vitamin A supplements.

- More than 90 percent of children aged between six months and 15 years received measles vaccinations
- 493,699 children received vitamin A supplements
- 199,924 women and children received insecticide-treated bed nets to protect them against malaria
- 376,6000 people now have access to safe water
- Almost 53,845 children were reached through counseling or play activities
- 230,000 sets of textbooks and learning supplies for 830,000 children were delivered.
- 135 temporary or semi-permanent schools were built

A year after the disaster, UNICEF published a special feature on the plight of children in eight of the affected countries – Indonesia, Sri Lanka, India, Myanmar, Maldives, Thailand, Somalia and Malaysia – and continuing efforts to assist them. It is at:

http://www.unicef.org/emerg/disasterinasia/24615_main.html

These two articles by Channel News Asia, about mobile clinics in Aceh and new homes built in SriLanka, are just two of many heartening examples of what has been achieved:

http://www.channelnewsasia.com/ptm/tsunami/index.htm

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

Jan Egeland, United Nations under-secretary general for humanitarian affairs, wrote that the Indian Ocean tsunami had kicked off a 2005 “Year of Disasters” that saw a huge earthquake strike Pakistan, starvation in Niger and Hurricane Katrina hit New Orleans.

The tsunami and disasters of 2005, wrote Egeland, highlighted four changes that needed to be made to international relief efforts. The first was the need for predictable funding.

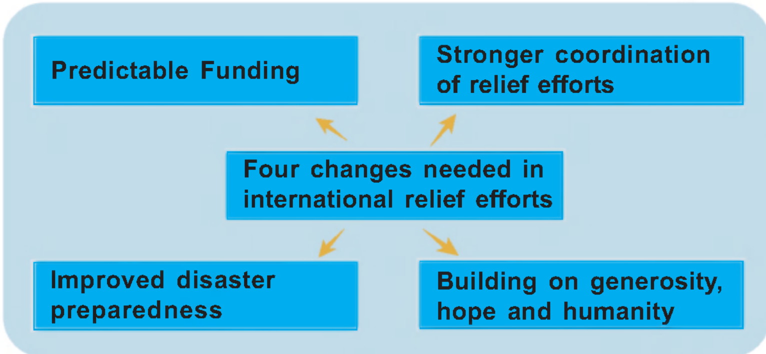
> “Imagine if your local fire department had to beg the mayor for money to turn on the water hoses every time a fire broke out. Now imagine numerous fires occurring simultaneously all over the globe, but no money on hand to turn on the hoses. That’s the situation faced by aid workers whenever a major crisis erupts.
>
> This hat-in-hand approach to funding relief operations is both dangerous and wasteful. Most lives are lost in the first days following a quake, flood or other disaster. To save lives, aid workers need immediate cash and supplies… It also costs donors more; the quicker we can respond in a crisis, the cheaper it is.”
>
> Jan Egeland, United Nations under-secretary general for humanitarian affairs

3.1.3 Tsunamis down the years - 3.1.3.3 The 2004 Indian Ocean Tsunami

The UN has approved the creation of a $500 million Global Emergency Fund to jumpstart relief efforts within 72 hours of an emergency. About $200m has been pledged to the fund, and Egeland called on all governments and the private sector to contribute the balance.

The second need was for stronger coordination of relief efforts. The third was for improved disaster preparedness. Egeland has suggested that donors dedicate 10 per cent of all aid spending to disaster preparedness: early warning systems could save “countless” lives.

Fourth, the world should “build on the hope and humanity evinced by millions around the world who came together this year as never before on behalf of the suffering”. Such generosity, he concluded, “should be the standard by which we always respond”.



The full text of Egeland’s article, entitled “Will we be ready when a tsunami strikes again?” is at:

http://comment.independent.co.uk/commentators/article335075.ece

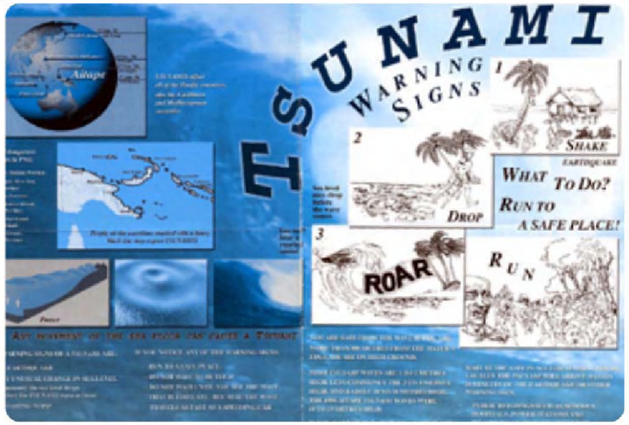
3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Tsunamis are a threat to life and property for all coastal communities, and they can strike at any time.

Waves can attack coasts near to the source of an earthquake within minutes, with shaking ground being the only warning that trouble might be on the way. Even authorities and people on coasts hundreds of kilometers away may not receive warnings in time for an effective response.

However, it is possible to take safety action within minutes, and for people on shores that are distant from a tsunami source, accurate warnings of when the waves might strike are possible because tsunamis travel at a known speed.

There are many ways to prepare for tsunamis that have already been shown to save lives, and there are also ways to minimize threats to the health of survivors after the event. For all of these actions, knowledge and its dissemination have been critical.



Tsunami Awareness poster created after the 1998 Papua New Guinea tsunami. Asian Disaster Reduction Center.

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Advances in tsunami detection and early warning systems, and their expansion worldwide, along with inundation models that predict the impacts of waves on coasts, are providing communities around the world with the tools to reduce the impact of future tsunamis.

More and more is also being learned about how to plan for tsunamis in ways ranging from educational outreach and evacuation plans and routes to protecting natural environmental barriers, where best to place new developments and how to construct buildings.

It has been estimated that using all tools available could avert up to 25 percent of tsunami-related deaths.

Contrasting casualties from the 1993 Sea of Japan tsunami with those of the 1998 Papua New Guinea event, the National Oceanic and Atmospheric Administration (NOAA) in the United States concluded that "these tools work":

"For the Aonae, Japan, case about 15 percent of the population at risk died from a tsunami that struck within 10 minutes of the earthquake because the population was educated about tsunamis, evacuation plans had been developed, and a warning was issued."

"For the Warapa, Papua New Guinea case, about 40 percent of the at-risk population died from a tsunami that arrived within 15 minutes of the earthquake because the population was not educated, no evacuation plan was available, and no warning system existed."

—NOAA

Increasing understanding in earthquakes and their potential to cause tsunamis is a key to long-term programme sustainability. Starting in 2006, the IOC and US Geological Survey partnered to conduct Seismology and Tsunami Warning training globally, starting first in the Indian Ocean region, Thailand, May 2006.

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Education is key

The value of information was dramatically illustrated during the Indian Ocean tsunami. Most victims received no warning – but thousands of lives were saved in cases where tsunami knowledge existed and was used.

When his observation tower on the remote Indian island of Tarasa Dwip started shaking, port official Abdul Razzak recalled a *National Geographic* programme on tsunamis and knew he needed to act. He rushed through villages screaming "Go to the hills!" and sent colleagues on his motorcycle to alert as many other people as possible. Razzak saved 1,500 lives.

In Thailand, Tilly Smith, 10, was reported to have saved over 100 lives when she raised the alert after noticing the sea retreating on the beach. She remembered a geography lesson on earthquakes and tsunamis two weeks earlier.

In the words of Markku Niskala, secretary-general of the International Federation of Red Cross and Red Crescent Societies:

"…in the face of disaster, the difference between life and death can be as simple as possessing the right information – and acting on it".

Read Abdul Razzak's story at:

http://news.nationalgeographic.com/news/2005/01/0107_050107_tsunami_natgeo.html

Read Tilly Smith's story at:

http://news.nationalgeographic.com/news/2005/01/0118_050118_tsunami_geography_lesson.html

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Education is key

Experts have argued that tsunami warning systems need to be underpinned by public awareness campaigns and emergency response plans if they are to be effective. Warnings are of little use if people do not know how to respond to them.

Knowledge becomes even more critical if warning times are short – or there is no warning at all – in which case people must know how to react immediately.

The value of indigenous knowledge was highlighted by Simuelue islanders, who lost only seven of their 78,000 inhabitants even though the 2004 tsunami struck them just eight minutes after the earthquake. Populations of other nearby coastal areas were decimated.

The Simuelue islanders have kept alive, through oral history, the lessons of a tsunami that struck in 1907, and knew exactly what to do when the tsunami attacked. They even have a word for the 1907 tsunami – "smong".

Tsunami of 26 December 2004 - UNESCO CSI-LINKS project leader Narumon Arunotai interviewing elderly Moken woman on indigenous knowledge of the tsunami ('La Boon' in Moken).

The importance of public awareness is stressed by this *National Geographic* story, "Education is key to tsunami safety, experts say":

http://news.nationalgeographic.com/news/2005/01/0124_050124_tsunami_warn.html

Read this article in *Medical News Today*:

http://www.medicalnewstoday.com/medicalnews.php?newsid=32174

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Surviving a tsunami

Knowledge can save lives and so the media, education systems, authorities, community groups and the private sector all have a crucial public interest role to play in providing general and safety information on tsunamis (and other threats) to the people they reach.

Education is not only about imparting the golden rule of tsunami response – if there is a warning or the ground shakes, move to higher ground – but also about keeping people in the loop about local tsunami hazard zones, evacuation routes and emergency responses.

There is also much that survivors can do to stay alive in the challenging days, weeks and even months after a disaster that destroys homes, infrastructure such as clean water and sanitation, and public services such as electricity supplies and clinics.

The information on the following pages, or variations of it adapted to local circumstances, could be widely disseminated, especially but not only to coastal populations around the world and people in high-risk tsunami regions.

Inamura no Hi, a Japanese folk story about tsunami response that has been localized and translated for Bangladesh, India, Indonesia, Malaysia, Nepal, Philippines, Singapore, and Sri Lanka by the Asian Disaster Reduction Center and the Asian Disaster Reduction and Response Network.

Refer [3.1.4.1 - 05 of 13] to learn more about Inamura no Hi, a Japanese folk story. in the CD - ROM

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media

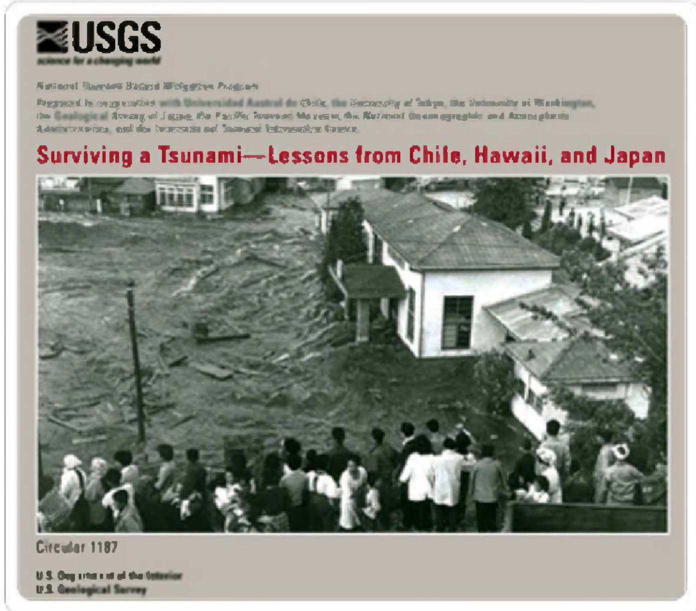
3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Surviving a tsunami

First, read through this booklet, *Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan*, produced by the United States Geological Survey and National Tsunami Hazard Mitigation Program in cooperation with Universidad Austral de Chile, University of Tokyo, University of Washington, Geological Survey of Japan, Pacific Tsunami Museum and ITIC.

It provides interesting and valuable first-hand accounts of actions that saved or cost lives, as recounted by eyewitness to the Chilean tsunami of 1960.

Refer [3.1.4 - 06 of 13] to learn more on the Surviving a Tsunami in the CD - ROM



Tsunamis teach valuable lessons in preparedness and mitigation, and improve emergency laws.

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Surviving a tsunami

The International Tsunami Information Centre has compiled safety and "What to do" advice for people before and during a tsunami.

What to do before a tsunami

- Be aware of tsunami facts. This knowledge could save your life!
- Share this knowledge with family and friends. It could save their lives!
- Determine if you live, work, play, or transit a coastal low lying area or tsunami evacuation zone.
- Follow the advice of local emergency and law enforcement authorities. Do not return until authorities say it is safe.
- Stay away from bodies of water.
  If you are at the beach or near the ocean, and you feel the earth shake, move immediately inland to higher ground. Do not wait for a tsunami warning to be issued. Stay away from rivers and streams that lead to the ocean due to strong tsunami wave action and currents.
- Take shelter.
  If you live in a tsunami evacuation zone and hear that there is a tsunami warning, your family should evacuate your house. Walk in an orderly, calm manner to the evacuation site or to any safe place outside your evacuation zone.
  If you are in school and you hear there is a tsunami warning, you should follow the advice of teachers and other school offcials.
  If you are unable to quickly move inland, high, multi-story, reinforced concrete buildings may provide a safe refuge on the third foor and above.

Refer [3.1.4.1 - 07 of 13] to learn more Tsunami preparedness [PDF] in the CD - ROM

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3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

People in Miyako, Japan, also went to high ground to escape the 1960 Chilean tsunami.

What to do before a tsunami

- Be aware
- Share this knowledge
- Determine your surroundings
- Follow advice of law enforcement authorities
- Stay away from water bodies
- Take shelter

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

Warning Signs – "Sensing a Tsunami"

This short safety message from the International Tsunami Information Centre shows how human senses can be used to detect tsunamis:

Strong local earthquakes may cause tsunamis.	As a tsunami approaches shorelines, water may recede from the coast, exposing the ocean floor and reefs.	Abnormal ocean activity, a wall of water and approaching tsunami waves create a loud "roaring" sound similar to that of a train or jet aircraft.
FEEL the ground shaking severely? Immediately evacuate low lying coastal areas and move inland to higher ground!	**SEE** an unusual disappearance of water? Immediately evacuate low lying coastal areas and move inland to higher ground!	**HEAR** the roar? Immediately evacuate low lying coastal areas and move inland to higher ground! Do not wait for official evacuation orders.

Refer [3.1.4.1 - 08 of 13] to learn more about Sensing a tsunami [PDF] in the CD - ROM

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

International Tsunami Information Centre safety rules

- All earthquakes do not cause tsunamis, but many do. When you know that an earthquake has occurred, stand by for a tsunami emergency message
- An earthquake in your area is one of nature's tsunami warning signals. Do not stay in low-lying coastal areas after a strong earthquake has been felt.
- Tsunamis are sometimes preceded by a noticeable fall in sea level as the ocean retreats seaward exposing the sea floor. A roar like an oncoming train may sometimes be heard as the tsunami wave rushes toward the shore. These are also nature's tsunami warning signals.
- A tsunami is not a single wave, but a series of waves that can come ashore for hours. The first wave may not be the largest. Stay out of danger areas until an "all-clear" is issued by a recognized authority.
- A small tsunami at one point on the shore can be extremely large a few kilometers away. Don't let the modest size of one make you lose respect for all.

Refer [3.1.4.1 - 09 of 13] to learn more about Tsunami Safty Rules [PDF] in the CD - ROM

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

International Tsunami Information Centre safety rules

- All warnings to the public must be taken very seriously, even if some are for non-destructive events. The tsunami of May, 1960 killed 61 people in Hilo, Hawaii because some thought it was just another false alarm.
- All tsunamis are potentially dangerous, even though they may not damage every coastline they strike.
- Never go down to the shore to watch for a tsunami. When you can see the wave, you are too close to outrun it. Most tsunamis are like flash floods full of debris. Tsunami waves typically do not curl and break, so do not try to surf a tsunami.
- Sooner or later, tsunamis visit every coastline in the Paciûc and all oceans. If you live in a coastal area, be prepared and know nature's tsunami warning signals.
- During a tsunami emergency, your local civil defense, police, and other emergency organizations will try to save your life. Give them your fullest cooperation.

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

What to do if you have a boat

The International Tsunami Information Centre provides the following advice to people on boats:

- Tsunami waves are imperceptible in the open ocean

Since tsunami waves cannot be seen in the open ocean, do not return to port if you are at sea and a tsunami warning has been issued. Port facilities may become damaged and hazardous with debris. Listen to mariner radio reports when it is safe to return to port.

- Tsunamis can cause rapid changes in water level and unpredictable dangerous currents

Tsunamis can cause rapid changes in water level and unpredictable dangerous currents that are magniûed in ports and harbors. Damaging wave activity can continue for many hours following initial tsunami impact. Contact the harbor authority or listen to mariner radio reports. Make sure that conditions in the harbor are safe for navigation and berthing.

- Boats are safer from tsunami damage while in the deep ocean

Boats are safer from tsunami damage while in the deep ocean (>200 fathoms, 1200 ft, 400 m) rather than moored in a harbor. But, do not risk your life and attempt to motor your boat into deep water if it is too close to wave arrival time. Anticipate slowdowns caused by traffic gridlock and hundreds of other boaters heading out to sea.

- In a locally generated earthquake-tsunami scenario, there will be no time to deploy a boat as waves can come ashore within minutes.

For a locally-generated tsunami, there will be no time to motor a boat into deep water because waves can come ashore within minutes. Leave your boat at the pier and physically move to higher ground.

- Listen for official tsunami wave arrival time estimates and plan accordingly.

For a tele-tsunami generated far way, there will be more time (one or more hours) to deploy a boat. Listen for ofûcial tsunami wave arrival time estimates and plan accordingly.

- Keep in contact with the authorities should a forced movement be directed.

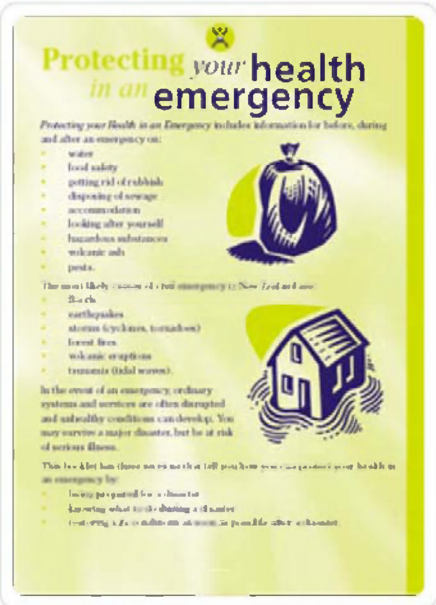
Most large harbors and ports are under the control of a harbor authority and/or a vessel trafûc system. These authorities direct operations during periods of increased readiness, including the forced movement of vessels if deemed necessary. Keep in contact with authorities when tsunami warnings are issued.

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

What to do after a tsunami

Emergencies often arrive with little or no warning and they can cause extensive damage.
After surviving a disaster, people often find themselves facing fresh threats to their safety such as lack of drinking water, unhygienic conditions that can lead to illness, lack of medical supplies and health services for the injured, and lack of food.

Protecting your Health in an Emergency, a booklet produced in New Zealand, contains a comprehensive set of tips on preparing for a disaster, knowing what to do during a disaster, and restoring safe conditions as soon as possible after a disaster.



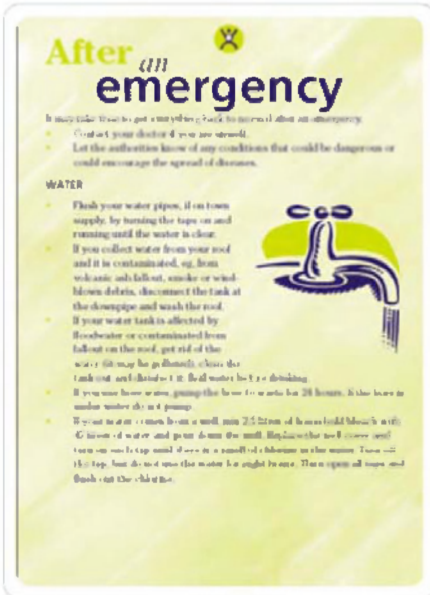
Refer [3.1.4.1 - 12 of 13] to learn more Protecting your Health in an Emergency in the CD - ROM

3.1.4 Dealing with Tsunamis - 3.1.4.1 Surviving tsunamis

What to do after a tsunami

While there are small aspects of the booklet that might not be applicable to developing country conditions, it provides a wealth of very practical tips ranging from basic hygiene to what common household goods can be hazardous if damaged, dealing with pests, how to dispose of sewerage and how to make a temporary toilet.

This information can be adapted to local circumstances and disseminated to the public in a variety of ways, including via media supplements and programmes, school lessons, or leaflets produced by authorities, community groups or businesses.



3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

Exhaustive studies of historical tsunamis and of tsunami science have produced a mass of knowledge about the great waves.

In an article in *2004 Science Year* Dr Laura Kong, director of the International Tsunami Information Centre, wrote that national and international organizations have been striving to put this information to vital use in three ways:

"(1) by assessing conditions that could lead to the development of a tsunami,

(2) by designing and implementing warning techniques that would alert coastal dwellers when a tsunami has formed, and

(3) by educating people who live in or visit potentially dangerous areas so that they can take appropriate actions when a tsunami has been forecast."

Scotch Cap lighthouse, Unimak, Alaska, before and after a 35-m high tsunami destroyed the 5-story lighthouse on 1 April 1946. The tsunami also caused death and damage in Hawaii, and soon after, the US started its first tsunami warning system.

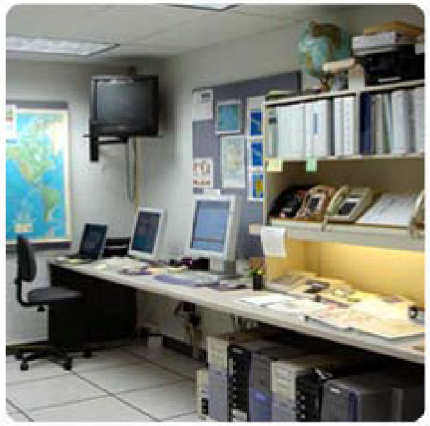
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

A Pacific Warning System

One of the first tsunami alert efforts was the United State's Seismic Sea Wave Warning System. It was set up in 1949 in Honolulu following the Aleutian Trench tsunami of 1946, which struck Alaska and Hawaii. Since most tsunamis are generated by earthquakes, its function was to monitor earthquakes and to send warning information to authorities in Hawaii.

In the wake of the 1960 Chile and 1964 Alaska tsunamis, UNESCO's Intergovernmental Oceanographic Organization (UNESCO-IOC) worked with governments in the Pacific Ocean region to create, in 1965, the Tsunami Warning System in the Pacific (ITSU).

The system's Intergovernmental Coordination Group (ICG), now called ICG-PTWS (Pacific Tsunami Warning System), is today composed of experts from around 30 Pacific countries. It is a subsidiary body of the IOC and reports to the IOC Assembly, which has around 140 Member States.



PTWC operations rooms.

3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

The Pacific Tsunami Warning Center, Honolulu

The ICG meets regularly to discuss tsunami technical monitoring and warning dissemination needs and improvements, coordinate tsunami risk assessment and preparedness activities, and share national experiences in building tsunami awareness through education outreach.

The Pacific Ocean system is operated by the United States National Weather Service, which is part of the National Oceanic and Atmospheric Administration (NOAA), and is based at the Richard H Hagemeyer Pacific Tsunami Warning Center (PTWC) in Honolulu, Hawaii.

Also in 1965, UNESCO set up the International Tsunami Information Center in Honolulu, among other things to coordinate the Pacific system, and its activities with those of other tsunami warning facilities worldwide.

PTWC operations rooms.

Take a look at the Pacific Tsunami Warning Center website:

http://www.prh.noaa.gov/ptwc/

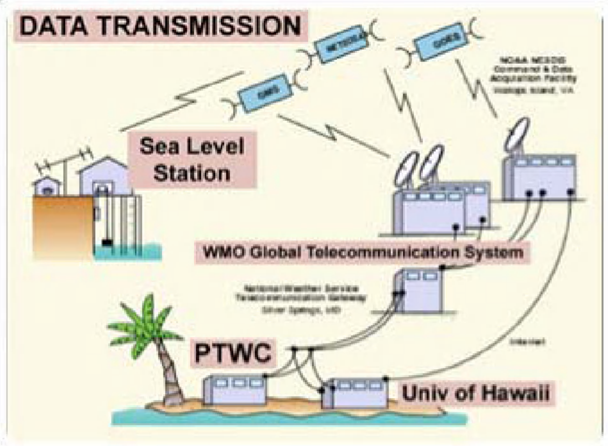
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

Tide gauges

Monitoring earthquakes did not prove a sufficiently accurate way of predicting tsunamis, as not every underwater earthquake generates a tsunami. According to Dr Kong, at least 75 percent of warnings issued in the early years of the system were false alarms.

False warnings are costly and can encourage people to be complacent. While earthquake monitoring gives a good estimate of the potential for a tsunami based on earthquake size and location, it gives no direct information about the tsunami itself.

To make warnings more accurate the system added tide stations, consisting of a gauge that measures changes in sea level and equipment that transmits the measurements to satellites, which then relay the information to warning centres.



Sea level data are transmitted in near real-time by environmental satellites and other methods that are part of the WMO's Global Telecommunications System to the tsunami warning centers such as PTWC.

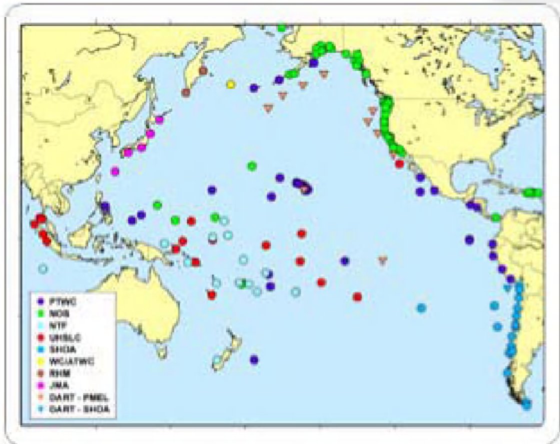
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

Tide gauges

Tsunami warning centres use the sea level data to confirm that a tsunami has been generated or to cancel a tsunami warning when a number of sea level records show no destructive waves. The more sea level readings that are available, the faster the warning centre is in accurately determining the tsunami's impact. Tsunami warning centres are always seeking ways to improve their forecasts by installing more stations and gathering more data faster. Presently in 2006, the sea level network in the Pacific consists of more than 100 reporting coastal stations and 10 DART deep-ocean tsunamimeters. Where possible, coastal stations are deployed because they are about 10 times cheaper and much easier to maintain. However, wrote Dr. Kong in 2004 Science Year:

"But tide stations also have their limitations. The gauges are all located at the shore. Although they can warn of approaching local tsunamis, they cannot predict the development and impact of distant tsunamis."

Further, according to NOAA, while tide gauges provide direct measurements of a tsunami, tsunamis are altered by local bathymetry and harbour shapes "which severely limits their use in forecasting tsunami impact at other locations".



Sea level stations used by PTWC to monitor tsunamis in the Pacific.

3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

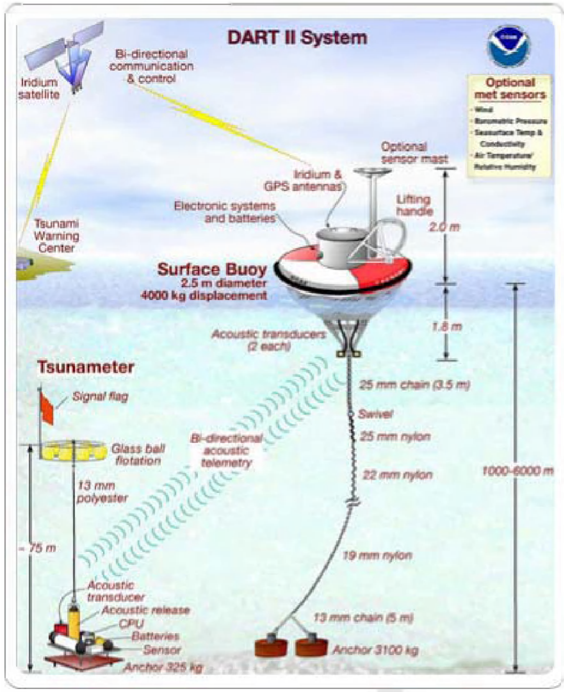
The DART system

The United States, through NOAA, tackled these problems in 1997 in a new project called the National Tsunami Hazard Mitigation Program, which promotes scientific advances in tsunami warning systems and all other aspects of tsunami preparedness.

Deepwater instruments were placed in the Pacific Ocean as part of a system called DART (Deep-ocean Assessment and Reporting of Tsunamis). By the end of 2005 there were 10 buoys deployed and the United States plans to expand the system to include 39 buoys located around the Pacific and Atlantic oceans and the Gulf of Mexico by the end of 2007.

Each DART instrument comprises a bottom pressure sensor, which rests on the ocean floor and is anchored by a weight, and a surface buoy the size of an automobile.

As a tsunami wave passes, the sensor detects an increase in pressure caused by the weight of the added volume of water. It can detect a tsunami wave that has increased the height of the ocean by as little as one centimeter (half an inch) at depths of up to 6,000 metres (nearly 20,000 feet).



NOAA illustration of the DART sensor and buoy system.

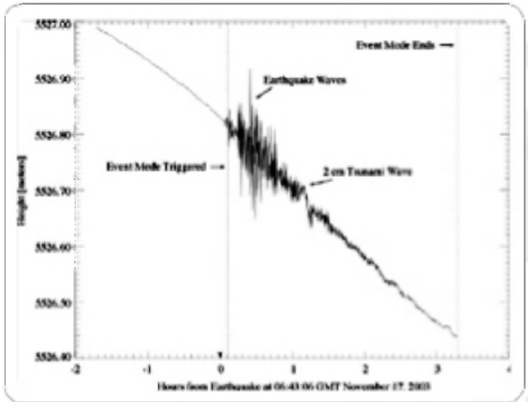
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

The DART system

The bottom pressure sensor transmits readings via sound waves through the water to the nearby surface buoy, which in turn transmits the data to a US weather satellite. The satellite relays the information to a land receiving station on Wallops Island, Virginia, and it is then sent to several tsunami warning centres.

Pacific Tsunami Warning Center staff are alerted when an earthquake with a magnitude of at least 6.5 on the Richter scale occurs.

Scientists analyze the data, estimate the earthquake's magnitude and watch for reports from tidal and DART stations near the earthquake's epicenter, which tell them whether tsunami waves have raised the water level of a coast and if there could be a tsunami hazard to other areas.



Tsunami recorded on DART instrument from 17 November 2003 earthquake off Rat Islands, Aleutian Islands.

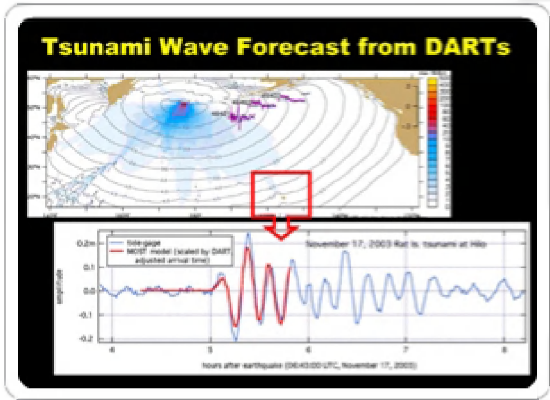
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

The DART system

If a tsunami is crossing the Pacific, one or more DART stations will report an increase in water pressure – a tsunami is on the way, and scientists then use other tools, such as tsunami modeling databases, to predict where it is heading and when it is likely to hit a coast.

The 17 November 2003 Rat Islands tsunami in Alaska provided a comprehensive test for the forecast methodology, according to NOAA. An earthquake near Rat Islands generated a tsunami that was detected by three "tsunametres" as the DART instruments are called, along the Aleutian Trench – the first tsunami detection by the new system:

"This real-time data combined with the model database were then used to produce the real-time model tsunami forecast. For the first time, tsunami model predictions were obtained during the tsunami propagation, before the waves had reached many coastlines."



The DART tsunami data from the Rat Island tsunami was used to predict offshore wave heights (top) and a wave forecast for Hilo Bay, Hawaii (bottom). In this example, the calculated forecast fits the observed tsunami record very well. Forecast (red line) …. record (blue line)…

Tsunami warnings

When the PTWC has determined that there is tsunami hazard, it informs national emergency authorities in the threatened areas. Tsunami warnings are issued for distant tsunamis to countries in the Pacific, and local tsunami warnings to Hawaii.

There are also Sub-Regional Warning Centers in the United States and Japan.

Initial tsunami bulletins are issued within 10 minutes of a potentially tsunami-generating earthquake, based on the magnitude and location of the earthquake. The warning indicates that a tsunami may be imminent and that coasts in the warned area should prepare.

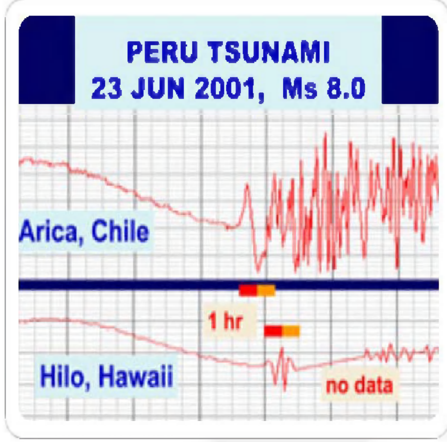
Emergency Operation Center, County Civil Defense, Hawaii, USA.

Tsunami warnings

After a tsunami has been monitored with sea level gauges and where possible with deep level sensors, and a more accurate picture of its threat and movements are obtained, a tsunami warning will either be cancelled, restricted or expanded in subsequent bulletins.

A tsunami watch is an alert that is issued to areas outside the warned area. The size of the watch area is based on the magnitude of the earthquake and tsunami travel times. A watch can either be upgraded to a warning in fresh bulletins, or cancelled.

Both tsunami warnings and watches include estimated wave arrival times for key coastal locations in the warned or watch area.



Sea level records of tsunami from 2001 Peru tsunami recorded in Arica, Chile, and Hilo, Hawaii, showing the differences in the arriving waves. In Arica, the 2nd wave came 1 hour after the first wave, but in Hilo, it came after only 30 minutes. Credit: ITIC

Take a look at the bulletins page of NOAA's Pacific Tsunami Warning Centre at:

http://www.prh.noaa.gov/ptwc/bulletins.htm

Indian Ocean Tsunami Warning and Mitigation System

The world has pledged that the next time a tsunami strikes in the Indian Ocean, there will be a warning system in place to detect it and alert coastal communities to the impending threat.

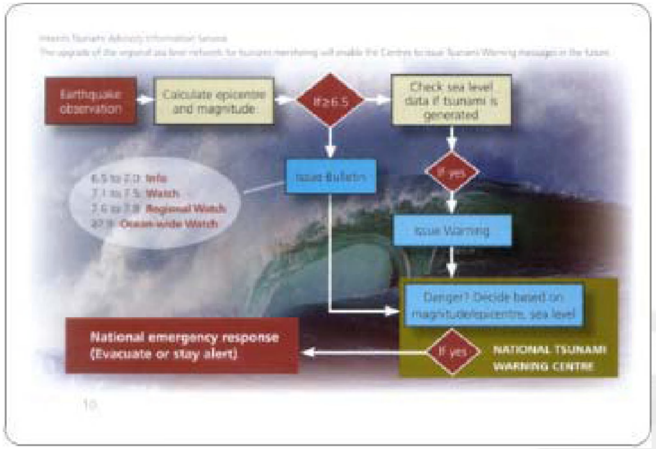
Tens of thousands of people on shores distant from the 2004 tsunami's source might have been saved had a warning system been in place. There was not one, because Indian Ocean-wide tsunamis have been extremely rare.

Based on UNESCO-IOC's successful Pacific tsunami warning system, coordinated by its Intergovernmental Coordination Group (ICG) for the Pacific Tsunami Warning System, in June 2005 UNESCO-IOC created three new ICGs for: the Indian Ocean; the Caribbean Sea and adjacent regions; and the Northeastern Atlantic, Mediterranean and its connected seas.

A fourth body, the UNESCO-IOC Intersessional Ad-Hoc Working Group, was also set up to discuss a global framework for an early warning system for all coastal marine hazards.

It is expected that the Indian Ocean Tsunami Warning and Mitigation System will be up and fully running in 2007. Meanwhile, UNESCO-IOC has helped install an interim warning system using six real-time sea-level stations.

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning



Interim Tsunami Advisory Information Service, December 2005. The upgrade of the regional sea level network for tsunami monitoring will enable the Centres to issue Tsunami Warning messages in the future.

Take a look CARIBE: ICG for Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions at:

http://ioc3.unesco.org/cartws/

Take a look PTWS: ICG for the Pacific Tsunami Warning and Mitigating System at:

http://ioc3.unesco.org/ptws/

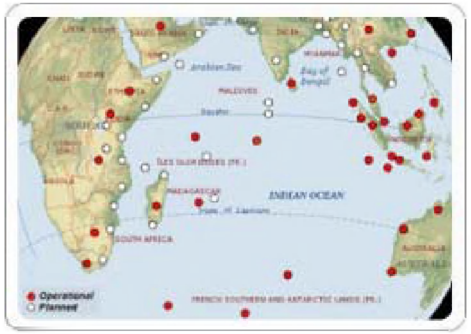
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

Indian Ocean Tsunami Warning and Mitigation System

During 2005 assessments of 16 countries in the Indian Ocean were conducted by teams of national and international experts, to identify capacity building needs and support requirements for developing a tsunami warning system in the region.

The teams' comprehensive investigations found, in summary, that:

- Most countries had established or strengthened disaster management laws, national platforms, and coordination mechanisms to guide all-hazard disaster risk reduction. Not all had addressed the tsunami coordination aspect.
- All countries except Somalia were receiving tsunami advisories and watch alerts on an interim basis from the Pacific Tsunami Warning Centre and Japan Meteorological Agency, and most had facilities that were able to receive warnings around the clock. But few operated a national tsunami warning centre or were able to receive or provide real-time seismic or sea level data.



Regional sea level monitoring network for the tsunami warning system in the Indian Ocean.

Regional earthquake monitoring network for the tsunami warning system in the Indian Ocean.

Detailed information on the mission, and assessments by country, can be found at:

http://ioc3.unesco.org/indotsunami/nationalassessments.htm

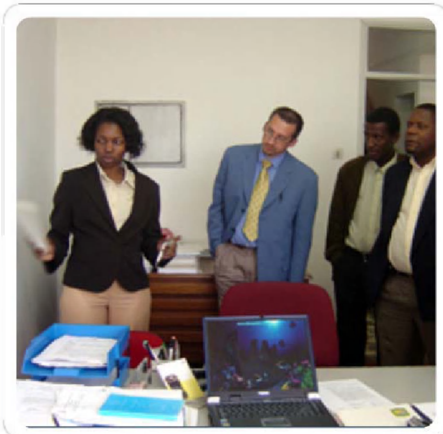
3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

Indian Ocean Tsunami Warning and Mitigation System

The rapidly developing Indian Ocean Tsunami Warning and Mitigation System is based on national tsunami warning centres, which are being established in 29 countries around the Indian Ocean rim. Three of the countries will host regional centres.

A technology assessment by experts concluded that a reliable Indian Ocean warning system would require three elements:

- An improved seismographic network to monitor earthquakes.
- A real-time sea level observing network covering all of the Indian Ocean basin.
- The deployment of deep sea pressure sensors capable of detecting tsunami waves as they travel over the deep ocean.



IOC IOTWS Assessment mission team visit Instituto Nacional de Hidrografia e Navigacao (INAHINA), Maputo, Mozambique, July 2005.

3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

Indian Ocean Tsunami Warning and Mitigation System

By the end of 2005, 26 national tsunami information centres had been established as an interim step, capable of receiving and distributing tsunami advisories around the clock, relying exclusively on seismic data from the Japan Meteorological Agency and the Pacific Tsunami Warning Center.

By mid-2006 there were 23 sea level stations continuously transmitting data in real-time across the Indian Ocean, improving the region's ability to more accurately predict tsunamis.

An international partnership, hosted by UNESCO-IOC, has been created to facilitate transfer of the technology needed to build the deep ocean pressure sensors already in place in the Pacific. The deployment of pressure sensors able to detect tsunami waves as they move across the ocean, will further improve the effectiveness of the Indian Ocean system.

Malaysia Tsunami Warning Centre.

3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning

As information from the new instruments and networks starts flowing, tsunami warnings will begin to be issued. This service will be provided by regional advisory centres.

The Indian Ocean system will also develop tsunami modeling capacity and training aimed at achieving accurate risk assessment, effective management of warning systems, and the transfer of knowledge and expertise in developing basic emergency preparedness tools such as inundation maps of high-risk coastal areas including cities.

Oman National Tsunami Warning Center, Department of Meteorology, Directorate General of Civil Aviation and Meteorology, Muscat, Oman.

Indian Ocean Tsunami Warning and Mitigation System

Experiments have been conducted to test communication links for the transmission of seismic information in real-time, and improvements have been made to the Global Telecommunications System to enable it to carry tsunami-relevant information.

An international partnership, hosted by UNESCO-IOC, has been created to facilitate transfer of the technology needed to build the deep ocean pressure sensors already in place in the Pacific.
The deployment of pressure sensors able to detect tsunami waves as they move across the ocean, will further improve the effectiveness of the Indian Ocean system.

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Refer [3.1.4.2 - 17 of 17] to learn more on Progress in the Indian Ocean is detailed in a summary booklet produced by UNESCO-IOC in early 2006. Click here to view From Commitments to Action: Advancements in Developing an Indian Ocean Tsunami Warning and Mitigation System in the CD - ROM

A global tsunami warning system as part GEOSS

UNESCO-IOC is working towards the creation of a Global Tsunami Warning and Mitigation System. A huge effort is underway to link regional monitoring efforts to create a coordinated global tsunami warning system that would contribute towards the Global Earth Observation System of Systems (GEOSS).

GEOSS originated from the 2002 call at the World Summit on Sustainable Development in Johannesburg for urgently-needed, coordinated Earth observation.

Today, an Intergovernmental Group on Earth Observations (GEO) oversees the GEOSS 10-Year Implementation Plan that was endorsed by nearly 60 governments and the European Commission at the 3rd Earth Observation Summit in 2005 in Brussels, Belgium. The Plan identifies deliverables and targets that will:

"... realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive, and sustained Earth observations and information."

The Global Earth Observation System of Systems (GEOSS):

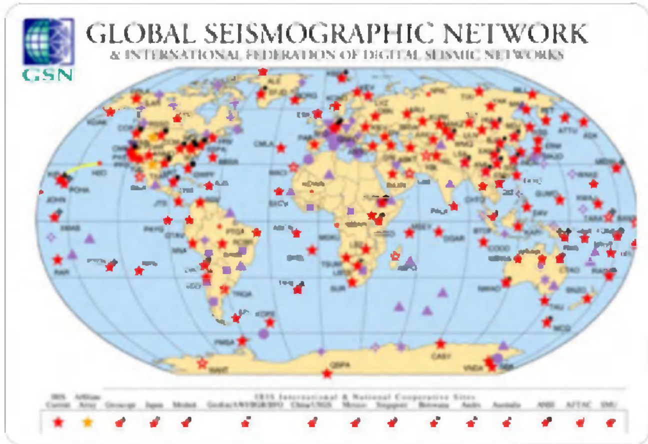
"...aspires to involve all countries of the world, and to cover in situ observations as well as airborne and space-based observations.

"...Through GEOSS, they [Earth observing systems] will share observations and products with the system as a whole and take such steps as are necessary to ensure that the shared observations and products are accessible, comparable and understandable, by supporting common standards and adaptation to user needs."

GEOSS aims to link up orbiting satellites currently used to gather environmental data and other observation technology, and pool all national and regional observation data gleaned from them, within the next 10 years.

For tsunamis, oceanographic observations under the Global Ocean Observing System (GOOS) and earthquake observations supported by the Global Seismographic Network (GSN) of the Federation of Digital Broadband Seismographic Network (FDSN), are being utilized to build real-time detection and evaluation systems for tsunami warning in the Pacific, Indian Ocean, Atlantic Ocean, and Caribbean and Mediterranean seas.

3.1.4 Dealing with Tsunamis - 3.1.4.2 Detection and early warning



The Global Seismographic Network, which makes data available to everyone for international monitoring of and research on earthquakes and tsunamis, is a contribution to GEOSS by the USA.

Take a look at the Group on Earth Observations website:

http://earthobservations.org/

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

Equipped with safety information, and with the possibility of warning time thanks to tsunami monitoring systems, the third arrow in the bow of preparedness is emergency response planning at local, regional and national levels – called tsunami mitigation.

Governments need to "manage tsunami risk", according to Patricio Bernal, Executive Secretary of UNESCO's Intergovernmental Oceanographic Commission, which implies:

"…emergency preparedness planning, legal and administrative frameworks, awareness campaigns and education, and the development of the operational capabilities to act in an emergency."

Tsunami warnings need to be accompanied by highly effective communication channels if they are to reach the people they are supposed to save. And once people get the message, they need to know where danger zones are, and where they will be safe.

It is the responsibility of governments to ensure that emergency services and plans are in place. But the media as well as schools, local authorities, community groups and businesses have key roles to play in disseminating disaster response information.

Dr. Patricio Bernal, Executive Secretary of UNESCO's Intergovernmental Oceanographic Commission (IOC)

Getting the message across

The ITIC's Dr Laura Kong has stressed the importance of understanding that tsunami preparedness is not just about earthquake data and tide gauges but also about making sure that warnings get out to government agencies that have a solid response plan.

"That is probably the hardest part. Some nations don't have the communications structures down to the local village level."

Reuters has used the example of Walagedo, a village 80 kilometres south of Colombo that was the first Tsunami Protection Village to be set up in Sri Lanka. A warning centre in Colombo will telephone a café owner in the town in the event of a tsunami, it reports. His "job is to trigger a siren on the beach – that is, if he is at home that day and not taking tourists on adventure safaris". This example highlights the importance of ensuring strong local communication support.

"Active awareness and education efforts are needed to start to build a better prepared public. Tsunami early warning systems must provide timely, understandable warnings within minutes that will then motivate ordinary citizens to quickly move out of harm's way."

Dr. Laura Kong, Director of the International Tsunami Information Centre (ITIC)

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media
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Getting the message across

Countries in the Indian Ocean rim, which had little experience of tsunamis until the 2004 event, are beginning to take mitigative actions. But it is a slow process. Countries lack capacity and expertise, and there is a danger that as memories of the disaster begin to fade, so too will tsunami preparedness efforts.

The 2005 expert assessments of capacity building needs of 16 countries affected by the 2004 Indian Ocean tsunami, overseen by UNESCO-IOC and other international agencies, covered progress being made in tsunami mitigation in that region. In 2006, the IOC will lead National Assessments of Iran, South Africa and Yemen, and conduct a technical mission to the Maldives to provide further assistance.

Refer [3.1.4.3 - 03 of 21] to learn more on IOC Consolidated Report on Assessment of Capacity Building. in the CD - ROM

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

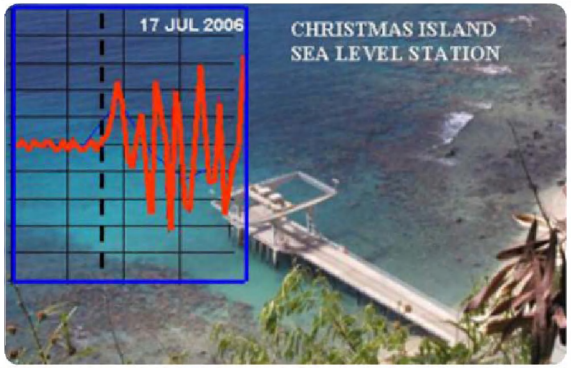
Overview

One of the cornerstones of tsunami mitigation is hazard assessment. Through this process, vulnerable coastal areas are identified and mapped, and the potential risk to the people who live there is understood.

Hazard maps require knowledge of the historical tsunami record in order to estimate the probability that a tsunami will occur in the future. Wherever there is a chance that a large, shallow, undersea earthquake might occur, there is a chance for a tsunami to be generated.

A new science that looks for tsunami sediments in areas where no human documentation exists, is helping to extend the tsunami historical record back in time so that more realistic hazard potentials can be calculated.

Maps outlining tsunami inundation zones – areas likely to be flooded by the great waves – can assist planners and decision makers in designating evacuation zones and routes to safety. For this, observations of runup and inundation from past events are essential to validate modeling-based inundation maps.



The Christmas Island sea level gauge south of Java, Indonesia recorded the 17 July 2006 local tsunami which killed nearly 500 people. The station is operated by Australia, which is building a strong national tsunami warning and mitigation system and supporting detection instrumentation upgrades and capacity building in both for both the IOTWS and the southwest Pacific of the PTWS.

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

Getting the message across

The story is different in many Pacific Ocean rim countries that have experienced destructive tsunamis regularly down the years.

In Japan – one of the most frequently struck countries – earthquake warnings are broadcast on television within 30 seconds of a tremor and tsunami warnings follow very rapidly.

In the Pacific, a number of countries have developed Standard Operating Procedures (SOP) that include tsunami evacuation procedures that emergency services and the public know how to follow when a warning is received. If available, sirens are activated and radio and television announcements warn residents.

In Hawaii, which has also been hit hard by tsunamis down the years, authorities hold annual evacuation and training drills and public awareness events.

In Hawaii, tsunami evacuation maps are printed on the front of the local telephone directory, showing people what areas are threatened by tsunami flooding and what evacuation routes to follow to move inland to higher ground. In the event of a nearby tsunami that arrives too soon for a warning, people are well versed through continuing public education on what to do with the time available.

Still, the challenge remains to sustain the high levels of awareness and preparedness forever, both for local tsunamis that strike within minutes and require everyone to recognize natural warning signs and immediately respond, and for distant tsunamis that will not be felt and take hours to arrive, but for which warning centres have time to issue warnings to enable coastline evacuations.

The M9.5 Chile earthquake in May, 1960 generated a distant tsunami that destroyed Hilo, Hawaii 15 hours later. It also killed people in Japan 22 hours later prompting the need for an international tsunami warning system. The ITSU (now PTWS) was established in response in 1965. Credit: Honolulu Advertiser.

Sharing Japan's experience

The Japanese government's Asian Disaster Reduction Centre shares a wealth of disaster-related policy, planning and mitigation experience, in its effort "to create a global culture of prevention".

There are links on its website, which has an English version, to a rich array of background information and resources under the following headings:

- Establishing a culture of prevention: natural disasters cannot be eradicated, but their impact can be reduced.
- Promoting effective measures against disasters, and incorporating disaster reduction into govern ment initiatives.
- Investing in disaster reduction.
- Information as a key to reducing the damage of disasters.
- Passing on experiences to the next generation to improve disaster reduction capability
- Strengthening partnerships.
- Building a network and strengthening international cooperation.

Go to *Sharing Japan's Experience in Natural Disasters: Anthology of Good Practices*

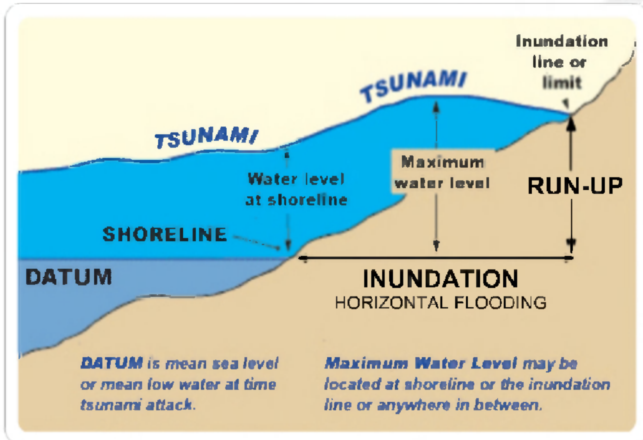
http://web.adrc.or.jp/publications/Japan_Good_Practices/index.htm

Hazard assessment – wave heights

An integral part of emergency preparedness is understanding the tsunami hazard or threat. Since earth-quakes are the most probable source, seismic hazard maps are needed to identify the potential earth-quake source zones. In the case of tsunamis, this also includes trying to predict the potential height of waves.

In high-risk areas where the maximum potential source of a tsunami is known – for example if there is an active earthquake subduction zone offshore – tsunami generation, propagation and runup can be mathematically modeled and wave heights estimated.

Also, historical records of previous tsunamis charting earthquake magnitudes, and wave heights and runup and inundation patterns, can be used to support tsunami hazard predictions.



Tsunami inundation

Hazard assessment – wave heights

Wave height and hazard assessment is more difficult to determine in coastal areas where the maximum potential tsunami source is not known and there is no historic record of events occurring before. Many potential sources must be considered to determine the hazard.

The Federal Emergency Management Agency (FEMA) in the United States considered tsunami wave heights while developing Flood Insurance Rate Maps for areas in Hawaii and the US West Coast.

NOAA's National Tsunami Hazard Mitigation Program has funded hazard assessment studies for many Pacific West Coast, Alaska and Hawaii communities. Now it is extending the process to the Atlantic coast.

Global Seismic Hazard Map constructed by the US Geological Survey showing the areas with the greatest likelihood for the strongest earthquakes.

Hazard assessment – inundation maps

One of the key tools for tsunami mitigation is the study of local coastal areas to ascertain how vulnerable they are to tsunamis – this can vary greatly along shorelines depending on the intensity of the waves, undersea features and the topographical lay of the land.

While one coastal community might experience no damaging waves during a tsunami, another community close by might be violently attacked and devastated.

The computer modeling of potential tsunami inundation – the horizontal inland penetration of waves from the shoreline – can reveal areas that are likely to be flooded during a tsunami, and what routes people can confidently use to reach pre-determined safe areas.

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

Tsunami hazards

In order to reduce the risks from tsunamis, each country must have a good knowledge of its tsunami hazard.

Documentation of the hazard requires identifying known historical and pre-historical tsunamis, and the expected or probable occurrence of tsunamis in the future based on numerical or statistical estimates. A tsunami hazard study should include listings of:

- Tsunami sources, including those from earthquakes, volcanoes and landslides.
- Tsunami impacts caused by the tsunami sources.

Such data can be compiled from

- Historical databases and tsunami catalogues held by the World Data Center for Tsunamis, NOAA National Geophysical Data Center, International Tsunami Information Center, Novosibirsk Tsunami Laboratory, and national data centres.
- Local sources such as archives, newspapers, survey reports, event logs, journals, oral history and personal interviews.
- Paleotsunami research and scientific studies of coastal deposits or evidence of uplift.
- Post-tsunami surveys collecting inundation and run-up data immediately after a tsunami
- Numerical modeling studies using likely tsunami source scenarios to numerically estimate tsunami coastal impacts.

In addition to being used to develop tsunami flooding and evacuation maps as part of a country's tsunami preparedness programmme, this kind of information is crucial to regional and national tsunami warning centres, which base warning alert criteria on the potential tsunami hazard for a coast.

Visit the NOAA National Geophysical Data Center's Historical Tsunami Database:

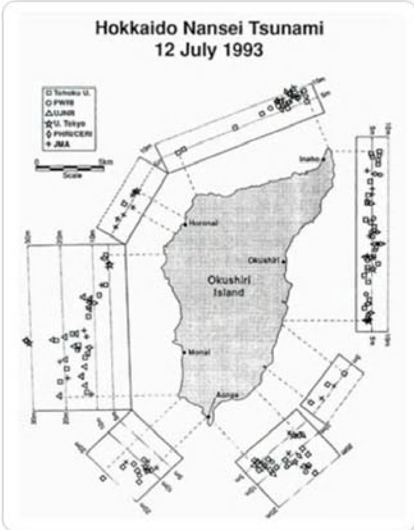
http://www.ngdc.noaa.gov/seg/hazard/tsu_db.shtml

Visit Russia's Novosibirsk Tsunami Laboratory's Interactive Tsunami Database:

http://tsun.sscc.ru/tsulab/On_line_Cat.htm

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.1 Media

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis



Distribution of runup heights from 1993 Japan Sea tsunami. The data were used to construct evacuation maps and sea walls to protect against the next tsunami.

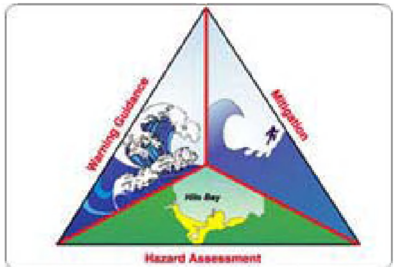
Thanks to advancements in internet and mapping technology in recent years, data that have been previously available only in textual form are now graphically represented using internet map viewers.

Two examples of internet map viewers focusing on natural hazards:

Visit the NOAA NGDC Natural Hazards Viewer:

http://map.ngdc.noaa.gov/website/seg/hazards/viewer.htm

A tsunami mitigation plan



In 1996 NOAA, FEMA and the US Geological Survey developed a Tsunami Hazard Mitigation Implementation Plan for Alaska, California, Hawaii, Oregon and Washington. It identified four primary issues for the US National Tsunami Hazard Mitigation Program that ought to be of concern to high-risk states. The needs to:

- Quickly confirm potentially destructive tsunamis and reduce false alarms.
- Address local tsunami mitigation and the needs of coastal residents.
- Improve coordination and exchange of information to better utilize existing resources.
- Sustain support at state and local level for long-term tsunami hazard.

It made four recommendations that were considered essential to the development of effective plans that would improve the awareness and preparedness of communities for tsunamis:

- Raise the awareness of affected populations.
- Supply tsunami evacuation maps.
- Improve tsunami warning systems.
- Incorporate tsunami planning into state and federal all-hazards mitigation programmes.

For more information go to:

http://nthmp-history.pmel.noaa.gov/

TsunamiReady communities

By early 2006, NOAA's National Weather Service had designated over two dozen at-risk coastal communities as "TsunamiReady," in an initiative aimed at improving public safety during tsunami emergencies. The programme promotes tsunami preparedness as:

> ***"…an active collaboration among federal, state and local emergency management agencies, the public, and the National Weather Service tsunami warning system. This collaboration supports better and more consistent tsunami awareness and mitigation efforts among communities at risk."***

TsunamiReady communities in the United States have developed hazard plans with evacuation routes to shelters outside hazard zones, as well as plans and drills for schools in hazard zones.

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

TsunamiReady communities

The communities were also required to establish an Emergency Operations Centre, disseminate tsunami warnings using sirens and local media, set up a community awareness programme, and develop multiple ways of receiving National Weather Service warnings.

Among the benefits to communities, it has been found, that they become more prepared to save lives, increase contacts with emergency experts, identify community readiness needs and enhance their core infrastructure to support other community concerns.

The TsunamiReady website is at:

http://www.prh.noaa.gov/ptwc/tsunamiready/tsunamiready.htm

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

Land use, siting and building design

In 2001 the National Tsunami Hazard Mitigation Program in the United States developed and published *Designing for Tsunamis: Seven Principles for Planning and Designing for Tsunami Hazards.*

The focus of the project is to develop tsunami mitigation guidelines as they relate to land use and building placement, design and construction, and its purpose is to help communities in five high-risk Pacific Ocean states to:

"…understand their tsunami hazards, exposure, and vulnerability, and to mitigate the resulting risk through land use planning, site planning, and building design.

The principles are:

Principle 1	Know your community's tsunami risk: hazard, vulnerability and exposure.
Principle 2	Avoid new development in tsunami run-up areas to minimize future tsunami losses.
Principle 3	Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses.
Principle 4	Design and construct new buildings to minimize tsunami damage.
Principle 5	Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects.
Principle 6	Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage.
Principle 7	Plan for evacuation.

Refer [3.1.4 - 14 of 21] to learn more on the Designing for Tsunamis.in the CD - ROM

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

Building for tsunamis

Many people have survived tsunamis by sheltering in the upper floors of sturdy buildings that have been able to withstand the immense forces of the waves, including during the 2004 Indian Ocean tsunami.

But much depends on the building's construction and on the height and power of the waves.

Whether buildings can be used as tsunami shelters, and if so which buildings, is a critical question for cities that cannot quickly be evacuated, where loss of life could be immense, or when tsunamis strike with no time for warnings.

Hotel guests during 1994 tsunami warning evacuation. Vertical evacuation to above th 3rd floor in tall, reinforced concrete buildings in Waikiki, Hawaii is allowed. Photo credit: Honolulu Star Bulletin

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

Building for tsunamis

A study by the United States National Tsunami Mitigation Program with Federal Emergency Management Agency in the United States concluded that tsunami loads were far too great for conventional buildings to be expected to withstand, and that it would be economically unfeasible to make the average building "tsunami proof."

However, organizations are is investigating "vertical evacuation" structures that are built to resist at least specific tsunami loads and could be used for evacuation. Such studies might contribute to and promote sturdy construction of high occupancy buildings like large seaside resorts.

It has been found possible to design and build structures able to withstand both earthquakes and tsunamis, guidance for the design of structures that could be used for vertical evacuation will be developed for coastal communities in the Pacific Northwest, Alaska and Hawaii. For more information on this topic, read through "Public and Private Sector module."

Protecting the environment

The natural environment can provide protection against tsunamis, and environmental destruction to make way for development can raise the tsunami risk of coastal communities. Following the 2004 tsunami, the World Wildlife Fund called for environmental issues to be considered essential to coastal protection, and to tsunami planning and mitigation efforts.

Tropical coastal ecosystems, it argued, have sophisticated natural insurance mechanisms to help them survive the storm waves of typhoons and tsunamis.

"Coral reefs are the equivalent of natural breakwaters, providing a physical barrier that reaches the sea surface, causing waves to break offshore and allowing them to dissipate most of their destructive energy before reaching the shore."

Great Barrier Reef, Australian coast

Mangrove forests also act as natural shock absorbers, "soaking up destructive wave energy and buffering against erosion". Systems of marshes, tidal inlets and mangrove channels also help limit the extent of inundation by floodwaters and enable flood waters to drain quickly.

"Places that had healthy coral reefs and intact mangroves were far less badly hit than places where the reefs had been damaged and the mangroves ripped out and replaced by beachfront hotels and prawn farms."

In the Maldives, for example, the WWF contends that tsunami damage could have been much worse had the government's protection of the coral reefs that buffer the islands from the open sea not been so diligent. Globally, it estimates that coral reefs provide "$9 billion annually in economic benefits associated with coastal protection."

For more information, please visit Section 3.3.6.7 of the Public and Private Sector in the CD - ROM

Environmental degradation

There has been widespread destruction of natural coastal habitats to make way for urban development, population growth, industry, aquaculture, agriculture and tourism in the Asia Pacific Region, according to the World Wildlife Fund.

"Hotels built too near the high tide mark were badly affected by the tsunami. In contrast, the Marriot Hotel in Phuket, Thailand, which was built and managed according to environmental guidelines, suffered substantially less damage and loss of life as a result."

Mangroves have been particularly hard-hit by development, with "estimates for many tropical coastal countries ranging up to 70 per cent loss compared to historical records." Indonesia is believed to have lost a third of its mangroves in two decades, and Thailand 50 per cent.

Many of the low-lying islands of the Seychelles are vulnerable to flooding from tsunamis.

Coral reefs have also suffered extensive damage from climate change, destructive fishing, tourism, aquaculture and agriculture. The destruction of these natural resources has also destroyed species habitats and damaged livelihoods. Estuaries too are under threat.

The WWF has recommended that tsunami mitigation strategies take into account:

- Rehabilitation and restoration of degraded coastal ecosystems that help protect from storm waves, especially coastal marshes and forests, mangroves and coral reefs.
- Adoption of integrated coastal zone management, including zoning and mandatory coastal setback. For example, hotels should not be built within a safety zone from the high tide mark.
- Strict enforcement of land and coastal-use planning and policies, including natural disaster risk assessments.
- Implementation of incentives to ensure that sensitive facilities are built away from high risk areas.
- Risk assessment that helps reduce the vulnerability of coastal development.

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

A better-prepared world

In its 2006 report, the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), argued that the crises following the Indian Ocean tsunami in 2004 and the South Asia earthquake in 2005, and massive food insecurity in Africa, highlighted the need for:

"…more focus on prevention and risk reduction measures and on predictability in response. As humanitarians, we must go beyond our current structures for addressing natural disasters to find new ways of strengthening preparedness and response at all levels – the local, the national, the regional and the global."

This too is the goal of *TsunamiTeacher*.

In 2006, the United Nations agency will focus on strengthening its work with "disaster-prone countries to support better preparedness and response, and on mobilizing the capacity of countries where such systems are already in place."

On the first anniversary of the 2004 tsunami, Jan Egeland, UN under-secretary general for humanitarian affairs, wrote in Britain's *The Independent* newspaper that it had kicked off a 2005 "Year of Disasters" that saw a huge earthquake strike Pakistan, starvation in Niger and Hurricane Katrina hit New Orleans.

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

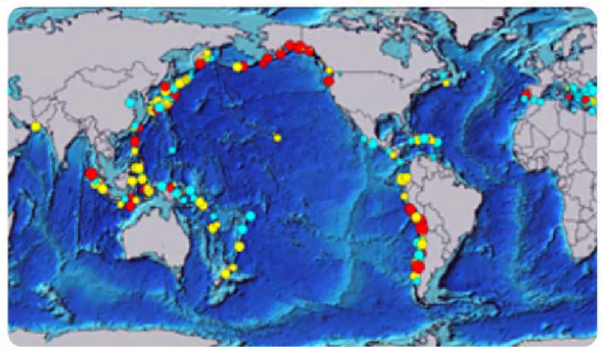
A better-prepared world

But "alongside the peril, there was also promise". In 2005 the world united as never before to aid victims of disaster, and push for an end to extreme poverty and revitalization of the UN:

"The world has no time to lose. Indeed, 2005 could be the shape of things to come. We will likely see more extreme weather and, with it, increased danger for millions of people. In the cruel calculus of disasters, poor communities are both most at risk and least able to survive.

"If nothing else, this year showed us that in our interconnected world, a disaster local in origin can be global in impact. No country, no matter how powerful, is immune.

"Today's threats – pandemic disease, entrenched poverty and hunger, extreme ideologies, conflict, mass migration and weather-related disasters – transcend borders. They require a truly global response in which solidarity, not charity, guides our approach to assistance. In the 21st Century, humanitarian aid is the responsibility of all, and benefits all."



Global distribution of earthquakes generating tsunamis. Circle color indicates extent of tsunami damage (greatest is red, followed by yellow, and blue). The size of the circle is scaled to the magnitude of the earthquake. Source: ITDB, 2005.

Example of Media Kit developed by Washington, USA

Refer [3.1.4.3 - 20 of 21] to learn more onMedia Kit resources developed by the Washington State Emergency Management Division.Media Book Cover in the CD - ROM

3.1 Media

3.1.4 Dealing with tsunamis - 3.1.4.3 Planning for tsunamis

You have now reached the end of the Media Module of the *TsunamiTeacher* resource kit. The intention has been to educate you and you should now be equipped to:

- Develop your interest, knowledge and skills in raising public awareness and understanding of tsunamis
- Build your capacity to report on, and help to develop, responses that have the potential to save lives and mitigate the impact of future tsunamis
- Be encouraged to keep tsunamis in the public eye, despite their infrequent occurrence, and monitor the integration of tsunami responses into broader national disaster strategies
- Share the valuable body of research and good practice already undertaken around tsunamis by many governments and groups, including United Nations agencies
- Provide high quality generic materials adaptable appropriately to local contexts

Hopefully, these have been achieved. If you need additional information, go to the additional training modules.

3.2 Schools

3.2.1 Introduction - 3.2.1.1 Overview

Lessons on tsunamis are part of the school curriculum in many countries bordering the Pacific Ocean, where the deadly phenomenon is a regular threat. But there is little learning about the great waves taking place in classrooms in most countries around the world.

An unprecedented number of children were killed by the 2004 Indian Ocean tsunami – over a third of the 231,452 people who are known to have died – and hundreds of thousands more lost family members and-or were left homeless. Many teachers were also killed.

The most devastating tsunami in recorded history left tragedy in its wake, but it also united humankind in the world's biggest ever relief effort, led by the United Nations. There were extraordinary accounts of courage and of survival against the odds, of children saving lives and of people from around the world rallying to support the survivors.

The 2004 event taught the world that tsunamis can happen anywhere, and not just in the seismically volatile Pacific – and it provided a compelling argument for the inclusion of tsunami lessons in school curricula everywhere.

The purpose of *TsunamiTeacher's* Schools module is to encourage teachers and school administrators to insert lessons and activities on tsunamis into their curricula, and to provide quality materials that support such efforts.

TsunamiTeacher brings together a wealth of classroom resources that were previously scattered around the world, and were not easily accessible to teachers.

3.2 Schools

3.2.1 Introduction - 3.2.1.2 Target audiences

The Schools Module is aimed at teachers and pupils from pre-school through primary to secondary education. More specifically, it is targeted at:

- Teachers who could appropriately conduct tsunami lessons in the classroom
- School department heads, those who can make curriculum content decisions
- Government officials who set national, regional or local curricula frameworks
- Principals who could decide to create tsunami-prepared schools
- Teacher trainers who might find the kit a useful training resource
- Student teachers who might be encouraged to conduct tsunami lessons in the future

This multi-use module can form the basis for training workshops, serve as a lesson or project resource, or encourage self-learning.

3.2 Schools

3.2.1 Introduction - 3.2.1.3 Aims and objectives

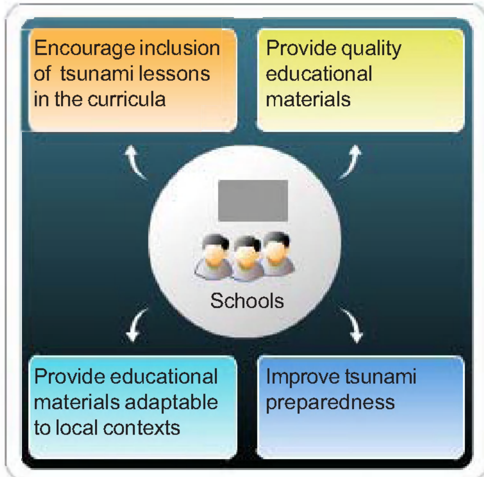
The over-arching goal of the *TsunamiTeacher* Schools module is to provide teachers with high quality, freely available educational materials from around the world that support teaching and learning about tsunamis in schools.

Aims and Objectives:

The educational objectives of *TsunamiTeacher* more specifically, are to:

- Encourage teachers to insert tsunami lessons into curricula, within a multi-hazard framework that helps prepare pupils for a range of threats
- Provide quality educational materials that support the efforts of teachers to enhance understanding of and preparedness for tsunamis among themselves and pupils
- Offer educational materials pertaining to tsunamis that have been developed worldwide, and that can be adapted appropriately to local contexts
- Encourage schools in vulnerable coastal communities around the world to draft tsunami readiness and evacuation plans

While teachers, schools and authorities in coastal communities everywhere are a primary target of the *TsunamiTeacher*, every person should know as much about tsunamis as they do about hurricanes and earthquakes. People commonly move and travel, and so it is possible for anybody to be on or near a coast where a tsunami could strike.



3.2.1 Introduction - 3.2.1.4 Intended Outcomes

The ultimate objective of *TsunamiTeacher's* Schools module is to encourage and support the dissemination of useful and potentially life-saving knowledge about tsunamis among pupils – and among teachers, a population that itself comprises millions of people worldwide.

Educators

Intended outcomes among educators

After working through *TsunamiTeacher*, educators should:

- Have better understanding of how tsunamis affect their locality, their country, and the world
- Appreciate the importance of adding tsunamis to school curricula, especially in coastal communities
- Be able to deliver quality tsunami lessons that are interesting and useful to pupils, and that help prepare them for the tsunami threat
- Have gained access to a range of information and educational materials on tsunamis contained both in *TsunamiTeacher* and on the Internet
- Be interested in developing institutional tsunami preparedness plans for schools close enough to the sea to be vulnerable to tsunamis

3.2.1 Introduction - 3.2.1.4 Intended Outcomes

Pupils

Intended outcomes among pupils

After learning about tsunamis – appropriate to their age and grade level – pupils should:

- Understand the causes of tsunamis and what happens when they strike a coast
- Be aware that tsunamis pose a risk to people living on or visiting coasts, and that low-lying areas are most vulnerable
- Understand that it is possible to plan for tsunamis, and that adults are working to improve detection and early warnings systems, and community preparedness
- Know about early warning systems and other signs that indicate a tsunami is on the way
- Be familiar with basic tsunami safety tips and survival strategies
- Recognize tsunami hazard zone and evacuation route signs
- Know when and how to evacuate a tsunami risk area
- Be familiar with school and community disaster and evacuation plans, and participate in safety drills
- Have the knowledge and skills needed to survive after an emergency, including information about health and other threats and how to combat them
- Engage parents and families in discussion about tsunamis, and provide information to them that they might not know and have not had the opportunity to learn

3.2.1 Introduction - 3.2.1.5 Tsunamis - education is key

Knowledge can be life saving, especially in an emergency, and much of what people know is learned at school. Education systems have a crucial role to play in providing information and safety tips on tsunamis and other hazards to today's children – tomorrow's adults.

Learning about tsunamis is not only knowing the golden rule of response – if there is a warning or the ground shakes, move to higher ground – but also understanding what causes tsunamis, how long danger might last and a wealth of other potentially critical information.

Tsunamis often arrive without warning, or with only a few minutes' warning, and so reading nature's signs – such as sea draining away from a beach – and knowing how to act immediately can also save lives.

In the words of Markku Niskala, secretary-general of the International Federation of Red Cross and Red Crescent Societies:

"…in the face of disaster, the difference between life and death can be as simple as possessing the right information – and acting on it."

The Federation's *2005 World Disasters Report* also stresses the importance of information:

"People need information as much as water, food, medicine or shelter. Information can save lives, livelihoods and resources. It may be the only form of disaster preparedness that the most vulnerable can afford."

3.2.1 Introduction - 3.2.1.5 Tsunamis - education is key

Advances in earthquake and tsunami detection and early warning systems, and their expansion world-wide, along with inundation models that predict the impacts of waves on coasts, are providing communities around the world with the tools to reduce the impact of future tsunamis.

More and more is also being learned about how to prepare for tsunamis in ways ranging from evacuation plans to protecting natural environmental barriers, where best to place new developments and how to construct buildings.

But experts have argued that tsunami warning systems need to be underpinned by tsunami school curricula, public awareness campaigns and emergency response plans if they are to be effective. Warnings are of little use if people do not know how to respond to them.

It has been estimated that using all tools available could avert up to 25 percent of tsunami-related deaths.

Seismology Training for new tsunami warning centre staff, Indonesia, May 2006.

3.2 Schools

3.2.1 Introduction - 3.2.1.5 Tsunamis - education is key

Contrasting casualties from the 1993 Sea of Japan tsunami with those of the 1998 Papua New Guinea event, the United States National Oceanic and Atmospheric Administration (NOAA) concluded, that "these tools work":

"For the Aonae, Japan, case about 15 percent of the population at risk died from a tsunami that struck within 10 minutes of the earthquake because the population was educated about tsunamis, evacuation plans had been developed, and a warning was issued.

"For the Warapa, Papua New Guinea, case about 40 percent of the at-risk population died from a tsunami that arrived within 15 minutes of the earthquake because the population was not educated, no evacuation plan was available, and no warning system existed."

Knowledge becomes most critical if warning times are short – or there is no warning at all – in which case people must know how to react immediately. The value of information was dramatically illustrated during the 2004 Indian Ocean tsunami. Many victims of the tsunami received no warning – but thousands of lives were saved in cases where tsunami knowledge existed and was used.

Graphic illustrations, like these illustrations of earthquake shaking and evacuation from Tsunami Warning! *are useful in conveying safety information across age and language barriers.*

3.2 Schools

3.2.1 Introduction - 3.2.1.5 Tsunamis - education is key

The following are three dramatic illustrations of cases during the 2004 Indian Ocean tsunami where knowledge saved lives:

Tilly Smith, a 10-year-old British schoolgirl, who was holidaying in Thailand on 26 December 2004, is a spectacular example. She saved over 100 people by recalling, from a recent geography lesson, that water rapidly receding from the beach meant that great waves were on the way.

Read Tilly Smith's story in *National Geographic* at:

http://news.nationalgeographic.com/news/2005/01/0118_050118_tsunami_geography_lesson.html

When his observation tower on the remote Indian island of Tarasa Dwip started shaking, port official Abdul Razzak recalled a National Geographic programme on tsunamis and knew he needed to act. He rushed through villages screaming "Go to the hills!" and sent colleagues on his motorcycle to alert as many others as possible. Razzak saved 1,500 lives.

Read Abdul Razzak's story at:

http://news.nationalgeographic.com/news/2005/01/0107_050107_tsunami_natgeo.html

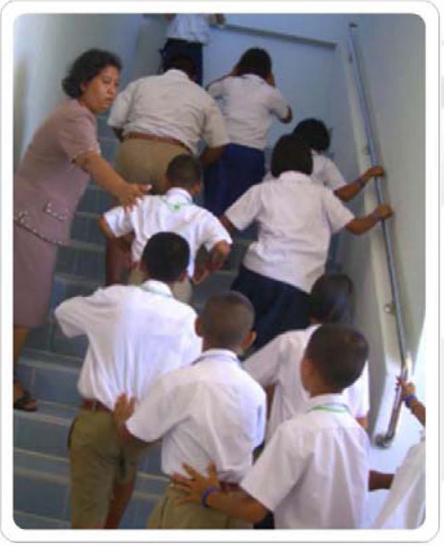
Schools that protect

Schools are not just about learning – they are also environments that protect children.

With the help of experts such as oceanographers, geologists or engineers, schools in low lying coastal areas can identify nearby hills or buildings where pupils and teachers could seek refuge from a tsunami, and go about planning safe routes to get there.

Vulnerable schools can add tsunami preparedness to emergency strategies and drills that they might already have in place.

Schools are nodes of community life that can help build awareness of the tsunami hazard among local people, assist in drafting community preparedness plans, and develop the means to act as communication, shelter and relief effort centres in a disaster's aftermath.



Vertical evacuation drill into a newly built, reinforced concrete school building at Tab Lamu School, Phang Nga Province, Thailand. The emergency tsunami evacuation plan was developed by principals and teachers, explained to the school children, and then a drill conducted to practice the plan. The campus is located along a flat coastal area surrounded by dense jungle, with no nearby high ground. Credit: ITIC

After a tsunami

One of the lessons of major disasters in recent decades has been that threats to lives linger long after the phenomenon has spent its course. Tsunamis are particularly destructive.

The demolition of homes, infrastructure such as clean water and sanitation, and public services such as electricity and clinics, force survivors- especially those who are injured or vulnerable, as children are- into unhygienic refugee conditions where disease thrives.

After the 2004 tsunami, the United Nations Children's Fund (UNICEF) warned:

"…three to five million people throughout the tsunami-affected region face fundamental health risks and challenges to their survival – at least one-third of them children. Without immediate, wide-scale action to provide safe water, sanitation and essential medicines, the affected populations will be at grave risk of diarrhoea, respiratory and mosquito-borne diseases."

Games can have great educational value in building preparedness. Children learning about natural disasters by playing Riskland board game developed by UN/ISDR and UNICEF. Credit: ISDR

The UNICEF Fact Sheet: Potential Disease Threats is at:

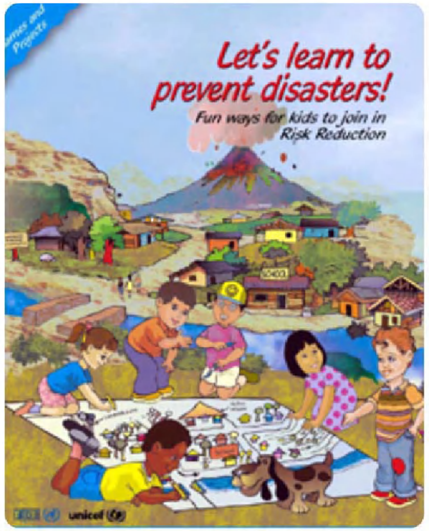
http://www.unicef.org/media/files/deadly_diseases.pdf

3.2.1 Introduction - 3.2.1.5 Tsunamis - education is key

Children should learn the “A to Z” of surviving in an emergency, including basic hygiene to help prevent illness, and avoiding dangerous items or situations, such as damaged wires or batteries. Children can also encourage their parents to stock up on essential supplies such as water and tinned foods.

Finally, natural disasters can destroy schools, claim the lives of teachers and pupils, and severely disrupt schooling for long periods. The 2004 Indian Ocean tsunami destroyed or damaged over 1,000 schools – especially in Indonesia – and killed thousands of teachers.

Schools could benefit from having contingency plans in place, outlining how they can get back, and up and running as soon as possible after disaster strikes.



ISDR and UNICEF have published the booklet Let’s Learn to Prevent Disasters! *to help children learn about natural hazard disaster risk reduction through fun games and interactive activities.*

In the words of UNICEF:

“Getting children back in class is essential for their recovery…even if it takes place in tents and other makeshift arrangements.”

A UNICEF report on the 2004 tsunami’s destruction of schools, and what the UN agency was doing to help, at:

http://www.unicef.org/media/media_24847.html

3.2.2 Teacher Guide - 3.2.2.1 Module overview

Recognizing the information overload that already exists in most school curricula, learning about tsunamis could be considered within a multi-hazard framework, slotting into curricula where they deal with other natural threats such as earthquakes or floods or hurricanes.

While geography is the natural “home” for tsunami teaching, it is a multidisciplinary subject and tsunami lessons could contribute to other subjects, for instance history (learning about the world’s worst tsunamis) or science (learning about waves).

Where curricula are already overloaded, teachers could focus on essential core areas while providing pupils with access to more in-depth and “nice-to-know” information where possible.

3.2 Schools

3.2.2 Teacher Guide - 3.2.2.1 Module overview

Tsunamis make interesting projects, and *TsunamiTeacher*'s Media Module could be used by teachers and pupils as a "library" that contains a rich collection of information as well as links to a wide range of internet articles and reports, photographs and illustrations.

Finally, *TsunamiTeacher's* content could be used by schools as a resource to assist themselves and their communities with tsunami readiness plans.

This Schools module contains background information, existing curricula and lesson plans from which teachers can draw, from *TsunamiTeacher* itself, from publishers around the world and from the Internet. There are many suggested activities, as well as loads of website links to articles and other resources for schools with Internet access.

All of the materials are freely available to be used and reproduced for educational purposes, indicating the importance with which getting tsunami information into classrooms is viewed by United Nations agencies such as UNESCO, many governments and non-profit groups.

Pre-elementary textbook, SHOA, Chile.

3.2 Schools

3.2.2 Teacher Guide - 3.2.2.1 Module overview

TsunamiTeacher presents a variety of educational resources, from comprehensive curricula including lesson plans and teacher guides designed for primary and secondary pupils, to activity ideas and materials such as worksheets and games, brochures and film.

All of the resources in this kit are in English, but teachers are welcome to translate them into local languages and a few are able to be edited on-page. Some of the resources have a developed country or developing country slant, but all are easily adaptable to local contexts. Teachers are free to use any part of a curriculum or lesson, or to combine bits and pieces of the resources to suit the needs of pupils and the time available.

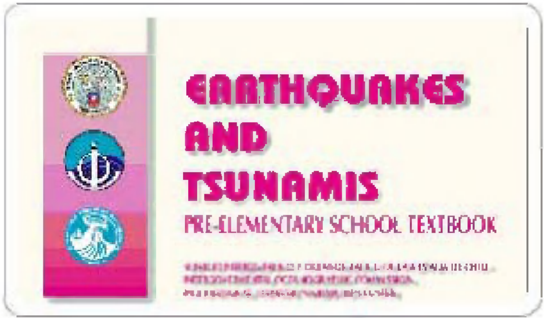
3.2 Schools

3.2.2 Teacher Guide - 3.2.2.1 Module overview

To make the module materials as easy as possible to access, they have been divided into two groups:

- Tsunami curricula and lessons

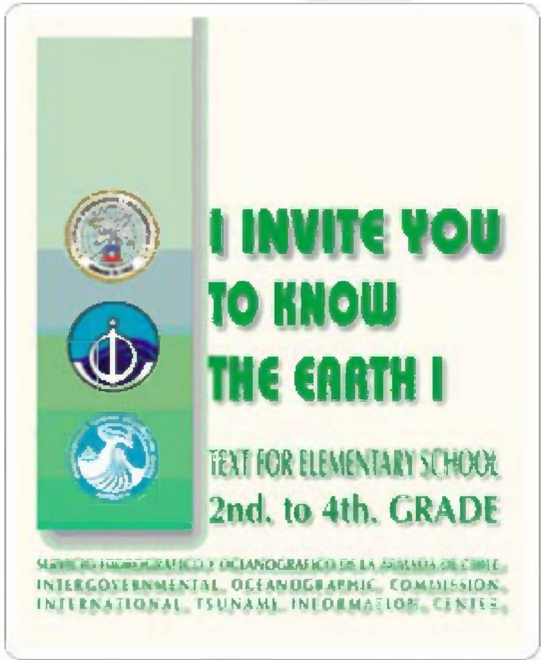
The "Tsunami lessons" section is further divided into: curriculum sets heldin *TsunamiTeacher's* Resource Collection, which can be accessed directly and printed out for use by teachers; and tsunami curricula on the Internet that provide additional choices for teachers with Internet access.



- Classroom support materials

The "Classroom support materials" section features films and booklets, information sources, activity books and games. It is divided into: film, photographs and graphics; classroom activity materials that are contained in *TsunamiTeacher* and can be accessed directly; and classroom support materials on the Internet, including tsunami-related games.

Before proceeding to the curriculum and support materials, it is recommended that teachers read through two short sections. The first contains tips for tsunami lessons, and curriculum coverage suggestions. The second provides background information on tsunamis, as well as extensive links to Internet articles, tsunami websites and agencies.



Classroom support materials

3.2 Schools

3.2.2 Teacher Guide - 3.2.2.2 Tips and suggestions

In January 2005 educational publishers, the McGraw-Hill group of companies in the United States, drew up 10 useful tips for teachers on how to incorporate the 2004 Indian Ocean tsunami into lessons plans.

Tips for tsunami lessons

- Cater the discussion to the age of your students. Children as young as four have a natural curiosity about the event.
- Adjust the curriculum as needed to incorporate the disaster into lessons.
- Link the lesson to something students are already learning or already know.
- Read articles about the tsunami collected from newspapers and the Internet to spur discussion and dispel rumours.
- Create a timeline of a world map showing how the disaster unfolded.
- Have students write essays on different aspects of the tsunami.
- Focus on the science first, then the people involved.
- Help make the event seem less remote by looking at articles in local newspapers.
- Measure the distance between your hometown and the disaster area.
- Relate it to natural disasters in your part of the world, such as hurricanes or tornados.

3.2 Schools

3.2.2 Teacher Guide - 3.2.2.2 Tips and suggestions

TsunamiTeacher editorial team member Professor Sirimali Fernando, chairperson of Sri Lanka's National Science Foundation, developed a set of suggestions on what broad areas tsunami lessons could cover in pre-primary, primary and secondary schools.

Pre-school

There should be formal teaching in a module to encourage:

- Appreciation of the ocean, beach, coastal environment and what happens if giant waves reach the shore. Pupils would be introduced to the word "tsunami" and to different kinds of waves.
- Learning about tsunami detection and warning systems, and the various means of informing people that tsunami waves are on the way, such as via radio, television and sirens. The impor tance of listening to the advice of adults during an emergency.
- Familiarization with warning signals such as sirens, and tsunami hazard zone and evacuation route signs.
- Participation in evacuation drills.

Primary school

There should be formal teaching in a module to encourage:

- Understanding of how tsunamis are generated and of basic plate tectonics. Children should learn that a tsunami is the result of the sudden displacement of a huge column of water in the ocean, and what kind of events can lead to that.
- Basic understanding of early warning systems, warning signals, signs and principles of evacuation.
- Knowledge of areas that are safe from tsunamis, and how to reach them safely.
- Understanding of other ways that people, families and communities can prepare for tsunamis, such as putting together a "survival kit" and learning about health threats following emergencies.
- Participation in evacuation drills.
- Pupils to discuss evacuation and other safety procedures with their families.
- Appreciation of the need for team work in the event of a disaster.
- Children to volunteer to join school disaster response teams.

Secondary school

There should be formal teaching of a module to demonstrate:

- Plate tectonics and the generation of tsunamis, the nature of tsunami waves and how long they take to reach the shore (and hence time available for evacuation).
- How scientists monitor tsunamis, how warning systems work, and how scientists are using past tsunamis to help assess the potential impacts of future events.
- How it is possible to identify coastal tsunami hazard zones and develop hazard and inundation maps that help communities to mitigate the potential impacts of tsunamis.
- The importance of protecting natural environmental tsunami barriers such as reefs, sand dunes and mangrove forests.
- The need for future development in coastal areas that are relatively safe from tsunamis, tsunami-oriented building codes and the identification of sturdy buildings where refuge from tsunamis can be sought.
- How to develop evacuation and relief plans and to conduct disaster drills in schools.
- Basic first aid procedures and how to deal with the health and other threats that can follow disasters such as tsunamis.
- How to set up volunteer groups of children to assist with evacuations, medical and other emer gency assistance, and rescue and relief operations.

3.2.2 Teacher Guide - 3.2.2.3 *TsunamiTeacher* background resource

Educators can draw upon *TsunamiTeacher's* wealth of information and materials to facilitate learning about tsunamis, support lessons, pupil research, and projects. There is a great deal of information about tsunamis in the Media Module, while all of *TsunamiTeacher's* background resources reside in the "Resource Collection".

The material in the Media Module is divided into three parts: "The great waves", which describes the causes and science of tsunamis; "Tsunamis down the years", which charts the study and history of tsunamis, including a substantial section on the 2004 Indian Ocean Tsunami; and "Dealing with tsunamis", which details the many ways of preparing for the great waves.

Seismographic station installation training, Indonesia, May 2006

3.2.2 Teacher Guide - 3.2.2.3 *TsunamiTeacher* background resource

Each section provides links to websites and other resources. As the material is the content of the Media Module, teachers will come across many links to articles and tsunami-related organizations, which provide useful research links. There are also exercises for journalists, which might produce worthwhile classroom activities for older pupils.

The Great Waves

A scientific snapshot

This section of *TsunamiTeacher* defines tsunamis and describes how the great waves move across oceans and form into massive waves in coastal waters. It investigates where tsunamis are most likely to happen, how offshore and coastal features influence the ways in which tsunamis impact on coastlines, and how the great waves cause damage.

Causes of tsunamis

This material looks at where tsunamis are most likely to occur and why, at plate tectonic theory and earthquakes – the main cause of tsunamis – and at other ways tsunamis can be generated such as volcanic eruptions or collapses, landslides or rock falls, and asteroid or meteorite collisions with the earth.

Refer [3.3.2 - 02 of 02] to view "The great waves" section of TsunamiTeacher

Tsunamis down the years

A short history

This section outlines the history of tsunamis and looks at how data banks and paleotsunami research, in which scholars study sediments deposited by past tsunamis, is helping to extend the historical record back in time and enhance understanding of tsunamis. There are also lists of major tsunami occurrences around the world.

Amazing tsunamis

Ten major tsunamis are briefly described, to paint a picture of the havoc that tsunamis have wreaked through history. Some tsunamis are included because of their devastating death tolls, others because of the great height of their waves or the widespread damage they caused.

These include the tsunamis of Port Royal (1692), Lisbon (1755), Krakatau (1883), Great Sanriku (1896), Sicily (1908), Aleutian Islands (1946), Alaska (1958), Chile (1960), Alaska (1964), and Papua New Guinea (1998).

Refer [3.3.2 - 02 of 02] to view the "Tsunamis down the years" section of TsunamiTeacher

3.2.2 Teacher Guide - 3.2.2.3 *TsunamiTeacher* background resource

The 2004 Indian Ocean tsunami

The world's worst tsunami occurred on 26 December 2004, claiming nearly 232,000 lives, including some 9,000 foreign tourists. This section describes in-depth how the tsunami was generated, where it struck and its multiple impacts on countries.

The 2004 event was not only the world's worst but also the most reported tsunami ever, and its story is told through the eyes of international media such as *National Geographic*, *Newsweek* magazine, *The Guardian* newspaper, the BBC and CNN.

There are survivor's tales and descriptions of the tsunami aftermath, its impacts on children and on the environment, and details about aid and reconstruction efforts during the world's biggest-ever relief effort – more than $13.6 billion was raised for aid and reconstruction.

Refer [3.3.2 - 02 of 02] to view "The 2004 Indian Ocean tsunami" section of TsunamiTeacher

Dealing with tsunamis

Tsunamis are a threat to all people living near the ocean, and they can strike at any time. But there are many ways to prepare for and respond to tsunamis that have been shown to save lives, and there are ways to minimize threats to the health of survivors after the event.

This section of *TsunamiTeacher* describes how it is possible to prepare for tsunamis, and to respond effectively to them when they happen.

Surviving tsunamis

More and more is being learned about how to plan for tsunamis in ways ranging from educational outreach programmes and evacuation plans to protecting natural environmental barriers, where best to place new developments and how to construct buildings.

It has been estimated that using all tools available could avert up to 25 percent of tsunami-related deaths. This section looks at how it is possible to survive tsunamis, and offers safety precautions before, during, and after tsunamis.

Detection and early warning

The international community is increasing efforts to develop new, or enhance existing tsunami detection and early warning systems.

3.2.2 Teacher Guide - 3.2.2.3 *TsunamiTeacher* background resource

This section looks at developments that have improved detection of the great waves – from earthquake measurement to tide gauges to deep-ocean sensors – at the warning system created in the Pacific, and at efforts to set up a global tsunami warning and mitigation system.

Planning for tsunamis

The third crucial aspect of tsunami preparedness is emergency planning at local, regional and national levels – tsunami mitigation.

This section investigates the many ways to manage tsunami risk. Among them:

- Effectively warning the public
- Understanding tsunami threats through wave height predictions and inundation maps
- Community emergency preparation
- Location and construction of buildings
- Protecting natural environmental tsunami barriers

Refer [3.3.2 - 02 of 02] to view the "Dealing with tsunamis" section of TsunamiTeacher

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

There are three school curriculum collections to which teachers need to be introduced. There is a brief description of each resource and links to the Resource Collection, from where materials may be accessed for classroom use.

These three curriculum collections are:

Earthquake and Tsunami Textbooks, Chile, UNESCO IOC, 1996-97

Developed by Servicio Hidrografico Oceanografico de la Armada de Chile, UNESCO's Intergovernmental Oceanographic Commission (UNESCO-IOC) and its International Tsunami Information Centre (IOC-ITIC).

Tsunami Curriculum, K-12 , Washington State, USA, 2000

Developed by the Washington State Military Department's Emergency Management Division and based in part on material from US FEMA Tremor Troops and Seismic Sleuths curricula.

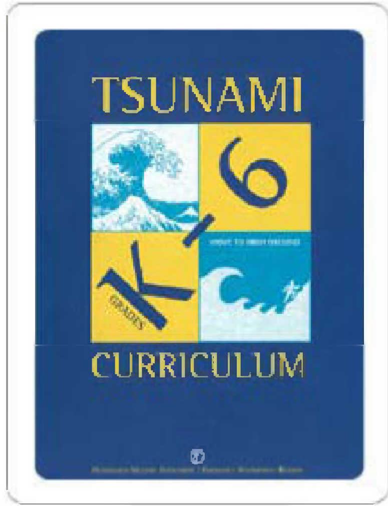
Tsunami, Grades 4-6, Asian Disaster Reduction Center, UNESCO IOC 2006

Developed by UNESCO-IOC, the ministries of Education and of the Interior in Thailand, and the Asian Disaster Reduction Center in Japan.

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

Move to High Ground

Move to High Ground – Developed by the Washington State Military Department's Emergency Management Division to support its public awareness program, and based in part on curriculum developed by the US Federal Emergency Management Agency, this two-part collection targets students in primary and secondary schools. A range of support texts and illustrations are included.



Grades K to 6

This comprehensive tsunami curriculum was developed by the Washington Military Department Emergency Management Division for primary school pupils. The content teaches children about earthquakes and tsunamis, and how to prepare for them. It contains:

- A teacher guide: background information; what to do when a tsunami occurs; and a pre-assess ment survey.
- Resources: tsunami website information; and a tsunami video list.
- Four units with different lessons for different grades, each outlining core concepts, vocabulary requirements, lesson frameworks and a range of exercises and activities.

  Unit 1: Defining an earthquake

  Unit 2: Defining a tsunami

  Unit 3: Recognizing an earthquake

  Unit 4: Tsunami preparedness: Move to higher ground
- Tsunami curriculum illustrations: a range of illustrations and activities to enhance learning about tsunamis. They can be copied for classroom distribution or displayed on overhead projectors for class discussions.

Refer [3.3.2 - 02 of 05] to view Tsunami Curriculum: Move to High Ground, Grades K-6

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

Grades 7 to 12

This weighty curriculum was developed by the Washington Military Department Emergency Management Division for secondary school pupils. While it is oriented to US systems and services, the materials can be adapted for pupils anywhere in the world.

The content comprises an interdisciplinary set of four lesson plans that does not differentiate between grades. The lessons teach children about the definition and causes of tsunamis, Pacific coast and regional tsunamis, the Pacific Tsunami Warning System, and tsunami preparedness.

More specifically it contains:

- A teacher guide; glossary of terms; lists of tsunami websites and videos; and the essential academic requirements and components of the curriculum.
- Four lesson plans, each including background information, learning activities, and reproducible master and activity sheets:

  Lesson 1: Tsunami: Definition and causes

  Lesson 2: Pacific coast and regional tsunamis

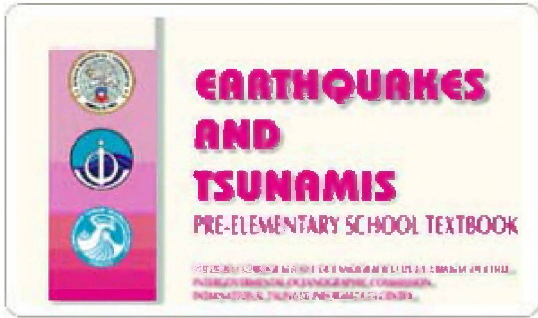
  Lesson 3: Pacific Tsunami Warning System

  Lesson 4: Tsunami preparedness: Move to higher ground

Refer [3.3.2 - 02 of 05] to view Tsunami curriculum: Move to High Ground, Grades 7-12

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

The UNESCO collection



Developed by Servicio Hidrografico Oceanografico de la Armada de Chile, UNESCO's Intergovernmental Oceanographic Commission (UNESCO-IOC) and its International Tsunami Information Centre (IOC-ITIC). Four curriculum sets, each comprising a text-book and a separate teacher's guide, target children at different stages of educa-tional development, from pre-school to high school. A cartoon character called Tommy Tsunami appears regularly through all the curriculum sets.

Earthquakes and Tsunamis

Pre-primary school

This collaborative Chile-UNESCO curriculum contains a separate activity textbook and teacher guide.

In the pupil activity book, children are introduced to two characters, Johnny Shaking and Tommy Tsunami, who appear regularly through five chapters. In the teacher guide, each chapter has lists of objectives, activities and sets of required materials. The chapters are:

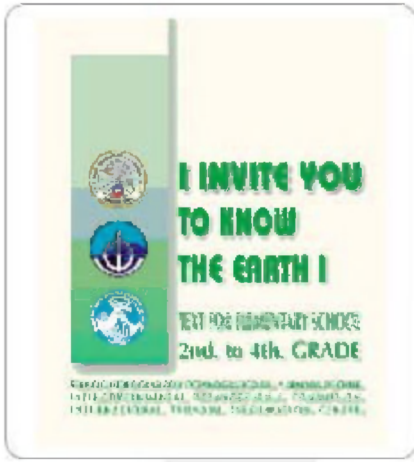
- Chapter I: Shape and movements of the water
- Chapter II: Permeability and buoyancy
- Chapter III: Lifestyles at different settings
- Chapter IV: Earthquakes and tsunamis
- Chapter V: Hazards prevention

Refer [3.3.2 - 03 of 05] to view Earthquakes and Tsunamis: Pre-elementary School Textbook

Refer [3.3.2 - 03 of 05] to view Earthquakes and Tsunamis: Teacher's Guidebook, Pre-elementary School

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

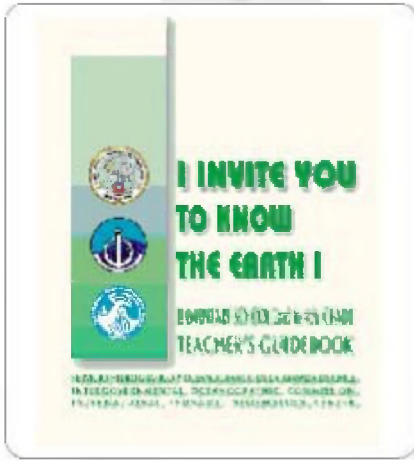
I Invite You to Know the Earth I
Grades 2 to 4



This joint Chile-UNESCO curriculum comprises a textbook and a teacher guide aimed at pupils of seven to nine years old, who have progressed beyond initial stages of reading and writing and have fine motor skills.

There are six units. In the teacher guide, each unit contains lists of objectives, activities and required materials. The units are:

- Unit I: What does our Earth look like?
- Unit 2: I invite you to know the inside of the Earth
- Unit 3: Earthquakes and tsunamis
- Unit 4: What is a natural hazard?
- Unit 5: Basic rules of natural hazard prevention
- Unit 6: Seismicity in your country



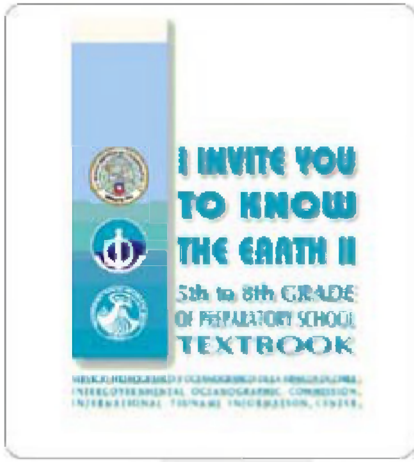
Refer [3.3.2 - 03 of 05] to view I Invite You to Know the Earth I: Text for Elementary School 2nd to 4th Grade

Refer [3.3.2 - 03 of 05] to view I Invite You to Know the Earth I: Elementary School 2nd to 4th Grade: Teacher's Guidebook

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
3.2 Schools

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

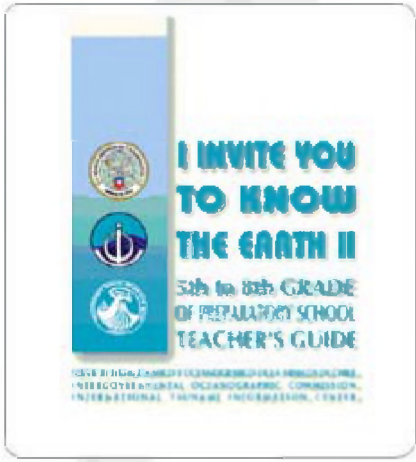
I Invite You to Know the Earth II
Grades 5 to 8



This Chile-UNESCO curriculum contains a textbook and a teacher guide aimed at pupils of 10 to 13 years old, who show many adult characteristics in their learning and are able to assimilate a large amount of information.

There are five units. In the teacher guide, each unit contains lists of objectives, activities and required materials. The units are:

- Unit I: The outside of the earth
- Unit 2: The interior of the earth
- Unit 3: Earthquakes and volcanoes
- Unit 4: Tsunamis
- Unit 5: Tsunami protection measures

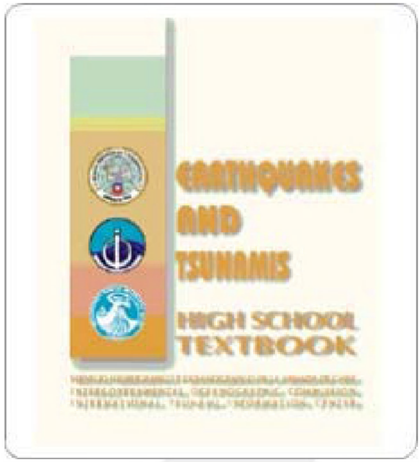


Refer [3.3.2 - 03 of 05] to view I Invite You to Know the Earth II: 5th to 8th Grade of Preparatory School Textbook

Refer [3.3.2 - 03 of 05] to view I Invite You to Know the Earth II: 5th to 8th Grade of Preparatory School Teacher's Guide

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

Earthquakes and Tsunamis
Secondary school



This collaborative Chile-UNESCO curriculum contains a textbook and a teacher guide targeting secondary school pupils.

The textbook is comprehensive and investigates earthquakes and tsunamis in-depth. There are six chapters, a wealth of suggested activities that enable the curriculum to cover a significant chunk of a subject curriculum, and tests. In the teacher guide, each unit contains lists of objectives and activities.
The chapters are:

- Chapter I: Outside and inside the earth
- Chapter 2: The earth's crust on the move
- Chapter 3: Seismicity of the earth and volcanoes
- Chapter 4: Tsunamis
- Chapter 5: Seismicity of the country
- Chapter 6: Earthquake and tsunami protection measures

Chapter 5 focuses on Chile, but teachers could make it more regionally relevant by using the lesson framework but inserting seismicity information from their own country or region.

Refer [3.3.2 - 03 of 05] to view Earthquakes and Tsunamis: High School Textbook

Refer [3.3.2 - 03 of 05] to view Earthquakes and Tsunamis: High School Teacher's Guidebook

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

Tsunami

Developed by UNESCO-IOC, the ministries of Education and of the Interior in Thailand, and the Asian Disaster Reduction Center in Japan, this newly-developed curriculum comprises a full-colour textbook designed for primary school pupils in grades four to six, and a teacher guide.

Primary school –Grades 4 to 6

This new curriculum set is a project of the Asian Disaster Reduction Center, the UNESCO-IOC ITIC, and Thailand. The curriculum comprises a full-colour textbook designed for primary school pupils in grades four to six, and a teacher guide to support tsunami and disaster preparedness teaching. It was developed cooperatively with the Thailand Bureau of Academic Affairs and Education Standards, Ministry of Education, and the Department of Disaster Prevention and Mitigation, Ministry of the Interior. The materials were developed in English and translated into Thai through a series of consultative workshops that culminated in a train-the-teacher workshop in Phuket, Thailand in April 2006 to explain and distribute the curriculum.

Refer [3.3.2 - 04 of 05] to view Thailand Tsunami Disaster Preparedness in Primary Schools

3.2.3 Tsunami Lessons - 3.2.3.1 Tsunami curriculum sets

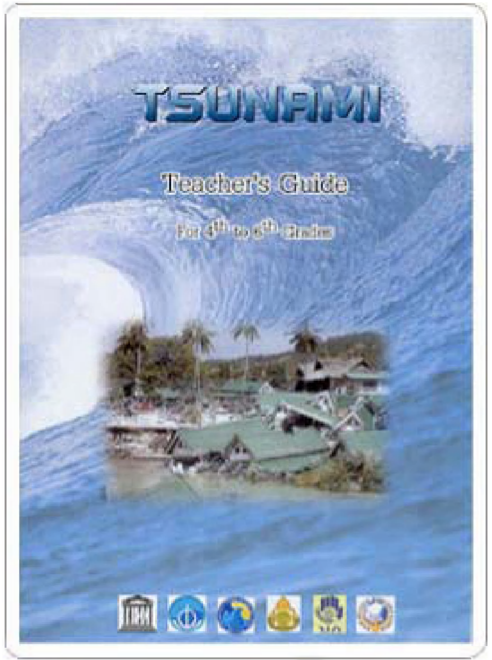
Tsunami – For 4th to 6th grades comprises a 32-page, full-colour, illustrated textbook and a teacher guide. It contains chapters on:

- The Earth
- Earthquake and tsunami
- Evacuation
- Countermeasures
- Shot story

There is also a list of reference sources, with website links.

Refer [3.3.2 - 05 of 05] to view Tsunami – 4th to 6th grades

Refer [3.3.2 - 05 of 05] to view Tsunami: Teacher guide



3.2.3 Tsunami Lessons - 3.2.3.2 Tsunami curricula on the internet

Tsunami curriculum materials and lesson plans may be found in abundance on the World Wide Web. Several are supported by animations, photographs and links to other tsunami-related websites.

Some of the curricula are quite comprehensive and are aimed at a broad age range, while others offer single lesson plans or are focused on specific educational levels. The *TsunamiTeacher* resource kit will briefly describe and provide links to tsunami lessons available on the internet.

Education Planet

Following the 2004 Indian Ocean tsunami, Education Planet – a leading United States provider of web-based education resources and services – compiled a collection of lessons and web links to help teachers interested in putting together instruction on tsunamis.

Education Planet pulled together tsunami lesson plans from a range of media, such as *National Geographic* and Discovery, aimed primarily at helping pupils grasp the mechanics of waves, especially tsunami waves.

Education Planet's tsunami website is at:

http://www.educationplanet.com/tsunami.html

3.2.3 Tsunami Lessons - 3.2.3.2 Tsunami curricula on the internet

Each lesson of Planet Education contains an overview, connections to core curriculum subjects (geography and mathematics), and geography standards, lesson times, materials required, learning objectives, geographic skills, suggested procedures, suggested student assessment, ideas for expanding lessons, and web links.

The Planet Education lesson plans are as follows:

Lesson #1: Wave Heights
Ages 3 to 5 years, and 6 to 8 years

In this *National Geographic* lesson, students learn about varying heights of ocean waves and what causes that variation. They can use the *National Geographic* Wave Simulator to experiment with creating different types of waves and learn about the different factors that influence wave formation. The lesson asks students to compare wave heights with landmarks around their school, giving them a concrete idea of possible wave heights.

The "Wave Heights" lesson is at:

http://www.nationalgeographic.com/xpeditions/lessons/07/g35/wavesheights.html

Lesson #2: Tsunami!
Ages 6 to 8 years, and 9 to 12 years

This lesson compares ocean tsunamis to fjord tsunamis. Pupils learn that tsunamis can cause massive destruction and are a formidable force of nature. The lesson includes a glossary, lesson adaptations and extensions, and thoughtful discussion questions.

The "Tsunami!" lesson is at:

http://school.discovery.com/lessonplans/programs/tidalwave/index.html

3.2.3 Tsunami Lessons - 3.2.3.2 Tsunami curricula on the internet

Lesson #3: Dynamic Earth!
Ages 3 to 5 years, and 6 to 8 years

Students complete a simple demonstration to understand how tsunamis are formed by an earthquake. There is a glossary and reading list available for further research. Students are asked to consider how much time people have to escape from a tsunami, and how they might avoid harm. This lesson asks students to relate tsunamis to disasters they may have experienced in their own lives.

The "Dynamic Earth!" lesson is at:

http://school.discovery.com/lessonplans/programs/dynamicearth/index.html

Lesson #4: It Comes in Waves
Ages 6 to 8 years, and 9 to 12 years

In this lesson from the *New York Times*, students learn about the behavior and origin of tsunami waves, and research and chart the path of certain tsunamis from recent history. They have the opportunity to examine a first-hand account of a tsunami survivor.

The "It Comes in Waves" lesson is at:

http://www.nytimes.com/learning/teachers/lessons/20020423tuesday.html

Lesson #5: Introduction to Waves
Early primary school pupils

In this lesson, pupils learn about ocean waves. They begin by learning the components of a wave. A demonstration can spark discussion about how to make waves, and an activity with the *National Geographic* Wave Simulator allows pupils to experiment with creating waves of varying sizes. This is a basic overview and offers several lesson extension ideas.

The "Introduction to Waves" lesson is at:

http://www.nationalgeographic.com/xpeditions/lessons/07/gk2/wavesintro.html

3.2.3 Tsunami Lessons - 3.2.3.2 Tsunami curricula on the internet

You will find below information on more tsunami resources on the World Wide Web.

Tsunami in Asia – Oxfam curriculum materials
[Ages 9 to 11 years]

Tsunami in Asia pulled together educational materials from Cool Planet and information from Oxfam and other websites to support teaching about the humanitarian crisis that the 2004 Indian Ocean tsunami left in its wake.

Aside from background information and links to resources, the website features a *Beyond the Wave* curriculum that offers teachers the choice of five half-day activities or five day-long sessions.

"Beyond the Wave" looks at the 2004 tsunami and what was happening a few months later in some of the countries that were struck by the great waves. Pupils are encouraged to consider "the wider issues of poverty and see why it is that the poor are always the worst affected by any natural disaster." Finally, pupils are encouraged to learn how they can make a difference.

"Beyond the Wave" can be found at Oxfam's Tsunami in Asia page:

http://www.oxfam.org.uk/coolplanet/teachers/tsunami/index.htm

Tsunamis – Australian curriculum resources
All school levels and ages

The Australian government's Department of Education and Training compiled a web-based tsunami curriculum resource that has as its overarching goal that "students understand and appreciate the physical, biological and technological world and have the knowledge and skills to make decisions in relation to it."

A wealth of background materials on tsunamis as well as outlines of classroom activities, worksheets, links to other websites with tsunami information, and animations are provided.

"Tsunamis" can be accessed at:

http://www.eddept.wa.edu.au/cmis/eval/curriculum/pathfinders/disasters/tsunamis/

3.2.3 Tsunami Lessons - 3.2.3.2 Tsunami curricula on the internet

Discovery tsunami lesson
Grades 6 to 8

Discoveryschool.com features a lesson plan on tsunamis for children covering one or two classroom periods. It lists lesson objectives, materials needed, classroom procedures and activities, an evaluation, vocabulary and definitions to be learned, and standards to be reached.

The materials list includes a video entitled: *Our Changing Earth* that needs to be ordered, but an alternative film resource could be substituted.

The Discovery tsunami lesson can be found at:

http://school.discovery.com/lessonplans/programs/tsunami/

Earthquakes and Tsunamis for Educators and Students

This website provides extensive links to earthquake and tsunami information, lesson plans, background resources and other internet sites. It covers all school levels from elementary to high school.

The website is published by Science Education Partnerships (SEPS), an organization committed to disseminating quality science education, and is maintained by Oregon State University in the United States and Corvallis School District.

The SEPS earthquakes and tsunamis web page is at:

http://www.seps.org/earthquakes_and_tsunamis.htm

Tsunami: The Big Wave – Teacher guide from NASA
Ages 10 to 18 years

The NASA Observatorium website provides a lesson plan and support article on tsunamis that opens with the 1946 Aleutian Islands tsunami and provides background and historical information on the great waves.

The focus, however, is on the Pacific Ocean and there is no information on the 2004 Indian Ocean tsunami. The teacher guide provides information on tsunamis, a list of objectives, classroom activities, links to websites and additional resources, and questions for discussion

Go to "Tsunami: The Big Wave" at:

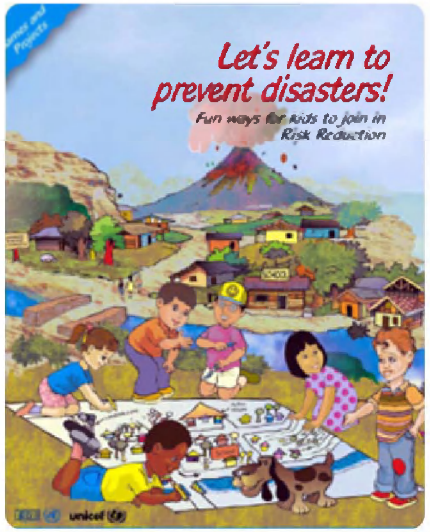
http://observe.arc.nasa.gov/nasa/education/teach_guide/tsunami.html#Agegrade

3.2.4 Classroom support materials - 3.2.4.1 Overview

This section enables educators to access additional relevant materials to supplement tsunami lesson plans. The next three sections describe films, booklets, brochures and photographs, activity materials, colouring books, stories, puzzles and games.

The first section outlines films, photographs and graphics that are available. Because they take up a lot of disk space, some of these resources are on *TsunamiTeacher's* supplementary CD-ROM. There are also links to tsunami photographs on the internet.

The second section contains classroom support materials that are stored in *TsunamiTeacher's* Resource Collection, for direct access by teachers. The third section features support materials that are available on the Internet. The Schools module is followed by a 'Workshop and Evaluation' section, which teacher trainers can use to evaluate workshops and the kit itself.



ISDR and UNICEF have published the booklet Let's Learn to Prevent Disasters! *to help children learn about natural hazard disaster risk reduction.*

3.2.4 Classroom support materials - 3.2.4.1 Overview

Run to High Ground!

A great classroom resource is to be found in *Run to High Ground!* It is an animated adventure for children five to 12 years old, but can be enjoyed by anybody.

Viola Riebe of the Hoh tribe tells a group of children the story, loosely based on events from 1700, of a giant earthquake and tsunami in the United States Pacific Northwest.

The dramatic events are seen through the eyes of a boy called Obi, who overcomes his fears to save his village.

The animated film, which runs for 14 minutes, was produced by the Washington State Military Department Emergency Management Division, and the Provincial Emergency Programme of British Columbia in association with Global Net Productions.

Refer [3.2.4 - 02 of 04] to View Run to High Ground! Video

3.2.4 Classroom support materials - 3.2.4.1 Overview

The Asia-Pacific Broadcasting Union (ABU) and the Japan Broadcasting Corporation (NHK) have produced and compiled video material and produced and broadcast short programmes on natural disasters and prevention measures. These have been made available to the *TsunamiTeacher*.

Asian Tsunami: Disaster of the Century

The Asia-Pacific Broadcasting Union (ABU) produced a 30-minute compilation of video material from its members throughout the Indian Ocean region following the 26 December 2004 tsunami, called *Asian Tsunami: Disaster of the Century*.

This valuable resource has been kindly made available to *TsunamiTeacher* by the ABU, free of charge. Teachers must use their discretion as to the age of pupils for whom the programme would be suitable.

Asian Tsunami: Disaster of the Century may be used for educational purposes only. It is stored in *TsunamiTeacher's* supplementary CD-Rom.

December 26, 2004 tsunami, Banda Aceh, Indonesia. Source: Eksklusif, Metro TV, Asian Broadcasting Union

NHK Japan – training programmes

The Japan Broadcasting Corporation (NHK) has been producing and broadcasting short programmes about natural disasters and prevention measures for more than 30 years, and is an acknowledged expert in this field.

NHK Japan has generously made the following two sets of programmes available to *TsunamiTeacher* free of charge. They are for educational use only and are contained in the supplementary CD-Rom.

Disaster Broadcast: An In-house Training Guide. Six film clips featuring very realistic footage of earthquakes and what happens next regarding tsunami alerts.

Notes on Disaster Prevention: Surviving a Tsunami Three 30-second clips on how to respond to a tsunami, which relate specifically to the 2004 Indian Ocean event.

Refer [3.2.4 - 02 of 04] to view Asian Tsunami: Disaster of the Century Video

Refer [3.2.4 - 02 of 04] to view Disaster Broadcast: An In-house Training Guide Video

3.2.4 Classroom support materials - 3.2.4.1 Overview

Photographs

TsunamiTeacher's supplementary DVD contains a range of resources that may be used by teachers to support learning in the classroom. In addition, teachers can access collections of tsunami photographs and photo-essays, most of them from the 2004 Indian Ocean tsunami, on the internet.

Please note that website addresses can change: if the web link is no longer operational, it should be possible to track down the photographic resources by either going to the home page of the media organization concerned and doing a search, or through an internet search engine.

Photographs featured on the National Geophysical Data Centre site:

http://www.ngdc.noaa.gov/seg/hazard/slideset/tsunamis/

This site contains 18,000 photographs, thousands of reports and nearly 200 albums:

http://www.photoduck.com/photos.aspx?gid=932

Waves of Destruction contains tsunami satellite imagery, photographs and videos:

http://www.waveofdestruction.org/

Tsunamis.com is a website built following the 2004 disaster, and contains photographs as well as reports and other tsunami-related information:

http://www.tsunamis.com/tsunami-pictures.html

The BBC has several collections of photographs of the tsunami striking and its aftermath, from the most-affected countries. You can find them at:

http://news.bbc.co.uk/1/hi/in_pictures/4125643.stm

This photo-library of the tsunami, in French, contains hundreds of pictures:

http://www.futura-sciences.com/communiquer/g/showgallery.php/cat/543

3.2.4 Classroom support materials - 3.2.4.1 Overview

Time Magazine's photo-essay on the tsunami:

http://www.time.com/time/photoessays/asia_earthquake/index.html

Time Asia has superb photo essays of the 2004 Indian Ocean tsunami, by country:

http://www.time.com/time/asia/photoessays/tsunami/

On CNN's tsunami website, in the left hand column are "Images of destruction:"

http://edition.cnn.com/SPECIALS/2004/tsunami.disaster/

A year after the tsunami *The Guardian* published a collection of photographs taken by inhabitants of the Indonesian village of Nusa, charting its rebuilding efforts.

http://www.guardian.co.uk/gall/0,8542,1673036,00.html

A photo essay of ceremonies held on the first anniversary of the tsunami to commemorate its over 232,000 victims, is published on *The Guardian's* website:

http://www.guardian.co.uk/gall/0,8542,1673870,00.html

Satellite imagery

NASA's Earth Observatory has a set of stunning satellite images of how the 2004 tsunami struck coasts in the Indian Ocean:

http://earthobservatory.nasa.gov/NaturalHazards/shownh.php3?img_id=12646

3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

The range of support materials that can be accessed directly through the *TsunamiTeacher* resource kit has been described here. The materials, including booklets and brochures, activity books and games, illustrated stories and articles, may be freely used by teachers.

Tsunami Warning!

UNESCO produced a cartoon booklet, *Tsunami Warning!,* aimed at informing young people about tsunamis, the dangers that they present and what can be done to save lives and property.

Tsunami Warning! is set in Honolulu, Hawaii, and in Anchorage, Alaska. It tells the story of an earthquake that occurs off the coast of Alaska, generating a tsunami that rapidly strikes the Alaskan coast and then travels across the Pacific Ocean to attack Hawaii

3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

Tsunami Warning! describes the many ways that people can respond to save their lives, and how tsunami warning systems work. Even if an earthquake and tsunami cause a lot of destruction, the important thing is to save lives and afterwards people can work to get life back to normal.

The booklet comes in two forms

1. A laid-out word document whose text can be rewritten or translated into a local language.

   Refer [3.2.4 - 02 of 06] to view the editable word document containing Tsunami Warning!

2. A set of cartoons that can be used to construct a new booklet. It may be reproduced for educational but not for commercial purposes.

   Refer [3.2.4 - 02 of 06] to view the printable PDF file of Tsunami Warning!

3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

Tsunami – The Great Waves

The 12-page *Tsunami – The Great Waves* brochure, suitable for older primary and secondary school pupils, provides reliable and detailed information on what a tsunami is, how fast and how big they can be and what causes tsunamis.

It also describes activities undertaken to mitigate the effects of tsunamis, including the development of tsunami warning centers, research projects, and safety rules describing what to do when a tsunami strikes.

Tsunami – The Great Waves was designed and published by the International Tsunami Information Centre, with support from the UNESCO-IOC Tsunami Programme, NOAA in the United States, and France's Laboratoire de Geophysique.

Refer [3.2.4 - 03 of 06] to view Tsunami – The Great Waves

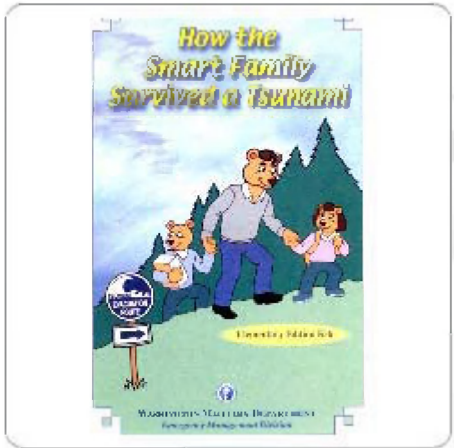
3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

How the Smart Family Survived a Tsunami

How the Smart Family Survived a Tsunami is a booklet that helps to prepare children for disasters. It was produced, by the Washington Military Department Emergency Management Division, in 2002.

The idea behind the cartoon booklet is that knowing what to expect can increase a child's confidence when a disaster occurs. It provides a very useful classroom resource for primary school children, and can be used only for educational purposes.

Refer [3.2.4 - 03 of 06] to View How the Smart Family Survived a Tsunami



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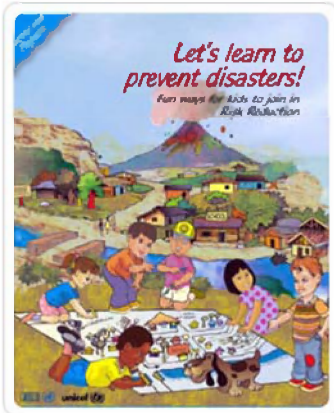
3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

The collection of materials listed here, include booklets and brochures, activity books and games, illustrated stories and articles and can be freely used by teachers.

Booklets

Let's Learn to Prevent Disasters! Fun ways for kids to join in Risk ReductionAges 8 to 12 years

The booklet aims to provide the educational community and children with an innovative and interactive tool for risk management. It suggests school activities and encourages the development of a long-lasting culture of prevention within communities. The package also includes the educational board game Riskland to help children learn as they play. It was produced and coordinated by the ISDR Regional Unit for Latin America and the Caribbean, with the invaluable support of the UNICEF offices of Costa Rica and Panama.



Refer [3.2.4 - 05 of 06] to read Let's Learn to Prevent Disasters!

Learning About Natural Disasters
Ages 8 to 12 years

The full title of this booklet is *Learning About Natural Disasters: Games and projects for you and your friends*, and it was prepared by the International Decade for Natural Disaster Reduction in the United Nations Department of Humanitarian Affairs, Switzerland.

The booklet encourages children to help protect their community from natural hazards, and features a range of community activities based on ideas used by children in many countries. It was designed for schools, to complement existing materials about natural disasters.

To obtain a hard-copy of *Learning About Natural Disasters: Games and projects for you and your friends* contact:

Marie-Lou Darricau
Library Coordinator
United Nations, International Strategy for Disaster Reduction
(UN/ISDR) International Environment House 2
7-9 chemin de Balexert
1219-Chatelaine/Geneva
Switzerland
Office:1-77
Tel: 4122 9178859
Email: darricau@un.org

Tsunami! Death Wave

Designed to accompany the book *Tsunami! Death Wave*, by Margo Sorenson, this is a booklet of reproducible pupil activities that explain how tsunamis form and how they travel. A tsunami warning system is also described.

The 32-page booklet was produced by Portals Plus: Activities Across the Curriculum, and published by Perfection Learning Corporation in Logan, United States.

True stories

A Living God

In 1896, three months after Japan's devastating Sanriku tsunami, Lafcadio Hearn Koizumi Yagumo wrote the true story of a Japanese chief who saved 400 villagers. It makes fascinating reading and is a good tsunami lesson resource.

The story recounts how, by recognizing tsunami warning signals such as a long and slow earthquake and the strange behaviour of the sea, chief Hamaguchi Gohei saved the people of Hiromura by setting fire to his rice harvest.

The villagers, who were at the seaside for harvest celebration, were drawn to the high ground of the chief's farm by the sight of a huge fire at his house and the sounding of the bell at a nearby Shinto temple, which was alerting the community to the fire. The tsunami destroyed the village and the year's harvest, but everybody survived.

Lafcadio Hearn's story was included in *Gleanings in Buddha-Fields*, published in 1897 by Houghton Mifflin Company of Boston and New York, and has been made available for educational purposes by kind permission of the writer's great-grandson.

Refer [3.2.4 - 05 of 06] to read "A Living God," by Lafcadio Hearn.

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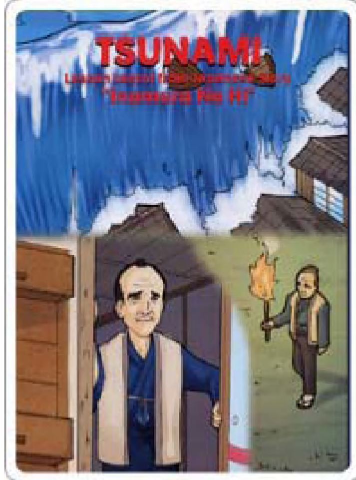
Tsunami – Lesson Learnt from Japanese Story "Inamura No Hi"



Following the 2004 Indian Ocean tsunami, Asian organizations that are financially supported by the Japanese government published colour booklets, aimed especially at young people, telling the same story of Japanese chief Hamaguchi Gohei, who saved his villagers from a tsunami disaster.

There are two booklets, both with colour illustrations and story text. The first booklet contains more detailed information than the second booklet about tsunamis and how to prepare for them, and is aimed at an older audience.

These booklets, that are supported by the Japanese government, are published by the Malaysian Medical Relief Society, Asian Disaster Reduction and Response Network and Asian Disaster Reduction Centre. They may be used for educational but not for commercial purposes.

Refer [3.2.4 - 05 of 06] to read– Lesson Learnt from Japanese Story "Inamura No Hi" (1)

Refer [3.2.4 - 05 of 06] to read – Lesson Learnt from Japanese Story "Inamura No Hi"(2)

The man who saved his village

Another story about a man who saved his village, this time from the 2004 Indian Ocean tsunami, is told by William Hermann of *The Arizona Republic*. It was featured in Sri Lanka's *Sunday Observer* in January 2005, and can be used for educational purposes.

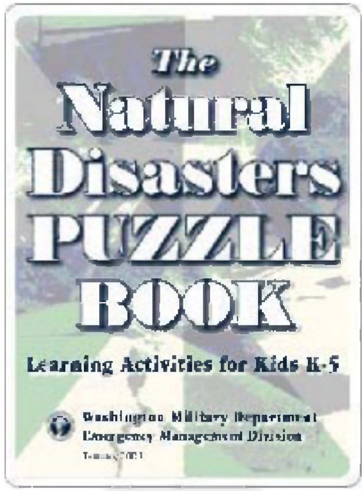
The story is about Victor Desosa, headman of Galbokka village, who related his experiences to a team of scientists who visited Sri Lanka to study the tsunami's impacts.

Desosa had been on a ship outside the harbour of Valparaiso, Chile, in 1982 when it was hit by an earthquake. Remembering that incident and seeing the sea "shaking" he somehow knew that people should get out of the village and run to high ground.

Refer [3.2.4 - 05 of 06] to read "The man who saved his village," by William Hermann

Activities

The Natural Disasters Puzzle Book



This activity book is aimed at imparting information and practical tips on how to respond to disasters. It was produced by the Washington Military Department Emergency Management Division in 2005, and is for primary school children.

Called *The Natural Disasters Puzzle Book: Learning Activities for Kids K-5*, it contains information, questions and puzzles, illustrations to colour and other activities.

Children are informed about how to make their homes safe; how to put together a disaster supply kit; how to respond to earthquakes, lahars, tsunamis, winter storms, fires, volcanoes, hot weather and evacuation orders; and how to take care of pets during a disaster

The book may be reproduced for educational but not commercial purposes.

Refer [3.2.4 - 05 of 06] to view The Natural Disasters Puzzle Book: Learning Activities for Kids K-5

Tommy Tsunami Colouring Book

A 15-page colouring book, based on the cartoon characters Tommy Tsunami and Ernie Earthquake, provides fun activity for primary school children while also imparting critical information on what to do when an earthquake or tsunami strikes.

The colouring book is a publication of the West Coast-Alaska Warning Centre.

Refer [3.2.4 - 05 of 06] to view the Tommy Tsunami Colouring Book

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3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

Tsunami Trivia Worksheet

The Oregon Department of Geology and Minerals Industries (DOGAMI) developed, among other things, a one-page quiz worksheet that asks a few pictorial questions about tsunamis and has a word search puzzle.

It is a fun activity for the end of tsunami lessons as a quick test of what pupils have learned, and is suitable for late primary and early secondary school pupils.

The *Tsunami Trivia Worksheet* was developed by Oregon's DOGAMI, using funding from NOAA's National Tsunami Hazard Mitigation Programme.

Refer [3.2.4 - 05 of 06] to view the Tsunami Trivia Worksheet

3.2.4 Classroom support materials - 3.2.4.2 Classroom activity materials

Tsunami Safety Guide – Teacher's Notes and Pupil coloring book

Each letter in the word "tsunami" is used to describe tsunamis or offer a safety tip, in this pamphlet produced by the Tsunami Memorial Institute in Hawaii.

T – Tsunamis are unusual waves that can cause great damage.

S – Sizes of tsunamis can be quite large.

U – Unusual changes in the ocean can tell you that a tsunami might be coming.

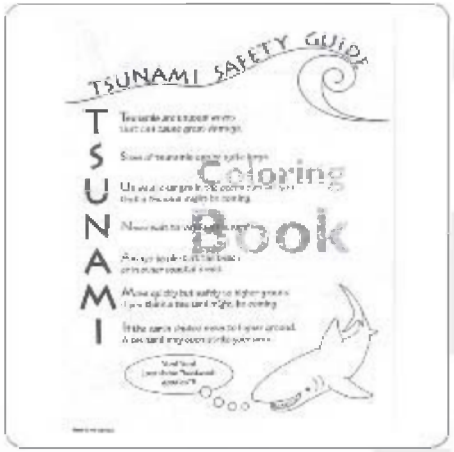
N – Never stay to watch a tsunami.

A – Always be alert at the beach or in other coastal areas.

M – Move quickly but safely to higher ground if you think a tsunami might be coming.

I – If the earth shakes move to higher ground. A tsunami may soon strike your area.

It contains succinct descriptions of tsunamis and how to prepare for them, and encourages teachers to tell pupils about tsunamis.



Refer [3.2.4 - 05 of 06] to view Tsunami Safety Guide – Teacher's Notes

Refer [3.2.4 - 05 of 06] to view Tsunami Safety Guide – Pupil coloring Book 1

Refer [3.2.4 - 05 of 06] to view Tsunami Safety Guide – Pupil coloring Book 2

3.2.4 Classroom support materials - 3.2.4.3 Internet classroom materials

This final section of the Schools Module describes various tsunami-related support materials for teachers and pupils with internet access

The resources include games and quizzes, web pages and collections of materials – some related only to tsunamis but others touching on tsunamis within a multi-hazard framework.

Activities

Tsunami Word Search Game

Children can play word search games using words related in various ways to tsunamis, such as tsunami, wave, earthquake and Hawaii.

The words to be found in the game can be written horizontally, vertically or diagonally, forward or backward. When a word is found, children highlight it by clicking on the first letter and dragging to the last. By clicking on the Restart button, new puzzles can be accessed.

This game, produced by the Association of Bay Area Governments in the United States, which is the regional planning and services agency for the nine-county San Francisco Bay Area.

The Tsunami Word Search Game is at:

http://www.abag.ca.gov/bayarea/eqmaps/wordsearch.html

Kid's Hazards Quiz

A set of quizzes covering a range of natural disasters, including tsunamis, can be found on the website of the United States' National Geophysical Data Centre, which is part of NOAA.

There are sets of five questions each on thunder storms, tornados, hurricanes, floods, water storms, earthquakes, tsunamis, volcanoes, landslides, wild fires and family disaster plans.

Most of the information in the quiz is found in the Red Cross publication *Talking About Disaster: Guide for Standard Measures*, and the project was made possible by funding from the Institute for Business and Home Safety in the United States.

The Kid's Hazard Quiz can be found at:

http://www.ngdc.noaa.gov/seg/hazard/quiz/jsp/quiz/kq.jsp?htype=Tsunamis

Disaster Discovery Board Game

An internet game that is a lot of fun and a further learning tool for pupils at the end of a multi-hazards disaster course is the Disaster Discovery Board Game, produced by the United States Federal Emergency Management Agency (FEMA).

The game can be played on the internet, downloaded to a computer or printed out and played as a board game by up to four participants – more, if children play in teams.

Pupils answer multiple-choice questions on a range of disasters and on disaster responses, and their game piece proceeds forward with a correct answer or stays in place with an incorrect one. "Chance cards" can set pupils back or move them forward. The game concludes when a game piece reaches the end.

Find the Disaster Discovery Board Game at:

http://www.fema.gov/kids/games/board/

Educational Resources

Earthquakes for Kids

While not directly about tsunamis, this children's website on earthquakes is a fun way to learn about the most common cause of tsunamis – earthquakes.

The page leads to a wealth of information, graphics and activities via buttons on the following topics: Latest Quakes; Science Fair Project Ideas; Puzzles and Games; Did You Feel It?; Today in Earthquake History; Earthquake Pictures; The Science of Earthquakes; Learning Links and Earthquake Activities; Cool Earthquake Facts; Become an Earthquake Scientist; Ask a Geologist; and Earthquake ABC.

Earthquakes for Kids - published by the United States Geological Survey can be found at:

http://earthquake.usgs.gov/learning/kids.php

After the Tsunami – US National Science Foundation

The National Science Foundation (NSF) in the United States compiled an excellent multi-media special report, *After the Tsunami*, which looks at the 2004 tsunami from a scientist's perspective and provides a range of tsunami information, links and resources.

After the Tsunami investigates the 2004 Indian Ocean tsunami, the worst affected countries, the science of tsunamis, and how to prepare for the great waves, among other things. There are animations, interviews, maps, and audio-visual resources that pupils will enjoy and learn a great deal from.

After the Tsunami is at:

http://www.nsf.gov/news/special_reports/tsunami/index_high.jsp

NOAA's Tsunami Education Resource Kit (TERK)
Grade 12

NOAA's Office of Education and Sustainable Development collected a range of educational resources on tsunamis to create a Tsunami Education Resource Kit (TERK).

TERK contains supplemental curricula, websites and standards, scientific publications, press releases, historical perspectives, brochures, hazard preparedness materials, and visual and multi-media materials.

There is also information about non-earthquake generated tsunamis, Native American tsunami stories, and film materials.

To find the TERK resources go to:

http://www.oesd.noaa.gov/terk_intro.htm

Discovery Channel – The Next Wave

This Discovery Channel multi-media presentation, called *The Next Wave – The Science of Tsunamis*, provides child-friendly background material on the 2004 Indian Ocean tsunami. The first page leads to an Indian Ocean map with click-through dots that call up brief explanations of the tsunami.

Go to The Next Wave – The Science of Tsunamis at:

http://dsc.discovery.com/convergence/tsunami/interactive/interactive.html

Global Education Tsunami Education Kit
Primary and secondary school pupils

Following the 2004 Indian Ocean Tsunami three groups – World Vision, the Australian Red Cross and the Australian government's donor agency AusAID – put together a useful tsunami schools kit featured on the Global Education website.

The kit "goes beyond the immediate disaster and examines how the disaster fits with bigger picture issues of poverty, development and aid," according to its website.

It contains primary and secondary school worksheets that provide background for teachers and pupils on these issues through information and key questions, as well as activity suggestions for all age groups and teaching resources.

The Global Education *Tsunami Education Kit* is at:

http://www.globaleducation.edna.edu.au/globaled/page1637.html

TV and Film series
Wave that shook the world

Public broadcaster PBS's award-winning Nova science television series produced a "Wave that shook the world" website that offers teaching materials.

The collection looks at what it would take to be ready for the next big tsunami, publishes answers to questions by a tsunami expert, has an "Anatomy of a tsunami" section that follows the 2004 Indian Ocean tsunami from the earthquake that generated it to the collision with coasts, and an interactive world map that looks at nine historical tsunamis.

Nova also offers a tsunami lesson plan based on its film, "Wave that shook the world."

Check out the "Wave that shook the world" website at:

http://www.pbs.org/wgbh/nova/tsunami/

Savage Earth

The four-part *Savage Earth* film series by PBS in the United States is narrated by actor Stacy Keach and tells the stories of "great natural disasters, the scientists who struggle to understand and predict them, and the people whose lives are forever changed by their merciless force."

The series has a related website with articles that explain the science behind volcanoes, earthquakes and tsunamis. The tsunami page contains a well-written article, photographs, flash graphics and an interview with a tsunami survivor. It is a good research resource for older primary and secondary school pupils.

The *Savage Earth* website is at:

http://www.pbs.org/wnet/savageearth/

The *Savage Earth* tsunami page is at:

http://www.pbs.org/wnet/savageearth/tsunami/index.html

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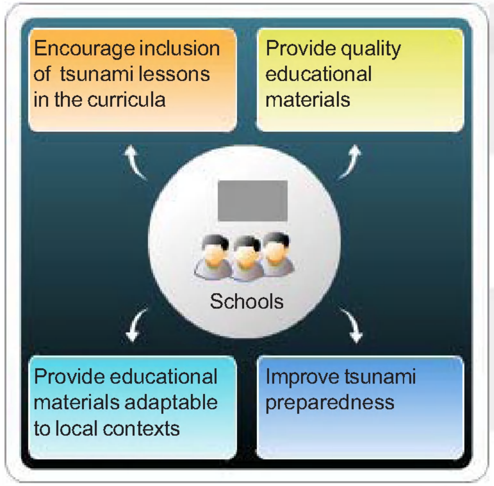
Summary

You have now reached the end of the Schools module of the *TsunamiTeacher* resource kit. The main objectives of this module were to:

- Encourage teachers to insert tsunami lessons into curricula, within a multi-hazard framework that helps prepare pupils for a range of threats
- Provide quality educational materials that support the efforts of teachers to enhance understanding of and preparedness for tsunamis among themselves and pupils
- Offer educational materials pertaining to tsunamis that have been developed worldwide, and that can be adapted appropriately to local contexts
- Encourage schools in vulnerable coastal communities around the world to draft tsunami readiness and evacuation plans



3.3.1 Tsunamis - Key Challenges - 3.3.1.1 Overview

Overview

The Indonesia earthquake and Indian Ocean tsunami of 26 December 2004 claimed nearly 232,000 lives and devastated coastlines across the Indian Ocean basin.

The great waves powered a massive surge in the death toll from natural disasters that year, and tsunamis were quickly afforded a place alongside floods and erthquakes and hurricanes as great natural threats to humankind.

Little media coverage of smaller events meant that most people did not know there had been 16 destructive local or regional tsunamis since 1990 that killed some 4,500 people in Papua New Guinea, Indonesia, Japan, Nicaragua, Russia, the Philippines, Mexico, Vanuatu and Peru.

The 2004 disaster also taught humanity that tsunamis happen everywhere, and not just in the seismically volatile Pacific Ocean.

Afterwards, governments around the world were charged with developing public awareness of and preparedness for tsunamis. At the international level, and drawing on long experience in the Pacific, governments began working together towards regional tsunami detection and warning systems that will link together and, within a decade, cover the entire earth.

"The December 2004 tsunami was, above all, a natural catastrophe, but much of the death and destruction that followed was a collective failure of human institutions."

So wrote Dr Laura Kong, Director of the International Tsunami Information Centre (ITIC), in the September 2006 edition of *The Liaison*, the professional journal of the Center of Excellence in Disaster. Management and Humanitarian Assistance, Hawaii.

She traces the development and growth of tsunami warning and mitigation systems, and argues among other things that "strong and sustained political commitment" by national governments, solid emergency and mitigation strategies, and the participation of tsunami-educated communities are all crucial to countering the great waves.

One of *TsunamiTeacher's* primary purposes is to provide governments, communities and businesses with the information they need to promote tsunami awareness and preparedness – and to ensure that never again will humankind be so devastatingly caught off guard.

The Public and Private Sectors Module shares the rich body of information, research and good practices developed over four decades by UNESCO's Intergovernmental Oceanographic Commission (UNESCO-IOC), and its International Tsunami Information Centre (IOC-ITIC).

It also draws on the experiences and resources of countries like Japan and the United States – especially the State of Hawaii – that have been historically, repeatedly attacked by tsunamis and are far advanced along the road to awareness and preparedness.

3.3.1 Tsunamis - Key Challenges - 3.3.1.1 Overview

TsunamiTeacher is a global resource with materials that are adaptable to local contexts, and it addresses some of the major needs of people around the world who have a role to play in mitigating the impacts of future tsunamis on countries and communities – capacity building, collaboration and information exchange.

The focus is on emergency response planning, management and operation, and the tsunami awareness and preparedness of authorities, businesses and the public. It stresses that, where possible, tsunami preparedness activities exist within a multi-hazard framework that readies countries and communities for all kinds of natural and technological disasters.

But while aspects of tsunami awareness and preparedness are common to all hazards (such as communication channels to warn people of danger), others are particular to tsunamis (such as the need to evacuate to higher ground). So there is a need to plan specifically for tsunamis, within a multi-hazard framework.

It is the duty of authorities to develop and implement disaster strategies and services at the national, regional and local levels. But governments cannot be held solely responsible for tsunami awareness and preparedness, as their functions and outreach have limits.

A variety of other organizations have key roles to play in tsunami awareness and preparedness, ranging from public and private businesses that must protect staff, clients, commercial operations or public infrastructure, to women's and other community groups that can deliver public tsunami education and social leadership during times of emergency.

3.3.1 Introduction - 3.3.1.1 Target audiences

Target audiences

This module is aimed primarily at people in government who make decisions about public safety, or who are responsible for planning or implementing such decisions at the national, regional or local level in coastal communities. It may also be used by private sector and coastal community organizations, which can draw both on materials in the government sections and on resources directed largely at them.

Most people who become involved in tsunami-related activities live in coastal areas. But responsibility for tsunami awareness and preparedness also involves national governments, media, education systems and private and public sector businesses with coastal operations, and they too could find *TsunamiTeacher* useful.

More specifically, the Public and Private Sectors Module is targeted at:

Strategy meeting for building tsunami awareness and warning services, SOPAC-IOC Southwest Pacific Tsunami Awareness Workshop, July 2004.

Elected officials and senior government decision makers

Elected representatives and senior government officials who make decisions about public safety, and might need to learn more about the tsunami threat and potential responses, and ways to integrate tsunamis into emergency planning and legislation.

People in national, regional and local governments

People in national, regional and local governments who have hands-on involvement in emergency planning and management, and who could use detailed information on ways to develop and implement tsunami awareness and preparedness plans.

Public and private businesses

Public and private sector businesses that operate public goods such as electricity, telecommunications and transport services which can be damaged or destroyed by tsunamis.

3.3.1 Introduction - 3.3.1.1 Target audiences

Coastal businesses and industries

Coastal business and industries that could be affected by tsunamis, and might want to put tsunami emergency procedures in place for clients and staff, and to consider ways of getting business back up and running quickly after disaster strikes.

Coastal hotels and tourism businesses

Coastal hotels and tourism businesses that provide recreational services to local people and visitors who enjoy visiting beaches and engaging in seaside activities.

Civil society organizations

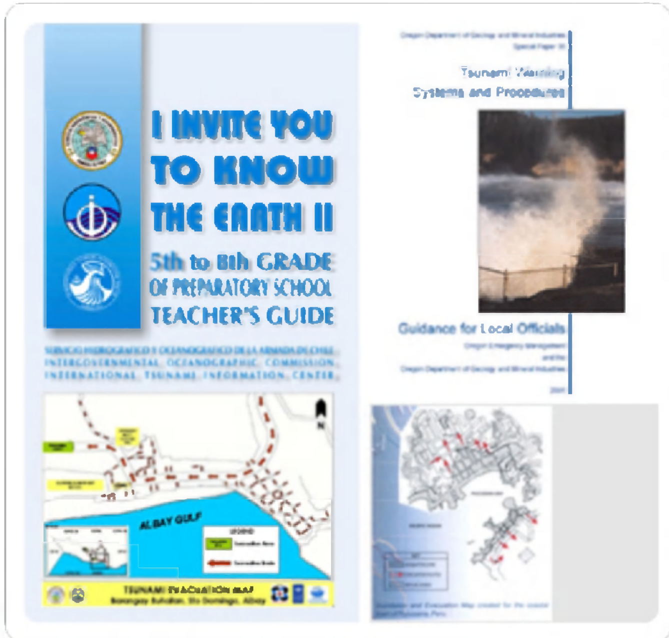
Civil society organizations such as labour, gender, religious and cultural groups that could play key roles in public education, social leadership and relief efforts.

3.3.1 Introduction - 3.3.1.2 Being prepared

Advances in tsunami detection and early warning systems and their worldwide expansion, along with inundation models that predict the impacts of waves on coasts, are providing communities around the world with the tools to reduce the impact of future tsunamis.

In addition, there is increased understanding about how to prepare for tsunamis in ways ranging from evacuation plans for hazard zones to protecting natural environmental barriers, where best to place new developments and how to construct sturdier buildings.

Experts have argued that tsunami warning systems need to be underpinned by tsunami school curricula, public awareness campaigns and emergency response exercises if they are to be effective. Warnings are of little value if people do not know how to react correctly to them.



3.3.1 Introduction - 3.3.1.2 Being prepared

It has been estimated that using all tools available could avert up to 25 percent of tsunami deaths. The challenge for coastal communities is to ensure that they use the tools before, during and after a future tsunami to save lives and alleviate the impacts of the great waves.

Contrasting casualties from the 1993 Sea of Japan tsunami with those of the 1998 Papua New Guinea event, the United States' National Oceanic and Atmospheric Administration (NOAA) concluded that "these tools work": In locally generated tsunamis, knowledge becomes most critical when warning times are short – or there is no warning at all – in which case people must know how to react immediately and without official guidance.

"For the Aonae, Japan, case about 15 percent of the population at risk died from a tsunami that struck within 10 minutes of the earthquake because the population was educated about tsunamis, evacuation plans had been developed, and a warning was issued."

"For the Warapa, Papua New Guinea, case about 40 percent of the at-risk population died from a tsunami that arrived within 15 minutes of the earthquake because the population was not educated, no evacuation plan was available, and no warning system existed."

- NOAA

A fishing boat was deposited on top of a concrete shore protection barrier at Aonae, Okushiri Island, Japan during the 1993 Japan Sea tsunami. Note wood debris from houses and other structures scattered about the area. Credit: ITIC

3.3.1 Introduction - 3.3.1.2 Being prepared

Preparing for natural disasters is the responsibility of everybody living in or visiting areas that may be attacked by them. When calamity strikes, everyone must respond – and people will do so most effectively if they have the information and support structures they need.

Authorities, community groups and the private sector – as well as the media and schools – have key roles to play in providing tsunami education, information and support systems.

National and local disaster strategies and services are the responsibility of national and local governments, ideally within an all-hazards framework.

In the case of tsunamis, this covers everything from running effective warning systems and developing evacuation maps and routes, to public education, building codes and integrating tsunamis into multi-hazard emergency plans. Authorities are also in overall charge of search and rescue operations after a disaster, relief efforts, and recovery efforts such as getting damaged infrastructure and services up and running.

Such efforts would ideally be supported by private sector organizations, where businesses consider the safety of staff, have disaster plans in place, insurance where possible and strategies to continue operating after a disaster. Community groups have key roles to play in public education, social leadership, and relief efforts during and after a disaster.

"Shadow Theatre" recreation of 2004 Indian Ocean tsunami from primary school students at Kalim School in Phuket, Thailand.

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors

3.3.1 Introduction - 3.3.1.3 Aims and Objectives

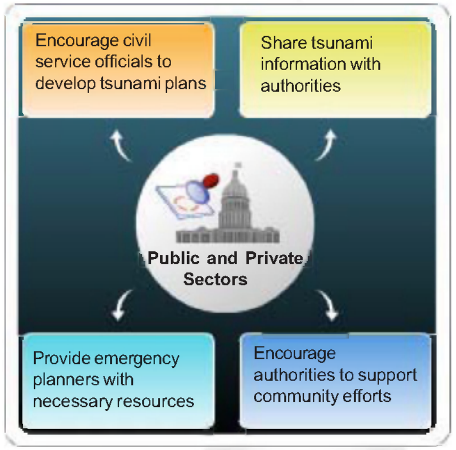
The overarching objective of *TsunamiTeacher* is to disseminate accurate, useful, potentially lifesaving information and materials about tsunamis among target audiences that have key roles to play in improving the tsunami awareness and preparedness of coastal communities.

One major purpose of the Public and Private Sectors Module is to support the efforts of government officials, businesses and community groups to promote public tsunami awareness and preparedness, by providing necessary information and materials. Another purpose is to gather tsunami materials from around the world, so that knowledge, experience and sound practices can be shared and adapted appropriately to local contexts.

The module's aims and objectives for authorities, community stakeholders and the private sector are given below.

Authorities

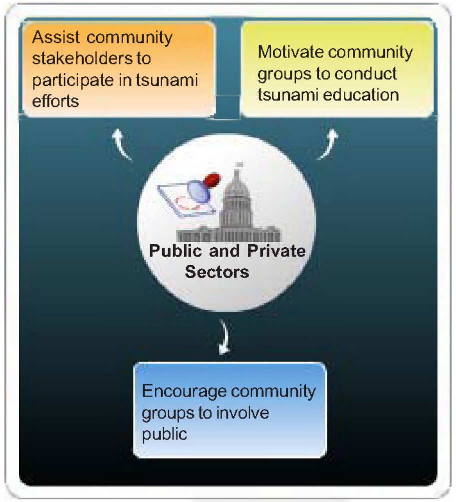
- Encourage elected and senior civil service officials to support the development of tsunami emergency response, public awareness and mitigation policies and plans.
- Provide hands-on emergency planners and managers with the resources they need to develop integrated tsunami warning, emergency and mitigation systems.
- Share with authorities the rich body of information and materials developed around the world on all aspects of tsunami warning, planning and preparedness that can be adapted appropriately to local contexts.
- Encourage national and local authorities to support coastal community groups and businesses with efforts to promote public tsunami awareness and preparedness.



3.3.1 Introduction - 3.3.1.3 Aims and Objectives

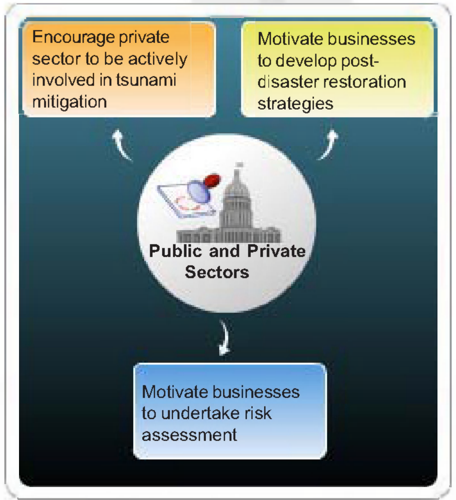
Community stakeholders

- Motivate and assist community stakeholders to become an integral part of local tsunami emergency response, preparedness and recovery planning and efforts.
- Encourage community groups to involve the people they reach in tsunami response exercises such as evacuation drills.
- Motivate and assist community groups to conduct public tsunami education.



Private sector

- Encourage the private sector to become actively involved in tsunami mitigation, preparedness, emergency response and recovery planning efforts.
- Motivate public and private businesses in coastal areas to undertake tsunami risk assessments, and to plan and implement emergency strategies that include tsunami events.
- Encourage public and private businesses to develop strategies that will enable services and operations to be restored as quickly as possible after disaster strikes.



3.3.1 Introduction - 3.3.1.4 Intended outcomes

The intended outcome for authorities, coastal community groups and businesses is for these audiences to gain access to and engage with tsunami information and resources that share valuable global experience on the subjects of tsunami detection and warning, emergency response and mitigation systems, and community awareness and preparedness.

More specifically, authorities, community groups and businesses ought to have learned more about, and been encouraged to become involved in, the following topics, issues or potential areas of activity:

Authorities

- Legal and regulatory frameworks for emergency management laws and policies.
- General terms of reference for tsunami coordination committees and institutions with tsunami respon sibilities at all levels.
- General standard operating procedures for institutions with tsunami responsibilities.
- Emergency response plans, including criteria for response.
- Examples of tsunami inundation, evacuation and population density maps, plans, routes and shelters.
- Marine and port authority guidance and alert systems.
- Public warning and notification systems, such as sirens, mass media broadcasts, or other locally available methods of communication.
- Tsunami training and exercises, such as coastal evacuation drills.
- How to build integrated warning and emergency response systems.
- Tsunami governance, management and resource considerations.
- Environmental policy considerations and land use policies.
- Structural and engineering mitigation to reduce tsunami impacts.
- Risk assessment and insurance considerations based, for instance, on flood maps.
- Tsunami community awareness and preparedness models.
- Post-tsunami disaster response and recovery efforts.
- Ways to improve mitigation, such as post-tsunami surveys.

3.3.1 Introduction - 3.3.1.4 Intended outcomes

Community stakeholders

- Collaboration with government and community stakeholders at local level.
- Tsunami early warning and communication systems.
- Hazard, inundation and evacuation maps.
- Standard operating procedures and signage.
- Insuring for recovery following disaster.
- Health issues and actions.
- Law and order and safety issues.

Private sector

- Collaboration with government and private sector stakeholders at local level.
- Tsunami early warning and communication systems.
- Hazard, inundation and evacuation maps.
- Standard operating procedures and signage.
- Building codes and land use issues.
- Insuring for recovery following disaster.
- Getting operations back up and running after a tsunami.

3.3.1 Introduction - 3.3.1.5 User Guide

Users of the Public and Private Sectors Module have some common but other quite different needs. Users can draw on any of the materials, but different categories of users will also be directed to materials appropriate to them during the course of the module.

All of *TsunamiTeacher's* background resources are accessed by clicking on the title of the material or the website address provided. The click-through resources come with brief outlines of what they contain, so that users can select what they want to access without having to read through all of the materials.

All users of the Public and Private Sectors Module will benefit from reading the following sections: "Tsunamis – Key Challenges" and "Tsunami science and history".

In the case of "Tsunami science and history", links to basic tsunami science materials and information on past events are offered, so that all *TsunamiTeacher* users emerge with an understanding of what causes tsunamis, how the great waves behave and the devastation they have caused through history. There are also links to more scientific articles that could be useful to people charged with hands-on tsunami emergency and mitigation planning.

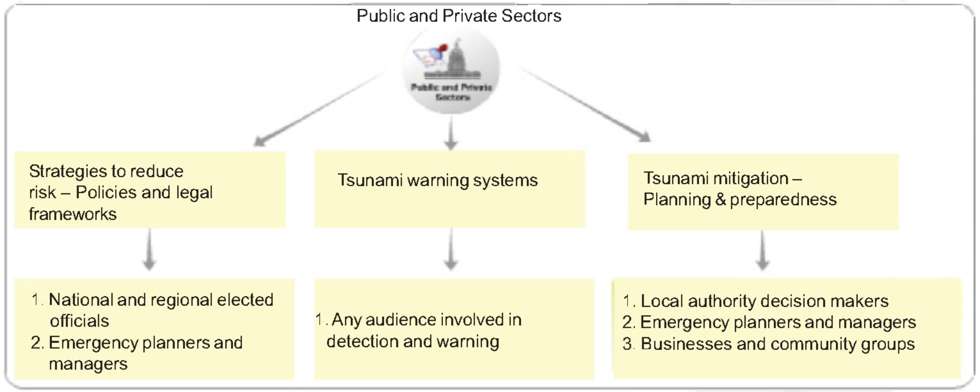
3.3.1 Introduction - 3.3.1.5 User Guide

Following this, the Public and Private Sectors Module presents descriptions of and links to materials in three categories – "Strategies to reduce risk – Policies and legal frameworks"; "Tsunami warning systems"; and "Tsunami mitigation – Planning and preparedness".

Decision makers, government officials and emergency managers will find information and background materials in all three sections, relevant to their various roles and responsibilities.

For example, "Strategies to reduce risk – Policies and legal frameworks" is directed at national and regional elected officials and emergency planners and managers, while "Tsunami warning systems" is of interest to any audience involved in detection and warning.

The "Tsunami mitigation – Planning and preparedness" section contains most of the information of interest to local authority decision makers and emergency planners and managers, and to businesses and community groups.



3.3.2 Tsunamis - Key Challenges - 3.3.2.1 Tsunamis - key Challenges

Background

The 1990s was the United Nations International Decade for Natural Disaster Reduction, and a multitude of policy, awareness and other actions were undertaken.

Since 2000, the United Nations International Strategy for Disaster Reduction (ISDR) has led the effort to substantially reduce losses from disasters of lives and the social, economic and environmental assets of communities and countries. The ISDR coordinates a United Nations Disaster Task Force to discuss and collectively work towards these goals.

In 2005, the ISDR organized the World Conference on Disaster Reduction held in Kobe, Japan, which was attended by more than 6,000 delegates from 155 countries and a range of UN, intergovernmental, non-governmental and specialized organizations.

There, the Hyogo Framework for Action 2005-2015 was adopted, committing governments and the international community to a set of concrete goals, including halving the number of lives lost globally to disasters.

> The Hyogo Framework for Action 2005-2015 states that people:
>
> "…are far from powerless to prepare for and mitigate the impact of disasters. We can and must alleviate the suffering from hazards by reducing the vulnerability of societies. We can and must further build the resilience of nations and communities to disasters through people-centered early warning systems, risks assessments, education and other proactive, integrated, multi-hazard, and multi-sectoral approaches and activities in the context of the disaster reduction cycle, which consists of prevention, preparedness, and emergency response, as well as recovery and rehabilitation."

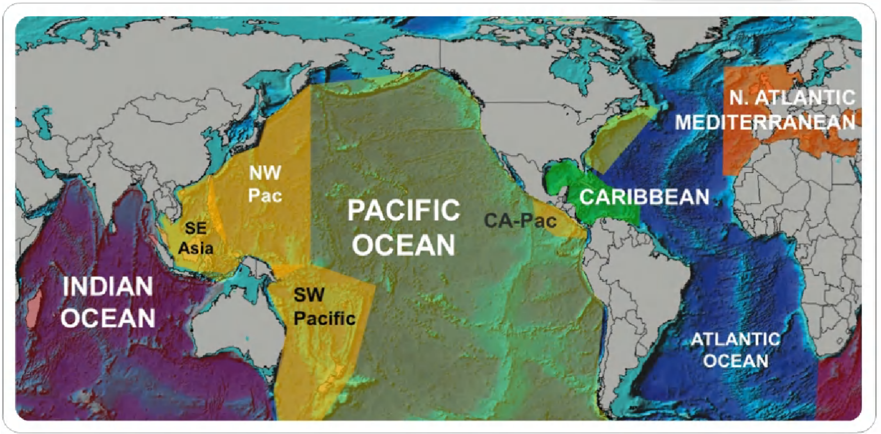
A multi-pronged approach

Tsunami warning systems are a critical part of any comprehensive tsunami awareness and preparedness programme, aimed at saving lives and mitigating the impacts of the great waves when they strike.

Much progress has been made in developing tsunami warning systems that in a few years they will straddle oceans and seas across the world. The important lessons learned from past experience have been that tsunami warning systems can succeed only through:

- International regional cooperation under the principle of open, free and unrestricted exchange of observational data.
- The availability of an effective National Tsunami Response Plan that is activated when warnings are issued.

Instrumental networks used for tsunami detection and early warning are, however, just one of many elements in a comprehensive tsunami warning and mitigation system. It is useless to issue a tsunami warning to a population that has not been prepared for disaster and does not know how to respond.



UNESCO-IOC Intergovernmental Coordination Groups oversee the implementations of internationally-coordinated tsunami warning and mitigation systems. In addition to the 40-year old Pacific Ocean system, new systems are being built in the Indian Ocean, Caribbean, and the North Atlantic and Mediterranean, and Pacific sub-regional systems exist for the North Pacific and are being discussed for the Southwest Pacific, Southeast Asia and Central America – Pacific Coast. The ICG meet regularly to discuss the tsunami technical monitoring and warning disseminations requirements and improvements, coordinate tsunami risk assessment and preparedness activities, and to share national experiences in building tsunami awareness through education and outreach in their countries. Source: ITIC

Training modules - 3.3 Public and Private Sectors
3.3.2 Tsunamis - Key Challenges - 3.3.2.1 Tsunamis - key Challenges

A multi-pronged approach

During the last 40 years, UNESCO's Intergovernmental Oceanographic Commission has gained invaluable experience on how to assess tsunami risk at the national and local levels, how to promote awareness and preparedness among populations, and how to build national and regional tsunami warning systems in the Pacific region.

The UNESCO-IOC approach to tsunami awareness and preparedness contains three essential components:

- Assessing the tsunami hazard and risk at the local level to identify vulnerable communities.
- Preparing the population so they know what action to take in case of a tsunami warning.
- Building a technological framework that warns of an advancing tsunami wave.

Master Plan for the operation and improvement of the Tsunami Warning System in the Pacific, 1999.

3.3.2 Tsunamis - Key Challenges - 3.3.2.1 Tsunamis - key Challenges

A multi-pronged approach

At the national level, governments and senior officials ought to integrate tsunamis into comprehensive disaster and emergency response policies, legislation and plans that provide a strong framework and guidance for tsunami management and activities at all other levels.

National tsunami mitigation programmes need to identify vulnerable coastal communities through risk assessments, and develop and widely publish evacuation or tsunami safe zone maps along with instructions to the public on how to respond.

Further, it is possible to reduce the impact of tsunamis on life and property through pre-disaster measures such as sea walls, water gates and vegetation barriers, and the construction of seismic- and tsunami-resistant buildings with critical lifeline infrastructure.

Social science also plays a key role in understanding how people perceive and respond to natural disasters and disaster warnings, and this knowledge can be used to ensure that the tsunami risk is communicated in an understandable, practicable manner to the public.

Such measures form part of wider government emergency systems that evaluate disaster risk, and develop response policies and plans that provide reasonable public safety from all natural hazards.

Intergovernmental Coordination Group meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework, UNESCO Headquarters, France, 3–8 March 2005.

3.3.2 Tsunamis - Key Challenges - 3.3.2.1 Tsunamis - key Challenges

A multi-pronged approach

Comprehensive tsunami preparedness involves educating everyone from national government leaders to local communities, households and even transient populations, such as tourists. Coordination between all stakeholders is critical. According to the International Tsunami Information Centre in Hawaii:

"An effective tsunami early warning system is achieved 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."

When tsunami warnings are broadcast, it is critical that their messages are communicated to the public in an understandable way that clearly and simply instructs people on the actions they should take to ensure their safety.

People in areas of potential flooding need to be evacuated to safe zones or shelters. People need to know when and where and how to go, what to take and how they will know when it is safe to return. Consideration needs to be given to people with special needs such as the elderly, physically impaired and those who cannot read, hear or understand conventional warnings:

"Although technology is essential for information analysis and delivery, successful early warning ultimately relies on the abilities of people to reach people."

A normally-crowded Waikiki Beach, Oahu, Hawaii is empty after a 1994 statewide tsunami evacuation advisory was issued. Evacuation and sheltering plans that are practiced through regular drills are essential to be able to move an estimated 300,000 people away from Hawaii coasts within three hours after a tsunami warning is issued. Credit: Honolulu Star-Bulletin.

3.3.3 Tsunami science and history -3.3.3.1 Tsunami Science and History

Overview

Understanding what causes tsunamis, the way the great waves behave, and where and how they are mostly likely to strike coasts, is essential knowledge for everyone with a potential role to play in promoting tsunami awareness or preparedness.

Knowing something about past tsunamis, the kinds of damage they caused, and the way research is helping to predict the possible impacts of future events might also interest some users, especially those involved in tsunami education.

The following pages lead to background material describing mostly the science but also some history of tsunamis. While a general overview will be sufficient for many users, others – such as emergency planners and technical staff who need to implement tsunami plans and policies – might find the more scientific materials useful.

There is a *TsunamiTeacher* section on the 2004 Indian Ocean tsunami, comprising summaries of what happened and click-throughs to media articles and websites, for users who might at some point want to reference information about the world's worst tsunami.

Example of tsunami safety poster.

3.3.3 Tsunami science and history -3.3.3.1 Tsunami Science and History

Brochures, presentations and scientific articles

Browse through all of the descriptions of resources below before deciding what is most appropriate for you to read.

It is recommended that officials who are involved hands-on in public safety and disaster planning, and who need fairly detailed background information, read the article entitled Tsunami – Understanding the Giant Wave by Professor Philip Liu of Cornell University, United States.

All other users may select what to read, depending on need and time available.

The Great Waves

The Great Waves is an illustrated, 12-page full-colour brochure aimed at growing awareness and knowledge of tsunamis.

It provides a basic description of what causes tsunamis, and how they race across the deep ocean at the speed of a jet plane and pile up into "walls of destruction" that attack coasts. There is information about tsunami warning centers, organizations involved in tsunamis-related work, research into tsunamis, and safety tips.

The Great Waves was produced by UNESCO's Intergovernmental Oceanographic Commission, its International Tsunami Information Centre, Laboratoire de Geophysique in France, and the United States National Oceanic and Atmospheric Administration. It can be reproduced for educational purposes.

Refer [3.3.3 - 02 of 04] The Great Waves brochure [PDF] in the CD-ROM

Tsunami Glossary

This illustrated, 36-page full-colour *Tsunami Glossary* is a useful resource for anybody wanting to get to grips with the many tsunami-related terms there are, and their definitions. It was produced by UNESCO-IOC and the International Tsunami Information Centre.

The Glossary is divided into six sections:

1. Tsunami classifications: describes different types of tsunamis.
2. General tsunami terms: defines tsunami-related words and phrases.
3. Surveys and measurements: describes terms and parameters that measure tsunami waves and their impact on coastlines, and are used to classify tsunamis.
4. Tide, mareograph and sea level: describes terms relative to the sea level, tide measurements and mareographs (tide gauges).
5. Acronyms and Pacific Tsunami Warning System organizations: describes acronyms, organizations and tsunami warning bulletins and publications.
6. Bibliography.

3.3.3 Tsunami science and history -3.3.3.1 Tsunami Science and History

TsunamiTeacher users can also access, at any point in the kit, the Glossary flagged by a button in the screen frame. There, users can look up words and terms in alphabetic order, with click-throughs to their definitions.

Refer [3.3.3 - 02 of 04] The Tsunami Glossary brochure [PDF] in the CD-ROM

Earthquakes: A Primer

The ITIC, in collaboration with earth scientists, has produced a series of training modules providing information on earthquakes, their science and how tsunami are generated and behave.

The modules offer a broad introduction to a number of topics, including:

- What is an earthquake?
- What makes the earth quake?
- Measuring earthquakes.
- Can we predict earthquakes?
- Should you worry about earthquakes?
- How can you minimize your risk?

View the seismology training modules at:
http://www.tsunamiwave.info/training

Tsunami – Understanding the Giant Wave

Tsunami – Understanding the Giant Wave is an illustrated, more than 5,000-word article that provides a comprehensive but easily digestible overview of the science and history of tsunamis, hazard mitigation, tsunami research and warning systems.

The article was written in 2000 by Professor Philip Liu of Cornell University in New York, and updated in 2006 by Dr Laura Kong, Director of the UNESCO-IOC International Tsunami Information Centre in Hawaii. It is based on a CD originally developed by Professor Liu.

3.3.3 Tsunami science and history -3.3.3.1 Tsunami Science and History

The contents are:

1. Tsunamis – An introduction: definition and general description of a tsunami, and information on how tsunamis are generated.
2. Destructive tsunamis in history: descriptions of seven notable past tsunamis, although the 2004 Indian Ocean tsunami is not included.
3. Tsunami hazard mitigation: describes warning systems and coastal defenses.
4. Tsunami research: explains source region prediction, numerical modeling of tsunami propagation and run-up, and tsunami forces on coastal structures.

Appendix – Tsunami warnings: the development of tsunami warning systems.

Refer [3.3.3 - 02 of 04] Tsunami – Understanding the Giant Wave.[PDF] in the CD-ROM

TsunamiTeacher background resources

TsunamiTeacher's Media Module features sections covering the basic science and causes of tsunamis, tsunami history and research, amazing tsunamis down the years and the 2004 Indian Ocean tsunami, which can be easily accessed by all users.

The material of possible interest to some Public and Private Sectors Module users is in two sections – "The great waves", which describes the science and causes of tsunamis; and "Tsunamis down the years", which provides an outline of tsunami history and research, and includes a substantial section on the 2004 Indian Ocean tsunami.

The two sections are further divided into five sub-sections, which are described below and have click-through links to them. Each section provides links to tsunami-related websites and media articles. There are some suggested exercises for journalists that could provide insights into the ways media report on topics like tsunamis.

A scientific snapshot

This 1,500-word section of *TsunamiTeacher* defines tsunamis and describes how the great waves move across oceans and form into massive waves in coastal waters. It investigates where tsunamis are most likely to happen, how offshore and coastal features influence the ways in which tsunamis impact on coastlines, and how the great waves wreak damage.

Causes of tsunamis

This material, 1,700 words long, looks at where tsunamis are most likely to occur and why, at plate tectonic theory and earthquakes – the main cause of tsunamis – and at other ways tsunamis can be generated such as volcanic eruptions or collapses, landslides or rock falls, and asteroid or meteorite collisions with Earth.

A short history

This 2,000-word section outlines the history of tsunamis and looks at how data banks and paleotsunami research, in which scholars study sediments deposited by past tsunamis, are helping to extend the historical record back in time and increase understanding of tsunamis. There are lists of major tsunamis that have occurred around the word.

Amazing tsunamis

Ten major tsunamis are briefly described in this 2,500-word section, to paint a picture of the havoc that tsunamis have wreaked through history. Some tsunamis are included because of their devastating death tolls, others because of the great height of their waves or the widespread damage they wreaked.

They are the tsunamis of Port Royal (1692), Lisbon (1755), Krakatau (1883), Great Sanriku (1896), Sicily (1908), Aleutian Islands (1946), Alaska (1958), Chile (1960), Alaska (1964), and Papua New Guinea (1998).

The 2004 Indian Ocean tsunami

The world's worst tsunami occurred on 26 December 2004, killing nearly 232,000 people, including some 9,000 foreign tourists. This 5,200-word section describes in-depth how the tsunami was generated, where it struck and its multiple impacts on 12 countries.

The 2004 event was not only the world's worst but also the most reported tsunami ever, and its story is told through the eyes of international media such as *National Geographic*, *Newsweek* magazine, *The Guardian* newspaper, the BBC and CNN.

There are survivor's tales and descriptions of the tsunami aftermath, its impacts on children and on the environment, and details about aid and reconstruction efforts during the world's biggest-ever relief effort – more than $13.6 billion was raised for aid and reconstruction.

Training modules - 3.3 Public and Private Sectors

3.3.3 Tsunami science and history -3.3.3.1 Tsunami Science and History

The following section of *TsunamiTeacher* is directed primarily at government officials and emergency planners.

Businesses and community groups may wish to proceed to the "Tsunami mitigation – Planning and preparedness" section of the Module, which covers aspects of mitigation such as local emergency response systems, environmental and engineering guidelines, guidance for businesses, and public education.

Training modules - 3.3 Public and Private Sectors

3.3.4 Strategies to reduce risk - 3.3.4.1 Managing Risk

Overview

Among their many other roles, governments are responsible for identifying threats to public safety, developing emergency systems and structures that respond to disasters such as tsunamis, and preparing citizens for them.

At the national level, hazard identification and emergency response covers a range of activities, from developing emergency policies and legislation, and disaster plans and management systems, to setting up support and stakeholder coordination committees, including for tsunamis.

It also involves building tsunami warning systems, integrating public safety and emergency policies and activities into other appropriate areas of government, and overseeing the implementation of disaster and emergency frameworks by regional and local authorities.

This section of the Public and Private Sectors Module is aimed primarily at government decision makers, planners and emergency managers, and discusses the high-level strategies and policies necessary to support subsequent risk reduction activities

Siren alert tower in Thailand.

Command module for emergency siren alert broadcasting system, Oahu County Civil Defense Agency, Hawaii. Credit: ITIC

3.3.4 Strategies to reduce risk - 3.3.4.1 Managing Risk

Managing Risk

"More effective prevention strategies would save not only tens of billions of dollars, but save tens of thousands of lives. Funds currently spent on intervention and relief could be devoted to enhancing equitable and sustainable development instead, which would further reduce the risk for war and disaster."

"Building a culture of prevention is not easy. While the costs of prevention have to be paid in the present, its benefits lie in a distant future. Moreover, the benefits are not tangible; they are the disasters that did NOT happen."

So wrote Kofi Annan, Secretary-General of the United Nations, in his 1999 Annual Report. He was calling on national governments, international agencies and non-governmental organizations to prepare for, rather than merely react to natural and man-made disasters as part of broader strategies promoting equitable and sustainable development.

In the case of tsunamis this would include, for instance, national policies that protect natural environmental barriers (such as coastal vegetation) against human encroachment, planning that places new urban development outside hazard zones, disaster lessons in schools and public disaster education and activities that reach everybody in at-risk populations.

Kofi Annan, Secretary General of the United Nations and Koichiro Matsuura, Director-General of UNESCO.

3.3.4 Strategies to reduce risk - 3.3.4.1 Managing Risk

More specifically, a country that is well prepared for disaster has a multi-hazard framework of national emergency legislation and plans, as described in the next section, and disaster and emergency committees at all levels of government that are coordinated in the interests of a nationally cohesive disaster warning and emergency response system.

National laws, plans and management structures guide the implementation of emergency and response systems, in collaboration with committees, planners and managers at the regional and local level.

Implementation of tsunami warning and mitigation systems takes place largely in coastal communities, where local civil defense or emergency services offices are responsible for on-the-ground planning, emergency response and disaster mitigation.

The following pages investigate the high-level policy, strategic and organizational aspects of emergency planning. They are directed primarily at national and regional decision-makers, planners and emergency managers, but could also be useful to local authorities.

The South Pacific Applied Geoscience Commission's Community Risk Programme provides overarching guidance on disaster risk reduction to 17 Pacific Island nations. 33rd Annual Session of the SOPAC Governing Council, Fiji, 2004.

Natural Disasters and Sustainable Development: Understanding the Links Between Development, Environment and Natural Disasters

Links between natural disasters and sustainable development are explored in a document prepared by the United Nations International Strategy for Disaster Reduction (ISDR) ahead of the 2002 World Summit on Sustainable Development in Johannesburg, South Africa.

The document provides useful overarching guidance to policymakers on how to link disaster and emergency strategies to development – and to other activities of governmental policy and planning, such as agriculture, the environment and education.

It argues that sustainable development, poverty reduction and environmental protection cannot succeed without taking natural hazards into account, and that humankind cannot afford the increasing costs and losses wreaked by natural disasters. Disaster reduction policies and measures need to be implemented, with two aims:

"...to enable societies to be resilient to natural hazards while ensuring that development efforts do not increase the vulnerability to these hazards."

Refer [3.3.4.1 - 04 of 08] to view Disaster Reduction and Sustainable Development, ISDR. [PDF] in the CD-ROM

Refer [3.3.4.1 - 04 of 08] to view World Summit for Sustainable Development, 2002 Report. [PDF] in the CD-ROM

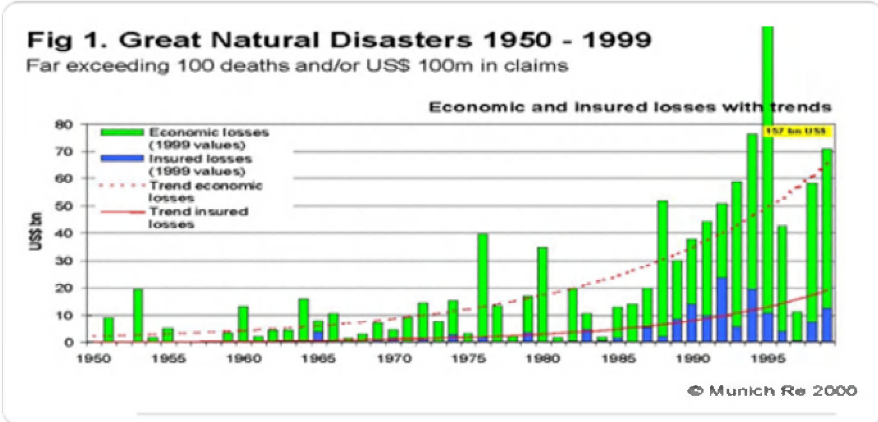
Natural Disasters and Sustainable Development

During the past four decades, natural and non-natural disasters have caused major losses of human lives and livelihoods, and economic, infrastructural and environmental damage. Economic losses have increased almost 10 times during this period.

"The associated rise in the cost of reconstruction efforts and loss of development assets has forced the issue of disaster reduction and risk management rapidly up the policy agenda of affected governments as well as multilateral and bilateral agencies and NGOs."

This trend led to adoption by national governments of the International Strategy for Disaster Reduction (ISDR), which developed and promoted implementation of proposals emanating from the International Decade for Natural Disaster Reduction. The ISDR's aim is to:

"...mobilize governments, UN agencies, regional bodies, private sector and civil society to unite efforts in building resilient societies by developing a culture of prevention and preparedness."



Losses from natural disasters continue to increase at ever faster rates. Natural catastrophes in 2003 resulted in over 50,000 deaths and US$ 60 B in economic losses.

Natural Disasters and Sustainable Development

No country is entirely safe from disasters, but lack of capacity to limit their impact remains a major burden for developing countries. According to the World Bank:

"… some 97 percent of natural disaster related deaths each year occur in developing countries and, although smaller in absolute figures, the percentage of economic loss in relation to the Gross National Product in developing countries far exceeds the ones in developed countries."

Although environmental problems such as climate change and deforestation increase vulnerability to disasters, primary reasons for increased losses are to be found in the global rise of people's vulnerability – particularly poor women – induced by "human-determined paths of development". The capacities to cope with disaster differ depending on social groups – such as rich or poor, male or female, or young or old.

The emphasis on disaster response and humanitarian assistance has absorbed significant amounts of resources, which would normally be allocated for development efforts.

"If this trend were to persist, coping capacities of societies in both developed and developing countries, are likely to be overwhelmed."

The Maldive Islands - An elderly woman from the tsunami-ravaged village of Kolhuvaariyaafushi, on the southwestern Mulaaku Atoll.

Natural Disasters and Sustainable Development

Four overriding objectives, necessary to effectively reduce the impacts of disasters, were formulated as the guiding principles for the International Strategy for Disaster Reduction. In summary they are:

Obtaining commitment from public authorities

There should be commitment from public authorities with regard to increased inter-sectoral coordination at all levels, risk management strategies, and the allocation of resources. Disaster reduction should be dealt with as a separate policy issue, and achieve cross-cutting policy integration among the various government sectors.

Increasing public awareness

There should be increasing public awareness of and participation in ways to reduce vulnerability to hazards. This involves formal and non-formal education, and could be addressed through public information, education and multi-disciplinary professional training. Media and school systems around the world have a crucial role to play.

Stimulating partnerships and networking

Partnerships and risk reduction networking among national and local governments should be stimulated, along with greater involvement of the private sector, academic institutions, NGOs and community-based organizations. This calls for strong coordination mechanisms, and the incorporation of disaster reduction concerns in national planning processes.

Fostering better understanding

Better understanding of the causes of disasters should be fostered through the transfer and exchange of experience and greater access to data and information. This can be accomplished through development of disaster databases, analysis of coping strategies of different social groups, early warning processes, and the promotion of scientific research, indigenous knowledge and transfer of knowledge and technologies.

The document outlines specific actions, including: capacity building and strengthening institutional arrangements to tackle risk reduction; school and public awareness campaigns; urban development strategies and land use plans; early warning and mitigation schemes; continued research into climate, natural hazards and vulnerabilities; and development projects that take into account risk assessment at the appraisal stage.

Refer [3.3.4 - 07 of 08] to view Natural Disasters and Sustainable Development: Understanding the Links Between Development, Environment and Natural Disasters.[PDF] in the CD-ROM

3.3.4 Strategies to reduce risk - 3.3.4.1 Managing Risk

Characteristics of Effective Emergency Management Organizational Structures

The Public Entity Risk Institute in the United States developed a self-assessment manual designed to help top local government administrators – elected or appointed – strengthen emergency management structures.

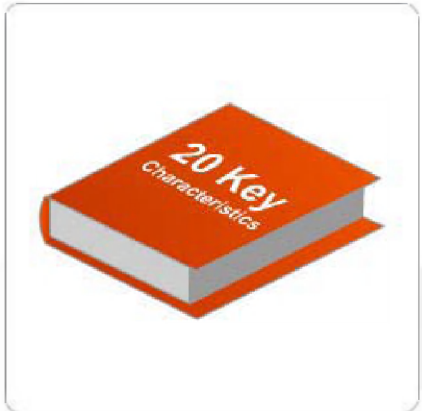
Characteristics of Effective Emergency Management Organizational Structures points out that disasters can happen anywhere, and that every city, town and rural county should have an up-to-date disaster response and recovery plan.

"Providing leadership during a time of severe crisis is challenging. It is next to impossible if you don't have a good understanding of what your specific role is during a disaster – either as an elected official or as a manager."

Produced in 2001, the manual originated from research conducted by the International City-County Management Association in the United States in the late 1970s. The research reviewed the operations of more than 300 local government emergency management agencies, and developed dozens of case studies of emergency management operations.

The result was the development of the 20 key characteristics that were found to contribute to an effective local government emergency management organizational structure.

Refer [3.3.4 - 08 of 08] to view Characteristics of Effective Emergency Management Organizational Structures. [PDF] in the CD-ROM



3.3.4 Tsunami emergency response planning - 3.3.4.2 Legislative Frameworks

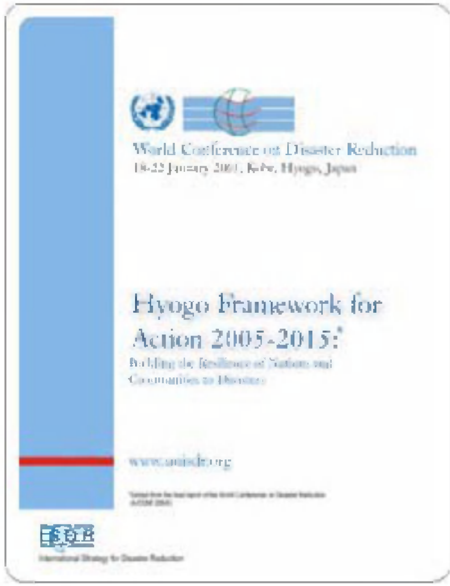
Overview

Many governments have committed their countries to a variety of international agreements that oblige them to protect the lives, health and well-being of their citizens.

In 2005 the Hyogo Framework for Action 2005-2015, negotiated at the World Conference on Disaster Reduction in Kobe, Japan, committed government and the international community to concrete goals including halving the number of lives lost to disasters and building disaster-protected schools and hospitals.

UN agencies such as UNESCO's Intergovernmental Oceanographic Commission, and its International Tsunami Information Centre in Hawaii, facilitate international collaboration and coordinate the movement of national governments towards globally agreed goals.

They also assist governments to develop the legislative frameworks that support compliance with international commitments, such as those made at Kobe in 2005.



Hyogo Framework for Action

Refer [3.3.4.2 - 01 of 03] to view the document Hyogo-framework-for-action-english. [PDF] in the CD-ROM

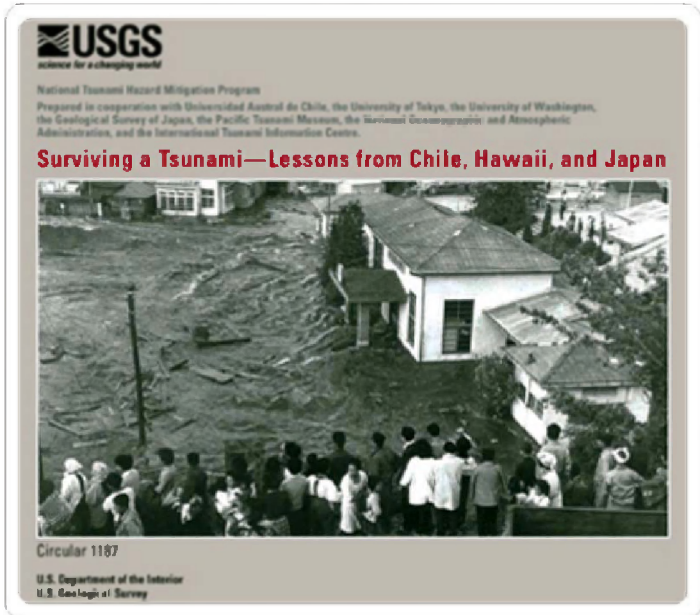
Refer [3.3.4.2 - 01 of 03] to view the Hyogo Summary Report .[PDF] in the CD-ROM

Overview

Legislation and plans formulated by national governments provide the frameworks that direct the disaster and emergency responses of countries.

Sound legal frameworks supported by solid organizational structures and management are a prerequisite for effective and coordinated emergency response.

While virtually all countries have legislation that deals with disasters and emergencies, few take the tsunami hazard seriously into account and many could use the experience of countries that have long been prone to natural disasters to improve emergency laws.



Tsunamis teach valuable lessons in preparedness and mitigation, and improve emergency laws.

Examples of national disaster laws and plans

The following pages briefly describe and lead to background legislation and plans produced by three countries: earthquake and tsunami-prone Japan, the United States – particularly Hawaii and California – and New Zealand.

Japan – Disaster Countermeasures Basic Act

Japan's Disaster Countermeasures Basic Act of June 1997 is a comprehensive model of disaster legislation. It was produced by the National Land Agency with the general purpose of protecting national territory and the lives and welfare of citizens and their property.

More specifically, the Act's aim are to: establish a machinery working through the state, local governments and public corporations, with clarifications where disaster responsibilities lie; provide for the formulation of disaster prevention plans and basic policies relating to preventive and emergency measures; and rehabilitation programs to deal with disaster:

"…thus ensuring an effective and organized administration of comprehensive and systematic disaster prevention with a view toward the preservation of social order and the security of the public welfare."

The Act gives the State responsibility for drafting and implementing by law disaster prevention plans, emergency measures to deal with disasters, and rehabilitation afterwards. It must also ensure and coordinate the performance of disaster activities of local governments and public corporations, and ensure fair and adequate distribution of financial burdens after a disaster.

The legislation requires disaster prevention, emergency and rehabilitation planning and activity to take place at all levels of government, and in public businesses, disaster agencies and local communities – and for there to be coordination and cooperation between them.

A high-level Central Disaster Prevention Council is in charge of drafting and implementing basic disaster prevention and emergency plans, coordinating activities countrywide, outlining urgent measures when disaster strikes and declaring states of emergency.

Each prefecture, city and town in Japan also has a disaster prevention council with similar responsibilities, and they can form joint committees in the interests of collaborative, coordinated planning and activity. There are laws for establishing local and regional disaster control headquarters, and lists of their responsibilities, organizational structures and rules.

Japan's advanced disaster legislation also contains sections describing how long term disaster prevention is planned and implemented, and what authorities, agencies and businesses do to keep emergency services at-the-ready.

There are details on how emergency responses are organized, how post-disaster recovery and financial relief are managed, how states of disaster emergency are conducted, and penal provisions for offenses committed during emergencies.

Refer [3.3.4 - 03 of 03] to view Japan's Disaster Countermeasures Basic Act. [PDF] in the CD-ROM

Hawaii – Civil Defense and Emergency Act

In the State of Hawaii's Revised Statutes, Chapter 128 of the Civil Defense and Emergency Act deals, among other things, with emergency activities relating to natural disasters such as tsunamis. According to a 2004 Congressional Research Service Report, it confers comprehensive powers on the governor.

The governor is authorized, among other things, to prepare civil defense plans, institute training and public information programmes, take operational control, require public or vital facilities to protect their property, and control mobilization, utility shutdowns and evacuation. The governor may also declare a state disaster for the entire state or a portion of it.

Local governments must establish local civil defense organizations, have power to make appropriations and authorize spending, and obtain materials and facilities for civil defense.

Public and private civil defense activities are coordinated by a State of Hawaii Civil Defense Agency, and there is a Civil Defense Advisory Council. The State Civil Defense Director is the Adjutant General of the Department of Defense (Hawaii Army and Air National Guard), which is responsible for defending Hawaii from natural or other mass violence. A Rehabilitation Coordinator administers disaster relief and rehabilitation aid.

The law also establishes an Emergency Response Commission in the Department of Defense, along with emergency planning districts and local emergency planning committees.

More particularly regarding natural disaster such as tsunamis, the Act's statutes provide for a coastal zone management programme to reduce hazards to life and property from tsunamis, storm waves, flooding, erosion, subsidence and pollution.

The Act established a state disaster revolving loan fund, funded by the legislature, and has a range of provisions for the awarding of disaster relief and mitigation funds. There are also provisions, outside of emergency situations, for minimizing the effects of disasters

The governor may requisition and take over any materials, facilities or property required for civil defense, and the statute outlines compensation and damages policies. In areas devastated by natural disaster, county councils may approve an urban project.

The statute provides for "the immediate relocation and rehabilitation of disaster victims by making public lands available" and specifies "disposition procedures, size limits, option to purchase and eligibility requirements." It also provides for psychological services after a disaster.

Hawaii Revised Statutes, in particular Chapter 128-18, outline the granting of immunity for liability to Hawaii's emergency management organizations during disaster-related duties, including from accidents, deaths and damages from tort lawsuits. Chapter 128-19 provides similar immunity to owners of Civil Defense-designated shelters for people in disaster situations, and people or entities who voluntarily permits use of property to shelter people.

Refer [3.3.4 - 08 of 08] to read the immunity from liability clauses in Revised Statutes, Chapter 128 of the Civil Defense and Emergency Act. [PDF] in the CD-ROM

California – Standardized Emergency Management System Regulations

In California, regulations were developed in 1996 by the Office of Emergency Services to standardize responses to emergencies involving multiple jurisdictions or multiple agencies – a critical move for a regional (or state) emergency system that aims to achieve cohesion.

The regulations established a Standardized Emergency Management System (SEMS), based on the Incident Command System (ICS), which was adapted from a system originally developed by the Firefighting Resources of California Organized for Potential Emergencies (FIRESCOPE) programme. SEMS is:

"…intended to be flexible and adaptable to the needs of all emergency responders in California. SEMS requires emergency response agencies use basic principles and components of emergency management including ICS, multi-agency or inter-agency coordination, the operational area concept, and established mutual aid systems."

State agencies and local government were obliged to use SEMS by December 1996, to be eligible for state funding of response-related personnel costs under activities identified in California Code of Regulations.

Refer [3.3.4 - 08 of 08] to view Chapter One of the SEMS Regulations. [PDF] in the CD-ROM

New Zealand – Civil Defense Emergency Management Act (2002)

A New Zealand Civil Defense Emergency Management Act came into force in December 2002. Over three years government agency, emergency services and a range of other sector stakeholders developed a National Civil Defense Emergency Management Plan, which took effect in July 2006.

The Act requires a risk management-based approach to the sustainable management of all hazards, both natural and man-made, according to a country report for the International Tsunami Information Centre written by Mike O'Leary, Manager: Readiness for the Ministry of Civil Defense and Emergency Management in New Zealand.

3.3.4 Tsunami emergency response planning - 3.3.4.2 Legislative Frameworks

Risk management is applied comprehensively across risk reduction, readiness, response and recovery – the "4Rs" – and is integrated through the involvement of all sectors and agencies in the Civil Defense Emergency Management (CDEM) community. The new Act:

- Promotes sustainable management of hazards to improve safety of the public and property
- Encourages communities to decide upon and achieve acceptable levels of risk
- Requires local authorities to coordinate CDEM planning and activity
- Provides a basis for integrating national and local CDEM planning
- Encourages coordination across a wide range of agencies that prevent or manage emergencies

One of the key aspects of New Zealand's improved emergency framework is the creation of regional Civil Defense Emergency Management Groups (CDEM Groups) – consortia of local authorities that work in partnership with emergency services (police, fire and health), lifeline utilities and others to deliver emergency management within regional boundaries.

Each new CDEM Group must produce an integrated Plan within two years, specifying the hazards and risks faced in each region, how the risks are managed, and how their management is to be improved.

As a result, O'Leary writes, CDEM Groups will specifically address the hazard and risks associated with tsunami. Also:

"The process will improve New Zealand's disaster management by allowing national and regional planners to prioritize their hazard study programmes and functional planning activity."

A standard risk-management methodology has been provided for the planning process.

Refer [3.3.4.2 - 03of 03]to view New Zealand's National Civil Defense Emergency Management Plan. [PDF] in the CD-ROM

To view other documents pertaining to New Zealand's emergency management laws and plans, visit:

www.civildefence.govt.nz

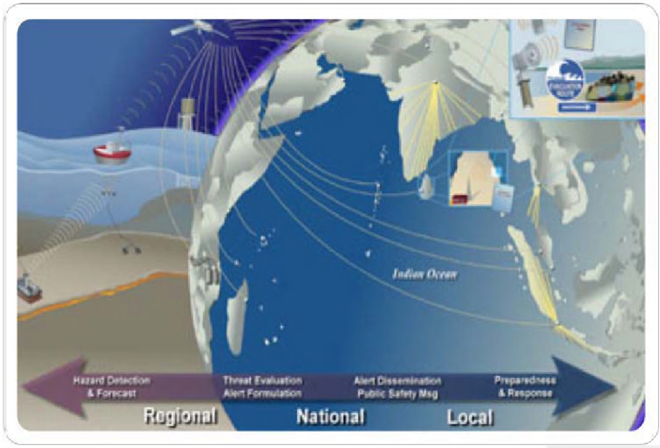
Refer [3.3.4.2 - 03 of 03]to view National Civil Defense Emergency Management Plan order 2005. [PDF] in the CD-ROM

3.3.5 Tsunami Warning Systems - 3.3.5.1 TWS - Overview

Within a decade, early detection and warning systems for tsunamis and other natural hazards, such as storms and floods, will cover the earth.

Advanced technology backed by considerable scientific capacity, international and regional institutions, global collaboration and information sharing, will detect tsunamis when they are generated and warn communities when the great waves are approaching.

Detection and early warning systems will eventually be supported by mitigation systems that prepare communities in a variety of ways, from ensuring that all people receive warnings quickly and producing hazard zone maps to developing evacuation routes and public education.



3.3.5 Tsunami Warning Systems - 3.3.5.1 TWS - Overview

This section of the Public and Private Sectors Module contains a wealth of information and resources on tsunami warning systems, and is aimed primarily at government officials at all levels who are involved – or might become so – in tsunami warning activities.

This section describes:

Existing warning systems: The development of the Pacific Tsunami Warning and Mitigation System, including technologies used for tsunami detection, and of the Japan National Tsunami Warning System as a warning system for local tsunamis

New warning systems: The evolving Indian Ocean Tsunami Warning and Mitigation System as an international warning system for basin-wide tsunamis, and the capacity needed to develop systems that cover all regions

Development of a global warning system out of existing and emerging regional tsunami warning systems, and the necessary characteristics of sustainable tsunami detection, warning and operational centres

Guiding principles for developing new tsunami warning and mitigation systems

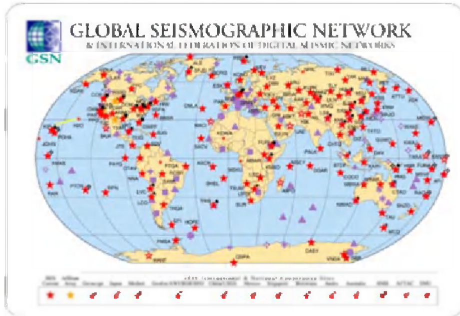
Maldives National Tsunami Warning Centre signboard.

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

Pacific Tsunami Warning and Mitigation System

One of the first tsunami alert efforts was the United States' Seismic Sea Wave Warning System.

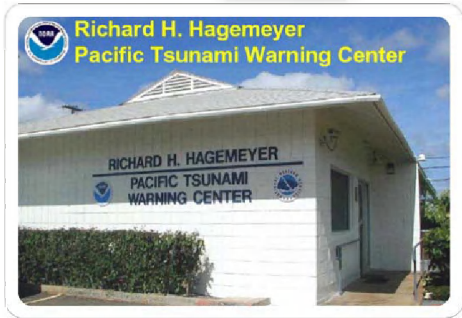
It was set up in Honolulu following the Aleutian Trench tsunami of 1946, which struck Alaska and Hawaii. Since most tsunamis are generated by earthquakes, its function was to monitor earthquakes and to send warning information to authorities in Hawaii.



Global Seismographic Network

In the wake of the 1960 Chile and 1964 Alaska tsunamis, UNESCO's Intergovernmental Oceanographic Organization (UNESCO-IOC) worked with governments in the Pacific Ocean region to create, in 1965, the Tsunami Warning System in the Pacific (ITSU).

ITSU stands for International Tsunami, and in doing so represents collective tsunami warning efforts globally that UNESCO-IOC is coordinating.



The Pacific system's Intergovernmental Coordination Group (ICG), called ICG-PTWS (Pacific Tsunami Warning and Mitigation System), is today composed of experts from about 30 Pacific countries. It is a subsidiary body of the IOC and reports to the IOC Assembly, which has some 140 Member States.

The ICG meets regularly to discuss technical monitoring and warning dissemination needs and improvements, coordinate risk assessment and preparedness activities, and share national experiences in building tsunami awareness through education outreach.

Its most important goal is to ensure the issuing of timely warnings to all countries in an understandable and reliable manner, so that national authorities can take action to save lives and property.

The Pacific Tsunami Warning and Mitigation System (PTWS) is led in its efforts by the Richard H Hagemeyer Pacific Tsunami Warning Center (PTWC), which acts as the operational headquarters for the international tsunami warning system and the UNESCO-IOC International Tsunami Information Centre (ITIC).

The PTWC's main purpose is to provide timely tsunami warnings, undertaking the following activities:

- *Seismic data collection and analyses.*
- *Sea level measurements.*
- *Message creation and dissemination.*

Operationally, its efforts are focused on continuously improving the accuracy of the information, providing it faster, and ensuring that the system is reliable in its evaluations and delivery to Member States.

Take a look at the PTWS website:
http://ioc3.unesco.org/ptws/

International Tsunami Information Centre

The ITIC, established by UNESCO-IOC, serves as an overarching coordinating and facilitating body for the Pacific operational warning system.

It monitors and recommends improvements, serves as the information resource for establishing new systems, builds capacity through training and internships, encourages preparedness, education, research and mitigation, and collects historical information on tsunamis and tsunami impacts.

The ITIC and PTWC are located on the island of Oahu in Hawaii, United States. The PTWC is operated by the United States National Weather Service of the National Oceanic and Atmospheric Administration (NOAA). The IOC-ITIC is hosted by the United States and Chile.

Both organizations actively support all IOC efforts to implement warning systems globally.

The PTWS Officers met in December 2004 at ITIC in Honolulu to assess the progress of ITSU (now the PTWS) in improving timely and effective tsunami warnings and effective mitigation across the Pacific. At the time, they met with the IOC GLOSS Group of Experts Chair and the University of Hawaii Sea Level Center to improve the coordination of sea level data to support tsunami warnings. Little did they know that three weeks later, the greatest tsunami catastrophe would occur, and that many of the discussions that took place at the Officers meeting would become immediately relevant for implementing new systems in the Indian Ocean, the Caribbean, and the Mediterranean. Peter Pissierssens (left, IOC Secretariat), Dr. Francois Schindele (middle, then ITSU Chair, France), Dr. Charles McCreery (right, then ITSU Vice-Chair, PTWC), and the ITIC Director became immediately involved in the coordination and design of the IOC new systems globally.

Take a look at the Pacific Tsunami Warning Center website:
http://www.prh.noaa.gov/ptwc/

Take a look at the International Tsunami Information Centre website:
http://www.tsunamiwave.info

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

PTWS – Earthquake Monitoring

In order to provide the earliest tsunami warnings, warning centres continuous monitor the earth's seismicity. Seismic waveform data from international networks, such as the Global Seismic Network (GSN), and national networks are used to determine the earthquake's location and magnitude. These waveforms are sent in real-time through satellites, the internet, and other dedicated communications lines, and received within seconds by the warning centres.

Automated processing and analyses methods, and a full-time, 7x24 hour staffing, make it possible for the PTWC, JMA, and other sub-regional and national centres to issue tsunami information bulletins within minutes of the earthquake's origin time. Earthquake monitoring currently provides the fastest means for early warning. This is because seismic waves travel much faster through the Earth than through water.

However, most earthquakes do not cause tsunamis. Warning Centres concentrate on monitoring for the largest, shallow undersea earthquakes along active subduction zones, and look for earthquakes that show normal or thrust faulting mechanisms of rupture. The criteria used by the PTWC is to issue a message to all earthquakes of magnitude M6.5 or greater, and to respond to earthquakes above M5.5. For the Pacific, the PTWC has issued messages on average 1-2 times a month, with tsunami watch or warnings 1-2 times a year. By contrast, PTWC staff respond to about 20 earthquake alarms a month.

GSN stations in the Seychelles, Iceland, and Falkland Islands.

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

PTWS – Sea Level Stations

Monitoring earthquakes did not prove a sufficiently accurate way of predicting tsunamis, as not every underwater earthquake generates a tsunami. At least 75 percent of warnings issued in the early years of the system were for non-destructive tsunami events.

Such warnings are costly and can encourage people to be complacent. Also, while monitoring gives a good estimate of the potential for a tsunami based on earthquake size and location, it gives no direct information about whether a tsunami has been generated or about the size of tsunami waves.

To make warnings more accurate the Pacific system added coastal sea level or tide stations, which consist of a gauge that measures changes in sea level and equipment that transmits the measurements to satellites, which then relay the information to warning centres.

Sea Level Station, Palau, Federated States of Micronesia.

New technology, such as the deep-ocean tsunami sensors (DART), are now able to provide confirmation of tsunamis as they travel across ocean basins where there are no islands for coastal tide stations. DART data are helping to improve the accuracy of tsunami warning bulletins by enabling better forecasts of tsunami impacts to be predicted. The data are also helping to reduce the number of 'false alarms' by justifying the cancellation of warnings when no significant wave is observed.

However, wrote Dr Laura Kong in an article in *2004 Science Year*:

…tide stations also have their limitations. The gauges are all located at the shore. Although they can warn of approaching local tsunamis, they cannot predict the development and impact of distant tsunamis."

Further, according to NOAA, while tide gauges provide direct measurements of a tsunami, tsunamis are altered by local bathymetry and harbour shapes "which severely limits their use in forecasting tsunami impact at other locations".

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

Pacific Tsunami Warning Center

Tsunami warning centres are the heart of early warning systems. They monitor the hazard every hour of the day, and initiate reports on actual threats so that authorities can take public safety actions.

In the Pacific, the Pacific Tsunami Warning Center in Hawaii acts as the operational headquarters for international warnings. When it has determined that a destructive tsunami has likely been generated, it informs national emergency authorities in threatened areas.

Outside of tsunami alarm events, PTWC staff focus on developing and implementing enhancements which make evaluations faster, more accurate and more reliable. These operations and activities are common to all tsunami warning centres.

The PTWC carries out four main operational activities in real time:

- *Earthquake monitoring through seismic data collection and analyses.*
- *Sea level monitoring through coastal and deep-ocean sea level measurements and associated wave forecasting using numerical models.*
- *Decision-making in order to determine the level of tsunami threat.*
- *Creation and dissemination of tsunami information, watch and warning messages to pre-deter mined authorities.*

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

Pacific Tsunami Warning Center

For the PTWC, like all warning centres, the most important overall requirement is for a very dependable communications system.

The communications infrastructure must be of high bandwidth to deliver all of the required data streams in real- or near-real time for monitoring, and also fast and comprehensive enough to deliver warning messages quickly to many different vulnerable communities and categories of citizens.

PTWC alarms trigger when an earthquake with a magnitude larger then 5.5 occurs, and duty staff in the office respond within tens of seconds to the alert.

Center scientists analyze the data, estimate the earthquake's magnitude and watch for reports from coastal tidal stations in the quake area, which tell them whether tsunami waves have raised the water level of a coast and if there could be a tsunami hazard to other areas.

If a tsunami is crossing the Pacific, one or more of the DART stations will report an increase in water pressure. Scientists use other tools, such as tsunami modeling databases, to forecast the intensity of a tsunami at selected locations along a coastline.

Satellites transmitting and receiving tsunami, seismic, and weather data at PTWC.

Testing the warning system

The DART system was successfully tested in near real-time following the 17 November 2003 Aleutian Rat Islands tsunami in Alaska. An earthquake generated a tsunami that was detected by three "tsunameters", as the DART instruments are called, along the Aleutian Trench – the first tsunami detection by the new system.

The height, arrival time and periods of the first tsunami waves to arrive at Hilo Bay, Hawaii, were correctly forecast: as they were non-threatening, this information along with other equally important data were used to justify the canceling of the tsunami warning. More tests are needed, but NOAA believes than when fully implemented, forecasts:

"…will be obtained even faster and would provide enough lead time for potential evacuation or warning cancellation for Hawaii and the US West Coast."

PTWC scientists stress, however, that successful threat evaluations require the use of all the different geological, geophysical, oceanographic and satellite or remote sensing data available, in addition to DART data. Each piece of data, and the unique information it provides after analysis, contributes to overall understanding of an event, and must collectively be used to determine the potential threat to a community.

Refer [3.3.5 - 07 of 13] to view this brief about the Pacific Tsunami Warning Center [PDF] in the CD-ROM

Chilean DART buoy deployed off the coast of northern Chile.Credit: SHOA

Tsunami information products

The PTWC issues initial tsunami bulletins within 10 to 15 minutes of a potentially tsunami-generating earthquake, based on the magnitude and location of the earthquake. The message indicates that a tsunami may be imminent and that coasts in the threatened area should prepare for evacuation.

After a tsunami has been monitored with sea level gauges, and where possible with deep ocean sensors, a more accurate picture of its threat and movements are obtained. Tsunami Information bulletins may be upgraded to Tsunami Watches and Warnings, or a Tsunami Warning can be cancelled, restricted or expanded in subsequent bulletins.

A Tsunami Watch is an alert that is issued to areas outside the warned area. The size of the watch area is based on the magnitude of the earthquake and tsunami travel times. A Watch can either be upgraded to a Warning in subsequent bulletins, or cancelled.

Both tsunami Warnings and Watches include estimated wave arrival times for key coastal locations in the warned or watch area.

View the bulletins page of NOAA's Pacific Tsunami Warning Center at:
http://www.prh.noaa.gov/ptwc/bulletins.htm

View the bulletins page of NOAA's West Coast-Alaska Tsunami Warning Center at:
http://www.prh.noaa.gov/ptwc/bulletins.htm

View the bulletins page of Japan Tsunami Warning Center at:
http://www.jma.go.jp/en/tsunami/

Sub-regional warning centres

The PTWC provides international tsunami warnings for distant tsunamis to countries in the Pacific, to US interests in the Pacific outside the coverage of the West Coast-Alaska Tsunami Warning Center (WC-ATWC), and local tsunami warnings to Hawaii.

There are also sub-regional warning centres in the US (WC-ATWC), Japan and French Polynesia. The WC-ATWC provides international and national tsunami warnings to Alaska and the west coast of the US, and to the west coast of Canada.

Since 2005, in addition to its national tsunami warning services, Japan – in coordination with the PTWC – has provided supplementary tsunami warning information for the northwest Pacific through its North-west Pacific Tsunami Advisory Center (NWPTAC). Since 2006, NWPTAC has issued interim tsunami advisory information for the South China Sea region.

France's Centre Polynésien de Prévention des Tsunamis, in Tahiti, has provided services to French Polynesia since the 1960s.

The US and Japan have also shared their tsunami warning expertise in other oceans. In 2005, the PTWC and Japan Meteorological Agency began providing interim tsunami advisory information to the Indian Ocean, and the WC-ATWC began providing warning services to Canada's east coast, in addition to the US Gulf of Mexico and eastern coast.

In 2006, the PTWC began also providing interim services to Puerto Rico, the US Virgin Islands and internationally to the wider Caribbean region.

Refer [3.3.5 - 09 of 13] to view Centre Polynésien de Prévention des Tsunamis [PDF] in the CD-ROM

To view the West Coast-Alaska Tsunami Warning Center website.

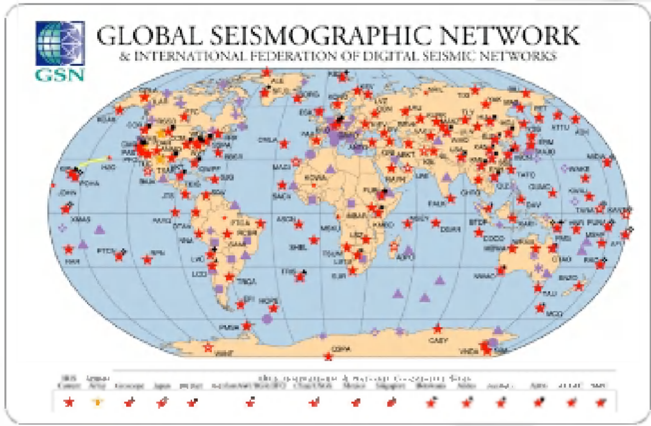
http://wcatwc.arh.noaa.gov/

To view the Japan Tsunami Warning Center website:

http://www.jma.go.jp/en/tsunami/

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors
3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

West Coast / Alaska Tsunami Warning Center, Palmer, Alaska.



Global Seismographic Network

The documents featured on this page describe aspects of the structure, organization and operation of the Pacific Tsunami Warning and Mitigation System, and will be of interest to officials and scientists involved in developing or operating a warning system.

ICG-PTWS – Master Plan

The Pacific Tsunami Warning and Mitigation System has been highly effective in alerting countries and communities to impending tsunamis, and at helping to develop systems and structures that mitigate the impacts of the great waves when they strike.

In 1999 the ICG-PTWS (Pacific Tsunami Warning and Mitigation System) produced a Second Edition of its *Master Plan*, which provides a brief overview of the tsunami hazard, describes the status of the warning system in the Pacific, and charts future directions.

The *Master Plan* also outlines the system's comprehensive tsunami mitigation programme including hazard assessment, warnings, preparedness, and research activities undertaken through international cooperation and coordination of activities. It is a valuable resource for planners and managers involved in tsunami warning and mitigation systems.

ICG-PTWS is now developing a Medium Term Strategy for the Pacific Tsunami Warning and Mitigation System that will provide a roadmap for implementing an effective end-to-end system.

Refer [3.3.5 - 10 of 13] to view Tsunami Warning System in the Pacific: Master Plan, 2nd Edition [PDF] in the CD-ROM

Communications Plan for the Pacific Tsunami Warning and Mitigation System

The *Communications Plan for the Pacific Tsunami Warning and Mitigation System* provides an overview of the structure of the warning system, discusses the general nature of tsunamis, and describes the operational warning and communication procedures of the PTWC and sub-regional warning centres comprising the Pacific Tsunami Warning System.

It is also a useful manual for planners and managers who become involved in warning systems or need to understand how they work. It is continually updated, distributed to Member States' operational warning centres, and posted on the PTWS website.

The *Communications Plan* contains information on the Northwest Pacific Tsunami Advisory Center, operated by the Japan Meteorological Agency, on the West Coast-Alaska Tsunami Warning Center, and on the Centre Polynésien de Prévention des Tsunamis.

Further, there is a list of designated operational contact points, and the communication methods by which bulletins are sent from the PTWC to them.

A set of annexes contains: the form to be used to inform the PTWC of changes to Tsunami Focal Points; a list of Tsunami Forecast Points used in bulletins; and information on the sub-regional tsunami warning centres, NOAA WC-ATWC and Japan's NWPTAC.

Refer [3.3.5 - 10 of 13] to view the Communications Plan for the Pacific Tsunami Warning and Mitigation System [PDF] in the CD-ROM

PTWC Operations, Systems and Procedures Manual

The Pacific Tsunami Warning Center has developed an *Operations, Systems and Procedures Manual*, edited by its Tsunami Warning Science Officer, Dr Stuart A Weinstein.

The Manual is a useful source of information on the PTWC's mission, operations, procedures, software and message products. It gives users involved in tsunami warning systems an understanding of the environment of the PTWC and the tools the organization uses.

The basic elements of the warning centre environment are introduced before the manual goes into progressively greater detail on the full range of its activities.

The WC-ATWC makes sections of its very informative *Operations, Systems and Procedures Manual* available online, and can be used as a model for new tsunami warning centres.

Refer [3.3.5 - 10 of 13] to view the PTWC Operations, Systems and Procedures Manual [PDF] in the CD-ROM

To view sections of the WC-ATWC Operations, Systems and Procedures Manual:

http://wcatwc.arh.noaa.gov/subpage3.htm

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

Japan Tsunami Warning System

The most responsive tsunami warning system in the world is operated by the Japan Meteorological Agency (JMA), to protect citizens from local, regional and teletsunamis. Established in 1952, the Japan Tsunami Warning System is responsible for issuing tsunami warnings to the public.

The people of Japan have been the regular victims of local tsunami attacks, suffering hundreds of thousands of casualties in the last 2000 years. The 1960, magnitude 9.5 Chile tsunami served as a wake-up call that Japan could be attacked by teletsunamis that crossed the Pacific. It was this event that led to the Pacific Tsunami Warning and Mitigation System.

Japan's Tsunami Warning System is focused on providing timely warnings for local tsunamis. The frequency of large earthquakes in Japan, and especially undersea ones, means that the system is exercised often.

Starting immediately after the 26 December 2004 tsunami, IOC and its ITIC, PTWC, and JMA officials shared their expertise and experience on tsunami warning operations and tsunami mitigation with many Indian Ocean nations. Former JMA Director-General Koichiro Nagasaka addressing Thailand national officials, May 2006.

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

Japan Tsunami Warning System

Japan also provides warnings to its citizens about teletsunamis, and operates the Northwest Pacific Tsunami Advisory Center. As mentioned the NWPTAC, in cooperation with the PTWC, has provided supplementary tsunami warnings for the northwest Pacific since 2005, and interim tsunami advisories for the South China Sea region, starting in 2006.

With the increase in the quantity and quality of seismic data, and improvements in the methodology and efficiency of seismic processing over the last 10 years, tsunami messages in Japan are typically disseminated only minutes after the earthquake.

To effectively provide early warning to citizens for local and regional tsunamis, the JMA continuously monitors seismicity using about 4,000 seismic intensity meters throughout Japan. Local governments operate about 3,000 of these instruments and contribute the data to the JMA.

Refer [3.3.5 - 12 of 13] to view a summary of the Tsunami Warning System in Japan [PDF] in the CD-ROM

Japan Meteorological Agency Operations Center.

3.3.5 Tsunami Warning Systems - 3.3.5.2 Existing warning systems

Japan Tsunami Warning System

The network is supplemented by more than 180 seismic stations and land-cabled ocean bottom seismometers, and seismic arrays to provide real-time determination of an earthquake's hypocenter and of its rupture characteristics

The seismic network enables the JMA to locate an earthquake within seconds, immediately broadcast information on seismic intensity (according to the Japanese magnitude intensity scale) through the media, and calculate and issue tsunami warnings and estimated wave heights within two to five minutes of an earthquake's occurrence.

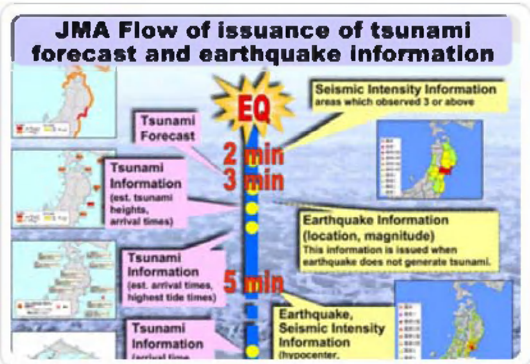
Pre-computed tsunami forecasts for 66 forecast blocks around Japan, based on earthquake location, are broadcast within minutes of an earthquake as part of a tsunami warning message. These are supplemented with tsunami observation information as it is received.

Starting immediately after the earthquake, the JMA continuously monitors data from more than 110 sea level gauges and land-cabled ocean bottom tsunami pressure sensors along its coasts to confirm the generation of a tsunami.

For teletsunamis, the JMA receives tsunami bulletins from the Pacific Tsunami Warning Center, and independently utilizes real-time data from the Global Seismic Network and the Pacific Tsunami Sea Level Network, along with techniques using its national seismic network, to estimate an earthquake's hypocenter and magnitude.

National tsunami warnings are then issued based on the evaluation of tsunami threat to Japan.

Refer [3.3.5 - 13 of 13] for the JMA Tsunami Warning Center [PDF] in the CD-ROM



3.3.5 Tsunami Warning Systems - 3.3.5.3 New warning systems

Indian Ocean Tsunami Warning and Mitigation System

The 2004 Indian Ocean tsunami disaster taught the world that tsunamis can happen in any ocean or sea at any time.

Following the tsunami – and over and above the world's biggest ever relief effort – there was, wrote International Tsunami Information Centre (IOC-ITIC) Director Dr Laura Kong in *The Liaison**, "immediate and continued support from many nations, the private sector and individuals wishing to support the building of a tsunami warning system in the Indian Ocean."

UNESCO-IOC and IOC-ITIC estimate that more than US$175 million had been pledged for the new warning system by early 2006. Soon after the tsunami, the PTWC and JMA began issuing interim tsunami advisory services to the Indian Ocean region.

"Guarding against tsunamis: The challenge of building preparedness at the national and local levels", The Liaison, September 2006.

Wrote Dr Kong, improved real-time monitoring networks are now being established:

"At the same time, active awareness and education efforts were begun to start to build a better prepared public. Tsunami early warning systems must provide timely, understandable warnings within minutes that will then motivate ordinary citizens to quickly move out of harm's way."

Refer [3.3.5 - 01 of 06] to view the article: Guarding against tsunamis: The challenge of building preparedness at the national and local levels"[PDF] in the CD-ROM

Indian Ocean Tsunami Warning and Mitigation System

In 2005, UNESCO-IOC was recognized as the appropriate United Nations body to facilitate the development of both interim and permanent tsunami warnings for the Indian Ocean and other oceans and marginal seas.

At the 23rd Session of UNESCO-IOC in June 2005, three new Intergovernmental Coordination Groups were created for: the Indian Ocean; the Caribbean Sea and adjacent regions; and the Northeastern Atlantic, Mediterranean and its connected seas.

> A fourth body, the UNESCO-IOC Intersessional Ad-Hoc Working Group, was also set up "to discuss a global framework for the establishment of an early warning system for all coastal marine hazards," according to Dr Kong in *The Liaison*:
>
> *"We have learned that such systems can only be built with strong and sustained commitment by national governments, and that these systems can only operate if countries agree to collaborate in a regional framework by sharing data and by jointly bearing the cost for the regional elements of the network."*
>
> *"In addition, some nations are threatened by tsunamis generated in more than one ocean basin, increasing the importance of regional and international coordination."*

You can view the ICG websites for the new warning and mitigation systems below.

ICG for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS):

http://ioc3.unesco.org/indotsunami/

ICG for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connecting Seas (ICG/NEAMTWS):

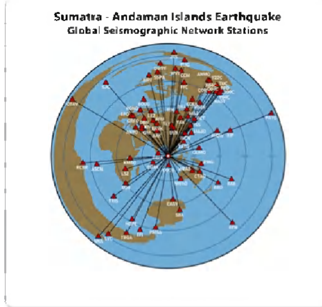
http://ioc3.unesco.org/neamtws/

ICG for Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE-EWS):

http://ioc3.unesco.org/cartws/

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors
3.3.5 Tsunami Warning Systems - 3.3.5.3 New warning systems

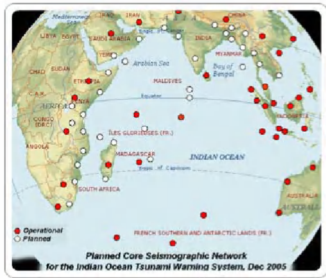
The Indian Ocean Tsunami Warning and Mitigation System is being built around national tsunami warning centers, which are being established in 29 countries around the Indian Ocean rim. A technology assessment by experts concluded that an Indian Ocean warning system would require three elements:



Seismic stations that recorded the 2004 Sumatra M9.3 earthquake.

Seismographic network

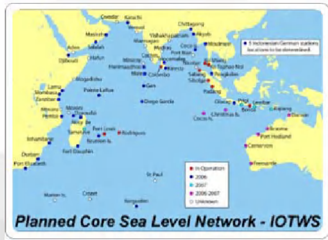
An improved seismographic network to monitor earthquakes.



Regional earthquake monitoring network for the tsunami warning system in the Indian Ocean.

Sea-level network

A real-time sea-level observing network covering the entire Indian Ocean basin.



Regional sea level monitoring network for the tsunami warning system in the Indian Ocean.

Deep-ocean sensor network

The deployment of deep-sea pressure sensors capable of detecting tsunami waves as they travel over the deep ocean.

Proposed locations of deep-ocean sensors for the eastern Indian Ocean.

By late 2005, 26 countries had set up communication centers to receive seismological information from operational centers serving the Pacific Ocean in Hawaii and Tokyo. Since only a few earthquakes generate tsunamis, this system on its own is prone to false alarms.

By mid-2006 there were over two dozen real-time sea-level stations continuously transmitting data across the Indian Ocean, improving the region's ability to detect and monitor the passage of tsunamis across the ocean basin, and to accurately forecast tsunamis.

Experiments have been conducted to test communication links and to ensure the transmission of seismic information in real-time with global transmission delays of less than 20 seconds between the field site and data centers. At the same time, improvements are being made to the Global Telecommunications System to enable it to disseminate tsunami warning messages in less than 2 minutes and transmit sea level data every 15 minutes.

An international partnership, hosted by UNESCO-IOC, has been created to facilitate transfer of the technology needed to build deep ocean pressure sensors, like those in place in the Pacific, which will further improve the effectiveness of the Indian Ocean system.

As information from the new instruments and networks starts flowing, tsunami warnings will begin to be issued. This service will be provided by regional tsunami advisory centers.

A comprehensive Indian Ocean Tsunami Warning and Mitigation System will require not only detection and warning, but also the other two sides of the mitigation triangle – hazard assessment, and awareness and emergency preparedness.

The unfolding Indian Ocean system is also developing tsunami modeling capacity and training aimed at achieving accurate risk assessment, effective management of warning systems, and the transfer of knowledge and expertise in developing basic emergency preparedness tools such as inundation maps of high-risk coastal areas including cities.

At the end of 2005, UNESCO-IOC produced an excellent booklet, titled *From Commitments to Action: Advancements in Developing an Indian Ocean Tsunami Warning and Mitigation System*, which can be used as a reference document for officials involved in tsunami activities.

Refer [3.3.5 - 04 of 06] to view From Commitments to Action: Advancements in Developing an Indian Ocean Tsunami Warning and Mitigation System [PDF] in the CD-ROM

The booklet looks at milestones along the path to an Indian Ocean system, commitments that have been made, actions taken and long term plans for IOTWS. An extraordinary amount was achieved in the year following the 2004 Indian Ocean tsunami.

The Centre Polynesien de Prevention des Tsunamis (CPPT) in Tahiti, provided tsunami warnings for French Polynesia since the 1960s.

Indian Ocean Tsunami Warning and Mitigation System

Still, many challenges remain. During 2005, assessments of 16 countries in the Indian Ocean were conducted by teams of national and international experts to identify capacity building needs and support requirements for developing a tsunami warning system.

The team's comprehensive investigations found, in summary, that overall in the region, much progress had been made – but much also remained to be done

1. Disaster management laws specifically addressing tsunami coordination

Most countries had established or strengthened disaster management laws, national platforms, and coordination mechanisms to guide all-hazard disaster risk reduction. Not all had specifically addressed the tsunami coordination aspect.

2. Few countries able to receive or provide real-time seismic or sea level data

All countries except Somalia were receiving tsunami advisories and watch alerts on an interim basis from warning systems in the United States and Japan, and most had facilities able to receive warnings around the clock. But few operated a national warning centre or were able to receive or provide real time seismic or sea level data.

3. Information needed to develop plans, yet to be collected

Few countries had developed tsunami emergency and evacuation plans and signage or tested response procedures for tsunamis or earthquakes. Much of the information needed to develop these plans, such as post-event surveys, inundation modeling, and tsunami hazard and vulnerability assess ment, has yet to be collected.

4. Community education programmes developed but not in place

Many countries had assessed local government capacity for disaster preparedness and emergency response but not community preparedness. Community education and outreach programmes were being developed but were largely not in place.

5. Local planning activities carried out first in target areas rather than as comprehensive national programmes.

Most countries had made progress developing policies, assessing technological needs, and setting up national coordination mechanisms for warning and mitigation. But local planning and preparedness activities were being carried out first in target areas, or cities and towns, rather than as comprehensive national programmes.

Refer [3.3.5 - 05 of 06] to view the UNESCO-IOC report, Assessment of Capacity Building Requirements for an Effective and Durable Tsunami Warning and Mitigation System in the Indian Ocean [PDF] in the CD-ROM

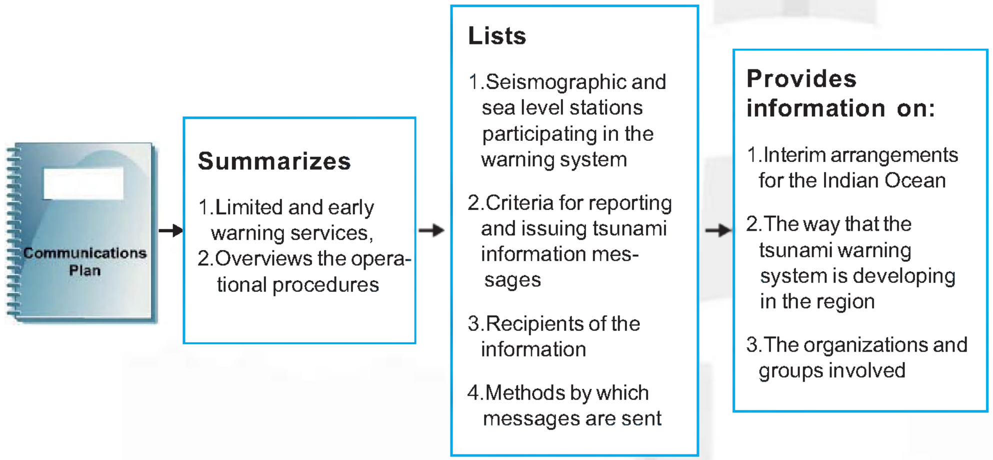
Communications Plan for the Interim Tsunami Advisory Information Service for the Indian Ocean Region

As in the Pacific, the Indian Ocean Interim Tsunami Advisory Information Service is described operationally by its *Communications Plan for the Interim Tsunami Advisory Information Service for the Indian Ocean Region.*

The document was provided by NOAA's Richard H Hagemeyer Pacific Tsunami Warning Center (PTWC) and the Japan Meteorological Agency (JMA) at the start of the Service in April 2005, and is continually updated.

Until the required infrastructure and robust systems are put in place for technical monitoring, evaluation and warning dissemination in the Indian Ocean, the PTWC and JMA are providing limited and interim early warning services to the region. The *Communications Plan* summarizes these services, and overviews the operational procedures involved.

It lists the seismographic and sea level stations participating in the warning system, the criteria for reporting and issuing tsunami information messages, the recipients of the information and the methods by which messages are sent. The *Plan* provides valuable information on the interim arrangements for the Indian Ocean, the way that the tsunami warning system is developing in the region, and the organizations and groups involved.



Refer [3.3.5 - 01 of 06] to view the Communications Plan for the Interim Tsunami Advisory Information Service for the Indian Ocean Region [PDF] in the CD-ROM

Towards a Global Tsunami Warning System

The devastating 2004 Indian Ocean tsunami created global awareness and motivation at high levels to implement tsunami early warning systems worldwide, to ensure that such a catastrophe would never happen again.

In 2005, the UNESCO-IOC began the process of coordinating a global tsunami warning and mitigation system through the establishment of intergovernmental coordination groups that committed governments to work together to create an observational detection network, appropriate evaluation techniques, and robust communication systems that would enable rapid notifications of large, tsunamigenic earthquakes to government emergency authorities.

From 3 to 8 March 2005, less than three months after the 2004 tsunami, UNESCO-IOC held the 1st International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a global framework. At the Paris meeting, nearly 300 delegates from 46 countries discussed requirements for developing an effective end-to-end system. A guiding principle emerged:

"... the better the national systems are, the better the entire system will be."

Thus, the strength and quality of the system would depend on the contributions and commitments of every country to build their national capacity to monitor, detect and evaluate tsunamis, and to contribute their knowledge and experience to building a regional system.

Building a global system from regional tsunami warning systems

For a warning system to be effective, every country and population that receives a warning must have full confidence that the tsunami information relayed is credible and issued using the best available science and scientific data.

Realizing this goal will require the collective contributions of scientists around the world, to continuously improve tsunamigenic potential evaluations and make them available to operational tsunami warning centres.

Just as a regional system draws its strength from each national system, a global system will draw from the contributions of each regional system.

The IOC has strongly advocated that each regional system should:

- Be fully owned by the countries of the region.
- Be based on international multilateral cooperation.
- Be based on open and free exchange of data.
- Protect all countries in the region.
- Be transparent and accountable to all members.

Each regional system must also:

- Be based on the joint operation of international networks of detection connected with national tsunami warning centres.
- Adhere to a United Nations governance mechanism as proposed by UNESCO-IOC
- Recognize that each nation is responsible for issuing warnings in its territory and protecting its own population.
- Acknowledge that national warning centres must have strong links with emergency preparedness authorities (national, provincial and local).

Characteristics of a warning system – Detection and operational centres

Delegates at the 1st International Coordination Meeting in Paris, March 2005 began the work of collectively building an Indian Ocean system by identifying key characteristics of the detection, warning and dissemination components of an early warning system.

Based on these discussions, experts have elaborated on fundamental building blocks for every regional tsunami warning system.

Tsunami detection

For tsunami detection, continuous real-time analysis of geophysical and sea level data is needed that:

- Is robust and automatic, and verifiable.
- Can be assimilated into a warning system, using continuous updating of analysis as data becomes available.
- Incorporates standards for analytical methods that are maintained across national and regional centres.
- Provides improved detection and localization of earthquake magnitude and location estimates.
- Provides improved estimates of source displacements, such as from positioning and ground deformation data.
- Provides tsunami wave data to one centimetre or better, with a one-minute or better sampling rate transmitted continuously to monitor the local tsunami threat, and at a minimum of five-to-15 minute frequencies to monitor the regional to basin-wide tsunami threat.

Operational centres

For tsunami warning systems, operational centres must:

- Have around-the-clock capabilities to a high degree of reliability: that is, 99.9 percent.
- Include experts in seismology, oceanography, data management and processing, and hazard analysis.
- Recognize that issuing warnings ultimately relies on national centres.
- Recognize that public safety actions following warnings should rely on local centres.
- Be linked and produce common content within their messages.
- Adhere to hierarchical rules for regional, national and local centres, so that one authoritative warning is issued, to avoid public confusion.
- Adapt to the type of event: that is, a local tsunami will have local centre precedence, and a mid-ocean generated tsunami will have regional centre precedence.

Characteristics of a warning system – Operational centers

In 2005, following the 2004 Indian Ocean Tsunami, the United States and Japan generously shared their experience and know-how in carrying out tsunami warning operations in the Pacific. Specifically, the Directors of the Pacific Tsunami Warning Center and Japan Tsunami Warning Center made several key presentations to guide the development of new operational centers.

In July, at IOC-ISDR (International Strategy for Disaster Reduction) Study Tours of the Hawaii and Japan warning systems, Dr Charles McCreery provided very important criteria for ensuring 100 percent operational reliability for tsunami warning services.
These criteria are:

Power

All operational systems are on a central Uninterrupted Power Supply (UPS) backed up by a generator with one week of fuel,

Hardware

Hardware is duplicated into primary and redundant systems.

Data sources

Seismic and sea level data are received through multiple sources.

Data communications

Data are received by the PTWC through multiple links whenever possible.

Data processing

Multiple algorithms are used for earthquake detection, alerting, locations, magnitudes and model guidance.

Messaging

Multiple dissemination methods are used to reach designated contact points.

Duty staff

Two people to ensure redundancy are always on duty in the Center, 24 hours a day.

Backup centre

Another centre should provide backup to the primary centre and be able to provide minimum levels of rapid evaluation and message dissemination.

Dr Charles McCreery also provided guidance on ensuring the long term sustainability of warning centres, since damaging tsunamis occur infrequently. In particular, requirements include:

National commitment to centre operations

This can be achieved by the sharing of resources and expertise that comes from a warning centre being part of an organization such as a meteorological service, that does around-the-clock monitoring of the environment in order to issues advisories and warnings.

Organizational support

International, national and local stakeholder organizations that include emergency managers, warning centre operators and scientists, providing an authoritative, sustained focus on tsunami issues.

Multi-function sensor data

Seismic and sea level stations operated by multiple organizations for multiple purposes. For example, seismic data can be used for earthquake and volcano monitoring and geophysical research, and sea level data documents tides, storm surges, El Nino and long term sea level rise.

Multi-function communication

Data communication methods are shared when possible, and message disseminations are made over multi-purpose circuits.

During the IOC-ISDR Study Tours of the Hawaii and Japan warning systems, Masahiro Yamamoto, then Director of the Japan Tsunami Warning Center, provided very important considerations on warning centre staffing and the management of a sustainable tsunami early warning system.

The type of tsunami hazard (local or distant) affecting the country determines the monitoring and response time requirements. Among the key considerations are:

- Type of operational centre – local tsunami or distant tsunami monitoring and, for distant tsunamis, the interpretation of advisories from other countries
- Operations schedules and daily work schedules for staffing an around-the-clock centre.
- Staff profiles and expertise requirements.

Training modules - 3.3 Public and Private Sectors
3.3.5 Tsunami Warning Systems - 3.3.5.4 Developing Warning Systems

- Staff training requirements.
- Operations centre manuals and documents needed.

Dr McCreery and Mr Yamamoto both strongly advocated the importance of the following to ensure a high-level of long term readiness:

- Frequent alarms: Duty Staff respond to one or two earthquakes a day on average.
- Frequent bulletins: Information messages and bulletin criteria are set so that the system is exercised regularly.
- Communications tests. Regular tests with responses ensure that communication links are working and reinforce readiness.
- Exercises: Tabletop and more realistic exercises expose weaknesses and provide practice. For a tabletop exercise, heads of responsible response agencies meet in one room and rehearse a response for a realistic tsunami scenario based on their standard operating procedures.

Refer [3.3.5 - 04 of 06] to view the article on Tsunami Warning Centre management and staffing [PDF] in the CD-ROM

Masahiro Yamamoto, IOC, formerly Director, Japan Tsunami Warning Centre (JMA), and Dr. Charles McCreery, Director, PTWC.

Characteristics of a warning system – Information dissemination

Warning sirens are an effective means to notify residents of an impending emergency.

For the dissemination of information, operational centers must:

- Issue messages that are clear and consistent, unambiguous, simple and practiced.
- Provide information sensitive to cultural setting, social patterns and perceptions of risk.
- Be effective by: Broadcasting quickly and broadly, using multiple paths.
  - Using existing mechanisms where possible – radio, television, emergency broadcast systems, SMS, beach sirens, temple bells, bicycles and loudspeakers among other means, especially within an all-hazards context.
  - Adhering to common rules to cancel an alert – an “all-clear”.
  - Engaging in periodic testing and verification, drills and exercises, and public education.

Installation of warning sirens in Hawaii began after the April 1, 1946 Aleutian Islands tsunami.

A global tsunami warning system as part GEOSS

UNESCO-IOC is working towards the creation of a Global Tsunami Warning and Mitigation System. A huge effort is underway to link regional monitoring efforts to create a coordinated global tsunami warning system that would contribute towards the Global Earth Observation System of Systems (GEOSS).

GEOSS originated from the 2002 call at the World Summit on Sustainable Development in Johannesburg for urgently-needed, coordinated Earth observation.

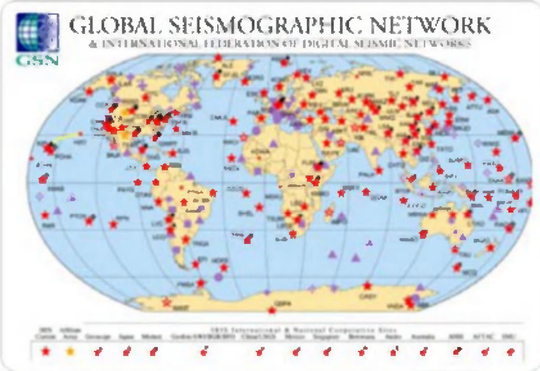
Today, an Intergovernmental Group on Earth Observations (GEO) oversees the GEOSS 10-Year Implementation Plan that was endorsed by nearly 60 governments and the European Commission at the 3rd Earth Observation Summit in 2005 in Brussels, Belgium. The Plan identifies deliverables and targets that will:

“… realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive, and sustained Earth observations and information.”

The Global Earth Observation System of Systems (GEOSS):

“…aspires to involve all countries of the world, and to cover in situ observations as well as airborne and space-based observations.

“…Through GEOSS, they [Earth observing systems] will share observations and products with the system as a whole and take such steps as are necessary to ensure that the shared observations and products are accessible, comparable and understandable, by supporting common standards and adaptation to user needs.”



The Global Seismographic Network, which makes data available to everyone for international monitoring of and research on earthquakes and tsunamis, is a contribution to GEOSS by the USA.

3.3.5 Tsunami Warning Systems - 3.3.5.4 Developing Warning Systems

GEOSS aims to link up orbiting satellites currently used to gather environmental data and other observation technology, and pool all national and regional observation data gleaned from them, within the next 10 years.

For tsunamis, oceanographic observations under the Global Ocean Observing System (GOOS) and earthquake observations supported by the Global Seismographic Network (GSN) of the Federation of Digital Broadband Seismographic Network (FDSN), are being utilized to build real-time detection and evaluation systems for tsunami warning in the Pacific, Indian Ocean, Atlantic Ocean, and Caribbean and Mediterranean seas.

> Take a look at the Group on Earth Observations website:
> *http://earthobservations.org/*

3.3.5 Tsunami Warning Systems - 3.3.5.5 Guiding Principles for Developing New Systems

UNESCO-IOC's International Tsunami Information Centre is compiling a handbook to assist coastal communities in building a comprehensive tsunami warning and mitigation system.

The following presents guiding principles in a question and answer format that will form the basis of the handbook:

1- What does this mean?

Building a Tsunami Warning and Mitigation System means establishing a comprehensive Tsunami Warning System (TWS) infrastructure and people-based knowledge level that is designed to save lives and reduce property damage from a tsunami.

2- What is involved?

The TWS infrastructure uses technology to disseminate tsunami warnings. Emergency management officials must translate warnings into public evacuation actions. To accomplish this, teams of subject matter experts and stakeholders needs to be established, forming government-funded Tsunami Warning and Mitigation Committees.

Ideally, these committees are established at national, provincial and local levels of government. Strategic country planning and resource commitment can take place at the national and provincial levels. Formulation and implementation of community specific strategies are best conducted at the local level.

3- What must be considered when building the system?

Look at desired outcomes, for example, human evacuation actions and mitigation strategies that reduce exposure to tsunamis. Determine programmes and systems that will reach the desired outcomes in an "end to end" approach. Assess the organizations and expertise that are available to implement the "three sides of the tsunami hazard mitigation triangle" – hazard assessment, warning guidance, and preparedness (mitigation).

4- What is required by communities in terms of information and equipment with respect to their specific culture, gender, language, economic status and other demographic factors?

Capacity building to develop tsunami-resistant and resilient communities requires implementing general mitigation strategies and practices that are tailored to the demographics and economies of a specific community.

5- How quickly does a tsunami warning and mitigation system respond?

In an ideal case involving a local or regional tsunami, an educated public will automatically and immediately head inland to higher ground (or conduct vertical evacuation) when picking up the natural warning signals such as strong ground shaking, receding beach waters or the roar of the ocean.

People will not wait for an official announcement. The public will have advance knowledge of evacuation maps and routes, and would have participated in tsunami drills. Authorities must rapidly broadcast whether a strong earthquake has generated a local tsunami, and must decide either to continue or stop the evacuation process.

In the case of a distant tsunami, the public will be alerted by sirens, radio, television, police loudspeakers, church bells or other means. People will turn to the authorities, who will know whether to instruct the public to evacuate. Embedding knowledge through public education is essential to sustain preparedness over the long periods between infrequent tsunamis.

6- How does one build the system – in steps and phases?

The three sides of the tsunami mitigation triangle must be developed simultaneously. An initial baseline capacity assessment must be conducted for each part of the triangle. Then short term (one to three years), intermediate (four to six years) and long term goals, objectives and milestones need to be established for each phase. Measurements of success also need to be established, for instance, complete evacuation of a coastal community in 30 or 60 minutes.

7- What are the highest and lowest priorities?

In a region susceptible to local tsunamis, education is the highest priority. The lowest priority is modeling and mapping, which can be costly and time consuming. Preliminary evacuation maps can be established by a committee of experts and emergency managers, until funding is available to update evacuation maps using scientific modeling and inundation mapping.

8- What are the funding considerations – how much?

A political commitment of country governments must be established to reduce tsunami and other natural hazard risks. Prioritize projects and operate within existing budgetary constraints. Establish organizational partnerships and leverage resources. Continually seek funding opportunities from the public and private sector.

9- What are the human resources required?

See question 2. Also, “Tsunami Champions” are identified and supported by both the public and private sectors, to lead tsunami preparedness and mitigation activities.

10- What examples are there of minimum and maximum systems?

One minimal example is Padang, Indonesia, which lacks a robust local or regional tsunami warning system. However, Padang community organizations, with support from local government,

took the initiative immediately after the 26 December 2004 tsunami to build awareness, community evacuation maps and plans, and to conduct drills and exercises to prepare against a strong local earthquake and possible tsunami.

One example of a maximum system is at Taro, Japan. The Japan Meteorological Agency transmits tsunami bulletins to an informed community that routinely conducts coastal evacuation drills with road signage, and massive sea walls shield the city. Another example is Hilo, Hawaii, where land use laws have created large, open park spaces along a waterfront that has been repeatedly devastated by tsunamis.

11- Are there examples of working systems that can be emulated?

Japan and the United States have the most mature “end to end” tsunami warning and mitigation systems. A number of other countries operate national warning centres to monitor seismicity and sea levels, and also strongly participate in and advocate active preparedness and mitigation activities aimed at saving lives and property.

France supports the Centre Polynésien de Prévention des Tsunamis in Tahiti, which provides sub-regional tsunami warnings for French Polynesia and has conducted several tsunami exercises to improve response times and procedures. The Servicio Hidrográfico y Oceanográfico de la Armada (SHOA) de Chile acts as that country’s national tsunami warning centre, working closely with the National Emergency Management Organization to develop evacuation maps from SHOA tsunami numerical modeling studies.

3.3.6 Tsunami Mitigation - 3.3.6.1 Tsunami Mitigation Overview

Overview

The need to prepare for tsunamis is obvious, in the interests of protecting lives and property. But tsunami mitigation planning and science is a multi-faceted, relatively new and generally under-resourced area of disaster preparedness, and much work needs to be done.

Also, while technology assists the evaluation of the tsunami threat and dissemination of the message, the success of early warning places communities at the heart of the response, and people in communities working together to ensure the safety of family and neighbours.

"To warn without preparing the response when confronted by an emergency is no help at all."

So stated Mr Koichiro Matsuura, UNESCO's Director-General, to island delegates at the Mauritius International Meeting for Small Island Developing States held from 10 to 14 January 2005, barely three weeks after the December 2004 tsunami.

Mr Raymonde Forde, President of the Barbados Red Cross Society and a Governing Member of the International Federation of Red Cross and Red Crescent Societies, further emphasized that:

"One of the main lessons from the Indian Ocean tragedy is that no coastal state can consider itself immune from such phenomena, and investments must be made in warning systems...

"Warning systems by themselves, are, however, of little value unless communities understand how they work and how warnings should be transmitted."

Refer [3.3.6 - 01 of 03] to view Developing TsunamiReady Communities: Translating Scientific Research into Useable Emergency Management Products. [PDF] in the CD-ROM

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Training modules - 3.3 Public and Private Sectors

3.3.6 Tsunami Mitigation - 3.3.6.1 Tsunami Mitigation Overview

Overview

In the United States, the *Implementation Plan for Tsunami Mitigation Projects*, a strategy guide for decision makers and emergency managers compiled for the National Tsunami Hazard Mitigation Program in 1998 by Humboldt University's Dr Lori Dengler, defines mitigation as:

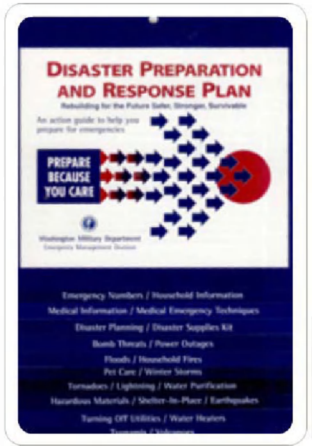
"…the sustained effort taken by communities at risk before a disaster strikes to lessen its impact. Effective mitigation not only reduces loss of life and property, but facilitates disaster response and recovery."

There have been tsunami mitigation efforts in many communities, regions and countries:

"For example, Canon Beach, Oregon, Crescent City, California and Port Alberni, British Columbia have established local tsunami warning systems. Chile and Oregon have developed a tsunami curriculum. Construction guidance for buildings in tsunami hazard zones has been incorporated into the State of Hawaii's building codes."

Until now, most of the knowledge generated by these efforts had not been brought together. Therefore, tsunami mitigation undertakings have often lacked information and experience, or duplicated each other's work. They have often also suffered from lack of technical expertise.

While programmes to mitigate other natural disasters, like as floods and hurricanes, can offer useful models for tsunami mitigation efforts, such information is not always easily available to emergency managers in areas that do not suffer regularly from these hazards.



Disaster Preparation and Response Plan, given by the Washington State Military Department Emergency Management Division.

3.3.6 Tsunami Mitigation - 3.3.6.1 Tsunami Mitigation Overview

Overview

As was the case for emergency management laws and policies, response plans and warning systems, tsunami mitigation efforts need to be placed within a multi-hazard framework, part of broader emergency efforts but also recognized as requiring specific responses.

TsunamiTeacher provides an invaluable collection of experience and practice on tsunami responses, planning and preparedness undertaken around the world over decades, as well as links to experts and tsunami organizations that can assist local governments and groups.

This last, large section of the Public and Private Sectors Module is aimed at government officials, public and private sector businesses and communities, and covers all aspects of tsunami mitigation, including:

- Meeting preparedness challenges.
- Community preparedness.
- Warning system response and public notification.
- Inundation and evacuation maps, exercises and signs.
- Environmental policy considerations.
- Building and land use considerations.
- Guidance for companies.
- Community awareness and education.
- Improving tsunami mitigation.

Tsunami scientists from Japan and New Zealand discuss the rebuilding of Okushiri Island, Japan after the 1993 Japan Sea tsunami. The southern tip of the island where the tsunami destroyed all buildings and infrastructure was converted to a park and memorial. Standing in the background is a reinforced concrete obelisk which was the only structure left standing. Credit: ITIC.

3.3.6 Tsunami Mitigation - 3.3.6.2 Meeting preparedness challenges

Critical elements of preparedness

The International Tsunami Information Centre lists eight elements of preparedness that have been shown to be critical to effective mitigation. They are, in summary:

No	Elements of preparedness	Explanation
1	**Proper instruments**	Proper instruments enable the early detection of potentially harmful earthquakes and tsunamis. The data obtained by these instruments must be readily available to all nations continuously and in real-time to be effective.
2	**Warning systems**	Warning systems reliably inform vulnerable populations immediately and in an understandable, culturally appropriate way. A Warning Centre must be able to analyze and forecast the impact of a tsunami on coasts, ahead of its arrival. Local, regional and-or National Disaster Management Organizations must be able to immediately disseminate information on the threat, and to enable the evacuation of all vulnerable communities. Communications methods must be reliable and robust, and work closely with the mass media and telecommunications providers to get broadcasts out fast.
3	**Awareness activities**	Awareness activities enable ordinary citizens to recognize a tsunami and know what to do. Citizens should be able to recognize a tsunami's natural warning signs and respond immediately. This is especially the case for local tsunamis, which may hit within minutes and before an official tsunami warning can reach communities.
4	**Preparedness activities**	Preparedness activities educate and inform a wide populace, including government responders and people providing lifeline and critical infrastructure services, on the procedures and actions that must be taken to ensure public safety. Drills and exercises before an event, and proactive outreach and awareness activities, are essential to reducing tsunami impacts.

No	Elements of preparedness	Explanation
5	**Planning activities**	Planning activities identify and create public safety procedures and products, and build capacity for people and organizations to respond quickly. It is necessary to create and widely disseminate tsunami evacuation and flooding maps, and instructions on when, where and how evacuate. Shelters and evacuation routes need to be clearly identified, and widely known by all segments of the coastal population.
6	**Strong buildings, safe structures, wise land use**	Strong buildings, safe structures and prudent land-use policies save lives and reduce property damage, when implemented as pre-disaster mitigations. Tall, reinforced- concrete buildings may be adequate places to which people can vertically evacuate if there is no time or too dense a population to reach higher ground inland. Long term planning to avoid placing critical infrastructure and lifeline support facilities in inundation zones will also reduce the time needed for services to be restored.
7	**Stakeholder coordination**	Stakeholder coordination is the essential mechanism that facilities effective warning and emergency response actions. Clear designation of the national or local authority from which the public will receive emergency information is critical to avoid public confusion, which compromises public safety.
8	**High level advocacy**	High level advocacy ensures a sustained commitment to prepare for infrequent, high-fatality natural disasters such as tsunamis.

Tsunami Mitigation

In working towards tsunami preparedness, local emergency managers – and the coastal communities they serve – face many challenges.

According to the US National Tsunami Hazard Mitigation Program's *Implementation Plan for Tsunami Mitigation Projects*, local emergency managers:

"…often have few resources for mitigation and in many cases have little technical background on the tsunami hazard. They are faced with a multitude of day-to-day responsibilities and personnel turnover is often high. They are often in the difficult position of balancing State and Federal mandates with local realities.

"For effective tsunami mitigation, local emergency managers must be supported and actively participate in the assessment of mitigation needs and implementation of mitigation programmes."

Local authorities and managers could benefit from support from "above" and "below". They need resources and assistance from national and regional governments for their emergency response and preparedness efforts, and from the private sector and community groups that connect them to the public they serve.

International Workshop held in Phuket, Thailand in February 2006 on Post Disaster Assessment and Monitoring of Changes in Coastal, Ocean, and Human Systems in the Indian Ocean and Asian Waters.

3.3.6 Tsunami Mitigation - 3.3.6.3 Community preparedness

The tsunami mitigation needs of coastlines and their communities differ according to their particular characteristics, and so there is no single "mitigation solution".

However, to prepare for tsunamis every country and community needs to take certain broad actions, such as assessing the tsunami hazard, producing evacuation maps and signage for at-risk areas, planning emergency responses, and raising public awareness.

"Early warning is not a slumbering system, only to be activated when the hazard emerges. Early warning is part of a continuous process of activities that strengthen the resilience of communities at risk, while developing a culture of readiness..."

"In short, disaster cannot be prevented with technological early warning systems alone...each community must pick out the warning signals, translate them into a suitable language and ensure local dissemination."

So emphasized Ms Amy Minsk, Senior Officer of the International Federation of Red Cross and Red Crescent Societies, at the 1st International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean in 2005.

The US (NTHMP) stresses that dialogue is essential between authorities, emergency managers and responders, and other local decision makers as it:

"...supports information exchange between local communities and the professional tsunami community. It solicits the input of coastal communities in defining mitigation needs and assessing priorities. It recognizes that the ultimate responsibility for sustained mitigation efforts is with the users of the coastal environment."

During 2005, preparedness building activities must focus on communities and their needs. Disaster Response Drill (top) and Coastal Police Station (bottom), Padang Indonesia, August, 2005.

Tsunami challenges for communities

The US National Tsunami Hazard Mitigation Program is a federal-state partnership whose purpose is to reduce risks from tsunamis.

NOAA, the US Geological Survey, Federal Emergency Management Agency, National Science Foundation, and five States have been collaborating to assess tsunami hazards, facilitate communication of hazard information, improve early detection of tsunamigenic earthquakes, reduce false alarms and support the mitigation efforts of at-risk communities.

The NTHMP's 1998 *Implementation plan for Tsunami Mitigation Projects*, compiled by Dr Lori Dengler of Humboldt University and referred to above, is a useful reference document for emergency planners, managers and responders, as well as communities.

In 2006, in the aftermath of the 2004 Indian Ocean tsunami, the NTHMP was expanded to include all coastal States and territories which have a potential tsunami threat in the Pacific, Gulf of Mexico, Caribbean Sea and Atlantic Ocean.

To View the US National Tsunami Hazard Mitigation Program at:
http://nthmp-history.pmel.noaa.gov/

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3.3.6 Tsunami Mitigation - 3.3.6.3 Community preparedness

Tsunami challenges for communities

While mitigating for tsunamis is similar in many ways to preparing for other natural hazards, tsunamis present particular challenges. Among these, according to the NTHMP Implementation Plan, are:

Tsunamis are very rare events

Most people have never experienced a tsunami, and so the hazard "seems remote and of less importance than more frequently reoccurring problems". This makes it difficult to secure scarce resources for tsunami mitigation and, along with inaccurate images portrayed by the media, "contributes to considerable confusion about tsunami risk and safety".

Local tsunami mitigation must rely strongly on education

Tsunamis can strike it within minutes, and often occur after an earthquake that damages infrastructure and hampers emergency response. Understanding how to respond, without official guidance, requires knowledge – from how to survive a quake and knowing a tsunami could follow to "identifying one's location as hazardous, knowing how to get to a safe area, and how long one must remain away from the coast before the danger period is over."

Tsunamis and their effects are uncertain

Tsunami science is young. Detailed inundation maps are available for few communities outside of Hawaii. Potential local tsunami sources are not fully understood. Even less is known about the interaction of tsunami waves and structures, or about the design of tsunami-resistant structures. This means that, compared to better understood hazards like earthquakes, few tools are available for effective tsunami mitigation.

Tsunami challenges for communities

Historically, tsunami mitigation efforts around the world have followed disaster. This is certainly the case in the Indian Ocean region after the 2004 tsunami. Such efforts have led to significant progress in mitigation.

The US NTHMP Plan to build community preparedness addresses five strategic planning areas -

1. Education
2. Tools for emergency managers
3. Construction, abatement and land use guidance
4. Information exchange and coordination
5. Long term tsunami mitigation

Refer [3.3.6 - 05 of 06] to view Implementation Plan for Tsunami Mitigation Projects [PDF] in the CD-ROM

The *Implementation Plan* argues that

"...the urgency of the situation often precludes a well-thought out, coordinated effort. Many post-disaster efforts wane with time, becoming less effective as memory fades, leaving the populace more vulnerable to the next event."

The purpose of the Plan is to:

"...reduce the tsunami risk to coastal communities by providing essential mitigation tools, implementing and maintaining local and regional tsunami mitigation programmes, and raising the awareness of individuals, businesses, emergency responders and decision makers at the local, state and federal levels."

Tsunami challenges for communities

The NTHMP *Implementation Plan* was an effort to provide direction and coordination for tsunami mitigation activities in the absence of disaster. Its goal is to develop tsunami resistant communities that:

- Understand the nature of the tsunami hazard.
- Have the tools needed to mitigate the tsunami risk.
- Disseminate information about the tsunami hazard.
- Exchange information with other at-risk areas.
- Institutionalize planning for a tsunami disaster.

The *Implementation Plan's* goals and objectives encourage communities to:

- Educate present and future community decision makers about tsunami hazards.
- Develop activist constituencies.
- Motivate officials and citizens to reduce risk.
- Encourage actions at the local level.
- Develop incentives to encourage risk reduction.
- Use limited resources effectively.

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Overview

Emergency planners and managers, mostly at the local level, are responsible for developing response actions for different types of tsunami bulletins. Well executed procedures will ensure that warning messages are clearly and quickly disseminated to the public.

According to the International Tsunami Information Centre, strong understanding of the various types of tsunami bulletins ensures that tsunami warning centre information is directly linked to emergency response plans. Under the current system for the Pacific and Hawaii, the PTWC issues a variety of bulletins.

These bulletin types are:

- Tsunami Information Bulletin
- Tsunami Advisory Bulletin
- Tsunami Watch Bulletin
- Tsunami Warning Bulletin
- Urgent (Local) Tsunami Warning Bulletin
- Tsunami Cancellation Bulletin

There also needs to be awareness that a country might simultaneously receive tsunami bulletins from two or three warning centres, each with different regional jurisdictions, bulletins types and criteria.

"…which may lead to confusion with the media, public and disaster response agencies. Response plans need to take this into account and work out solutions prior to the next real world tsunami event."

At the 1st International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean in 2005, Senior Officer of the International Federation of Red Cross and Red Crescent Societies, Ms Amy Minsk emphasized the following:

"Early warning systems must be understandable, trusted by and relevant to the communities, which they serve. Warnings have little value unless they reach those people most at risk – who must be trained to react to the message."

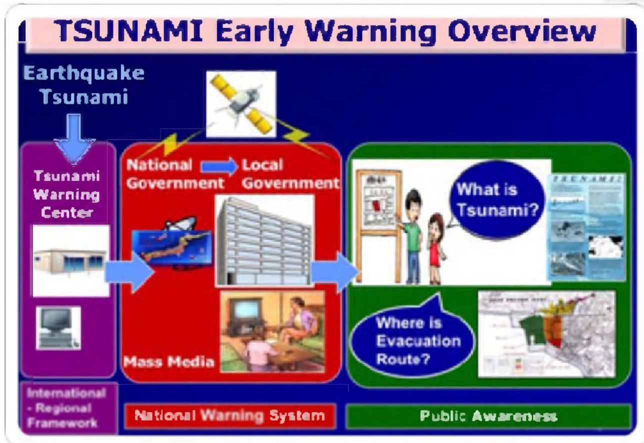
3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Once a tsunami warning is issued, the message needs to reach people rapidly.

Highly efficient notification and alert systems that use multiple communication channels ranging from sirens to police and citizen-based patrols and the mass media, have been developed by coastal communities prone to tsunamis and related hazards, like earthquakes.

In Japan, earthquake information is immediately issued by the Japan Meteorological Agency through the mass media, starting within 30 seconds of an earthquake occurrence. As more reports are received, they are immediately broadcast.

The following pages describe various ways in which tsunami warnings are disseminated to the public in several countries. They will be of interest to emergency planners and managers, as well as to businesses and community groups.



Credit: Japan Cabinet, Disaster Preparedness, Public Relations, and International Cooperation.

Hawaii – Tsunami Emergency Response After Receiving a Warning

The ITIC's Brian S Yanagi, former Earthquake and Tsunami Programme Manager for Hawaii State Civil Defense, describes Hawaii's emergency response procedures after receiving a tsunami warning as an example of an "end to end" warning and mitigation system:

"An 'end to end' system refers to the ability of the Tsunami Warning System to detect and disseminate tsunami information to the emergency management community and to the public for coastal evacuation, as ordered by Civil Defense officials."

Tsunami Status Board, Hawaii State Civil Defense Emergency Operations Center, Honolulu, Hawaii.

He defines the different types of tsunami bulletins that can be received and the various procedures that are followed once a warning is received.

Hawaii Civil Defense needs at least three hours to evacuate over 300,000 residents and tourists from its coastlines, using over 300 sirens state-wide, Civil Air Patrol aircraft and its Emergency Alert System on radio and television. GIS capabilities were used to identify critical facilities, such as schools and infrastructure, in at-risk tsunami evacuation zones.

A short film on tsunami waves and warnings in Hawaii was produced by the International Tsunami Information Centre in 2005. It describes the 1986 and 1994 tsunami warnings for Hawaii, and how authorities, the media, tourists, and residents responded.

Refer [3.3.6 - 02 of 19] to view Tsunami Emergency Response After Receiving a Warning – Hawaii State and County Civil Defense [PDF] in the CD-ROM

Refer [3.3.6 - 02 of 19] to view Hawai'i Tsunami Warnings 1986, 1994 – Waikiki and Oahu islands [video] in the CD-ROM

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Canada – British Columbia Tsunami Warning and Alert Plan

The British Columbia Provincial Emergency Program produced a tsunami warning and alert plan in 2001, identifying actions to be taken by the government to disseminate warnings to coastal communities of a potentially destructive tsunami.

The 53-page Plan describes procedures to be used in British Columbia to evaluate and disseminate information provided through the Tsunami Warning System. It acknowledges the importance of public awareness, and introduces an education programme.

Its purpose is to develop warning and dissemination procedures for British Columbia coastal communities, ships and float planes, not to outline in detail what actions they should take.

The British Columbia Tsunami Warning and Alert Plan focuses on different types of tsunami warnings and their purposes, coordination between services, and procedures for warning dissemination to the public.

A series of appendices looks at the characteristics of tsunamis and their threat to British Columbia, the Tsunami Warning System in the Pacific and the West Coast-Alaska Tsunami Warning Centre, as well as dissemination agencies. Other appendices provide locations and maps of coastal communities at risk, outlines of tsunami warning exercises and hazard mitigation, and components of British Columbia's Tsunami Mitigation Strategy.

Refer [3.3.6 - 02 of 19] to view the British Columbia Tsunami Warning and Alert Plan [PDF] in the CD-ROM

Tsunami Warning Systems and Procedures – Guidance for Local Officials

Local officials are the primary target of a comprehensive booklet on local tsunami warning public notification systems and procedures prepared by Oregon Emergency Management for the National Tsunami Hazard Mitigation Program of NOAA in 2001.

The purpose of *Tsunami Warning Systems and Procedures – Guidance for Local Officials* is to assist coastal authorities in planning and developing warning procedures for their areas.

The Oregon booklet covers general tsunami information, and describes the Pacific, West Coast-Alaska and Chile Tsunami Warning Centres and their roles in tsunami detection, warning and local notification processes

The guide differentiates between “systems” and “procedures,” defining them as follows:

Systems

The hardware to alert people to evacuate to high ground. These systems can also be used for other hazards, prompting people to turn on the radio or television for information on whether to evacuate or take other protective action. Tsunami alerts should be incorporated into a jurisdiction’s all-hazards warning system.

Procedures

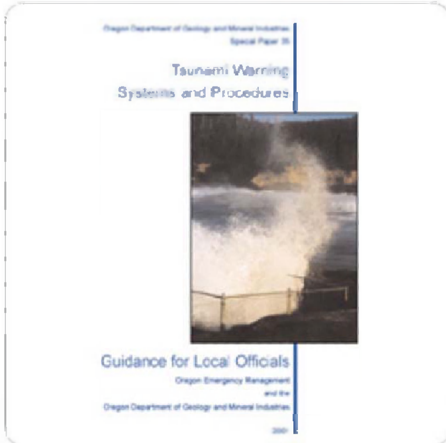
The protocols followed to activate the systems. The booklet describes two types of warning systems and procedures. One is warnings from Tsunami Warning Centers in Hawaii and Alaska that a tsunami has been generated; the other is notification that evacuation from low-lying areas is necessary.

It also outlines existing notification systems from different countries, including Japan, and the US states of Hawaii, Alaska, California, Oregon and Washington – and describes in detail various evacuation notification systems and their associated procedures.

The booklet stresses that no one evacuation notification system is best for all coastal areas, as different communities have distinct characteristics. Several factors must be considered when deciding what system is best for an area:

- The size and layout of the area. Is it compact or spread out? Is it adjacent to a beach or to a harbour?
- The make-up and activities of the population. Is the town mostly retirees? Is there a large transient population? Are people mainly on the beach or in or near the bay?
- The financial resources of the community.
- Any existing notification systems in each jurisdiction as well as in adjacent cities or areas. Is there a need for system consistency within a jurisdiction and between other jurisdictions and regional govern ments?

It outlines the pros and cons of a variety of options to help local officials make decisions.



Refer [3.3.6 - 05 of 19] to view Tsunami Warning Systems and Procedures – Guidance for Local Officials [PDF] in the CD-ROM

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Hawaii – When Can the Public Return? "All-Clear"

Once the public has evacuated a coastline, public officials must also provide information to inform everyone when it is safe to return. This is a simple, but very important concept and it must be very clearly understood by the public.

In Hawaii, a tsunami "All Clear" broadcast is used to convey that it is safe to return to the coast. The broadcast is initiated by local authorities over television, radio and other means, after inspection of impacted coastlines.

If an area has received little or no damage from tsunami waves, an "All Clear" can be issued within hours after a Tsunami Warning cancellation. However, if an area has been severely damaged by a tsunami, it can be many hours or days before communities are allowed back to coastlines, because debris may make roads impassable, gas and electric lines may be down and pose dangers to safety, and search and rescue operations may be carried out.

While sirens are used to alert the public to prepare for an emergency and possible evacuation, they are not used to signal an "All-Clear."

The "All Clear" is issued by local authorities some time after the cancellation of a Tsunami Warning or Watch. (It should not be confused with Warning or Watch cancellations, which are issued by the Tsunami Warning Centre.)

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Alerting the Public – How?

"… Sustainable communications are the backbone for early warning…Every economy and community has different requirements and different challenges. There is no single solution, but all solutions must work together."

Those are the words of Kelly Sponberg of RANET, a programme started in Africa in 1999 with the goal of providing environmental information to rural communities. He noted further that complementarity of solutions is necessary, and that technologies should build on existing capacities and be developed, embedded and owned by local people.

Ultimately, the success on any tsunami early warning system will be measured by its ability to move people out of harms way before the first wave hits.

Detection networks to measure earthquakes and tsunamis allow officials to determine the tsunami threat and provide the earliest possible warning – but the key is make sure every person on the coast gets the message and moves inland or to higher ground to escape the destructive waves.

Many different means are available for alerting, and all are effective in reaching segments of populations.

Some require high levels of technology and communications infrastructure to ensure reliable satellite broadcasts that reach 100 percent of the inundation zone, while others – such as Bangladesh's Cyclone Early Warning System – use simple means that include bicycles and loudspeakers to communicate the warning.

Finally, and especially for local tsunamis, there are many stories which recount the life-saving role that traditional knowledge and oral history have played, enabling villagers to recognize natural tsunami warning signals and immediately evacuate.

Alerting the public – NOAA Weather Radio Emergency Information Network

The NOAA Weather Radio (NWR) Emergency Information Network provides a good example of an all-hazards approach to public alerts and notification that communicates disaster messages rapidly and comprehensively to the public.

It provides state and local officials with the capacity to address any hazardous situation around the clock.

With the support of the public and private sectors, NWRs have been placed in critical facilities such as hospitals, police and fire stations, schools and business operations centres. NWR receivers can also be placed in homes, to enable local residents to directly tie into the information network.

The Network is backed up by an All Hazard Alert Broadcasting (AHAB) Radio that, it says, “fills that void of rapid notification to areas that are high traffic or require outdoor notification”.

Refer [3.3.6 - 08 of 19] to read more about how the Washington State has used the NOAA Weather Radio Emergency Information Network and the All Hazard Alert Broadcasting (AHAB) Radio to reach people on the beach. [PDF] in the CD-ROM

Alerting the public – Sirens (AHAB)

Through public and private partnerships, Washington State has developed the All-Hazard Alert Broadcasting (AHAB) Radio to provide immediate alert and warning notification to citizens, and to give emergency managers the ability to disseminate real-time emergency information quickly and effectively.

AHAB Radio provides both tone and voice alert capability and uses several communication protocols that allow national, state and local authorities to activate the system for watches, warnings and evacuation orders. It can be designed to meet alert and notification requirements for any hazard.

Among the many advantages of the flexible AHAB Radio are:

1. Installation at high-risk facilities or in areas highly trafficked by both the public and private sectors, and that are prone to natural and man-made hazards.
2. Installation in areas where no power is available, such as a beachhead. It can be wind powered, solar powered or can use commercial electrical power.
3. Indoor and outdoor alerting capabilities via installed speakers, or by interfacing with existing Public Address Systems. The system uses high-power speakers for both voice and tone alerting that produces 360 degree coverage and the best voice reproduction of any omni-directional system. Voice capabilities can take away the confusion as to what the notification is for, and what actions need to be taken.
4. Use of a distinct blue strobe light to provide a visual extension of the warning signal for the hearing-impaired and in areas of high ambient noise. The strobe light is UL Listed as “Visual Signaling Equipment for Hearing Impaired” (UL1971) and com plies with America’s Disabilities Act requirements when properly installed. The light remains lit for the duration of the activation.

Refer [3.3.6 - 09 of 19] to view a description of the All Hazard Alert Broadcasting (AHAB) Radio [PDF] in the CD-ROM

Alerting the public – The role of the mass media

The media is crucial to the rapid dissemination of tsunami warnings. News media can provide effective communication channels that immediately reach a broad segment of the population.

In Japan, earthquake intensity information is broadcast as an information crawler on television screens within a minute of an earthquake occurring. For this, the Japan Meteorological Agency has well-coordinated working procedures with the Japan Broadcasting System (NHK) that automatically and seamlessly insert earthquake and tsunami information upon receipt from the warning centre.

In Hawaii, the State and County Civil Defense Agencies, the National Weather Service, and the Pacific Tsunami Warning Center work closely to immediately activate the State Emergency Alert System (EAS). Through the EAS, sirens are sounded, television crawlers are broadcast, and voice alerts are communicated through radio stations.

These systems are exercised regularly through drills and exercises in order to ensure that the public safety system goes into action immediately and carries out pre-planned responses that start within seconds of the triggering of alarms in warning centres.

Refer [3.3.6 - 10 of 19] to view media broadcasts of tsunami warnings in Hawaii [vedio] in the CD-ROM

An Emergency Alert System immediately broadcasts warnings through multiple methods to the public.

Alerting the public – Bangladesh Cyclone Preparedness Programme and warning dissemination

In Bangladesh, it is estimated that more than 775,000 people have died in coastal areas and offshore islands since 1775 from cyclones and storm surge disasters, due to an inadequate early warning and preparedness system.

Starting after 500,000 people died in a major November 1970 cyclone, and through the 1990s International Decade for Natural Disaster Reduction, Bangladesh has continually improved its Cyclone Preparedness Programme (CPP) and early warning system. By May 1997, when another big cyclone struck, a million people were evacuated and only 193 people died.

The early warning system focuses on the use of an advanced detection system to forecast weather, dissemination of cyclone warnings to communities and vulnerable citizens frequently through radio and television, and local alerting using trained CPP volunteers with through bicycles, loudspeakers and mosque Imams.

Presently, the CPP covers 11 districts reaching about eight million people through more than 140 wireless stations.

More than 1,600 cyclone shelters have been built to accommodate 1.3 million people, with a further 2.3 million people taking refuge in school and office buildings – and these measures are still considered a minimum since more than 15 million people are potentially at risk.

Cyclone reports are issued through High-Frequency Radio Stations operated by volunteers along the coast. More than 35,000 trained volunteers are ultimately notified to take action in local villages using megaphones and hand-cranked sirens.

The coordinated dissemination and response system under the Ministry of Food and Disaster Management is triggered by warnings issued by a forecasting centre operated by the Bangladesh Meteorological Department. The early warning response involves local administrations, Port Authorities, the Armed Forces Division, Disaster Management Bureau, Directorate of Relief and Rehabilitation, other responsible ministries and departments, and the CPP and Bangladesh Red Crescent Society.

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

In the future, Disaster Management Information Centres (DMICs) at the District level are planned to facilitate multi-channel communication means to reach people at risk.

Bangladesh Cyclone shelter.

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Alerting the public – Sustainable solutions

Delivery of environmental information through RANET

RANET (Radio and Internet) is an international collaboration* with the goal of making hydro-meteorological and climate-related information available to rural populations, to aid their day-to-day resource decisions and preparations against natural hazards.

The programme combines innovative technologies with appropriate applications and partnerships at the community level, in order to ensure that the networks it creates serve the full spectrum of community information needs.

Community ownership and partnership is the core principle of RANET's sustainability strategy.

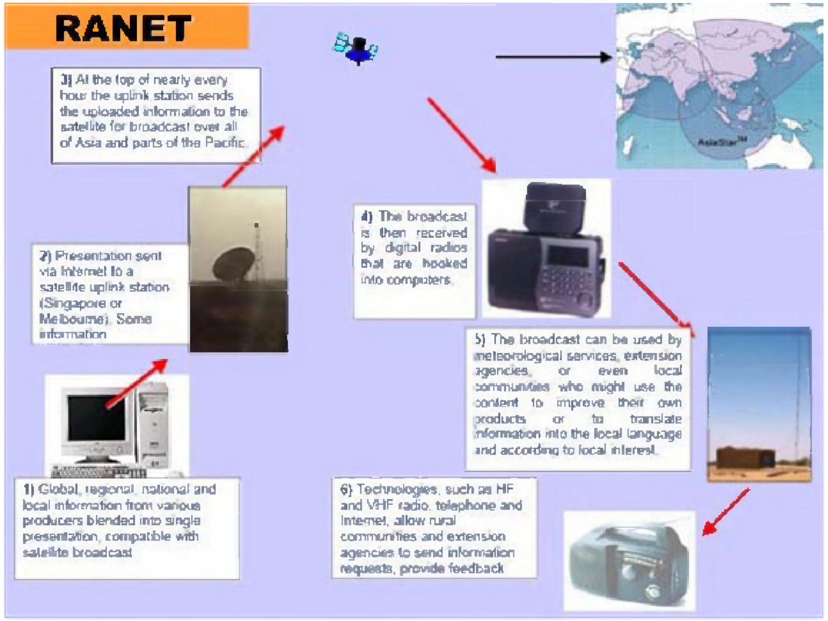
The RANET programme addresses its core objectives by applying technologies that can bridge and extend existing dissemination networks, by providing training on the use of information and maintenance of networks, and by developing community-based dialogue on issues related to weather and climate. It works to identify and train partners in the use of technologies that are appropriate to their information needs and serviceable in their area.

RANET is often associated with the use of the WorldSpace digital satellite system, which enables audio and one-way multimedia (data) transfers to anywhere in Africa, Asia and the western Pacific via satellite receiver systems no more expensive than a quality FM stereo.

Each node receiving the broadcast is some 10 to 30 times less expensive than other satellite based systems.

The networks RANET develops, however, are not limited to satellite systems. The programme works with a variety of partners to standardize appropriate FM community radio station equipment, HF systems, and even energy solutions such as solar and wind.

Primary program support and management occurs through regional centers in Africa, Asia and the Pacific, with the backing of the USAID Office of Foreign Disaster Assistance, the NOAA Office of Global Programs, and the NOAA-NWS International Activities Office. Significant technical and network support has been provided by First Voice International, Wantok Enterprises Limited, the FreePlay Foundation, and Volunteers In Technical Assistance. Additional funding and content support has been made available through Meteo-France, the UK Met Office, National Meteorological Service of Spain, French Embassy of Niger, United States Embassy of Niger, FAO, UNDP and SNV.



RANET information are uplinked to the AsiaStar satellite and broadcast down where they are receive through a number of different receivers including radio, computers, and the Internet.

Refer [3.3.6 - 12 of 19] to view Click here to view a Summary of RANET [WORD Doc] in the CD-ROM

View the RANET web site at:

http://www.ranetproject.net/

View the video on RANET in Zambia, Africa at:

http://www.ranetproject.net/video/index.html

Delivery of environmental information through RANET

RANET programmes are designed to enable communities potentially to reduce their vulnerability to and the impact of natural hazards and climate variations, based on the delivery of forecasts, observations, bulletins and warnings through locally owned infrastructure that is also able to carry other humanitarian and development information.

Since 2003, the ITIC has discussed with RANET the possibility of disseminating time-critical tsunami warnings to the Pacific. In early 2005, in the aftermath of the 2004 Indian Ocean tsunami, the ITIC requested and RANET made available a simple SMS heads-up alert to national governments of Pacific Tsunami Warning Center official tsunami messages.

In 2006, RANET worked to enable services which will provide time-critical broadcasts of international and national tsunami warnings to rural and remote communities in Pacific and Indian Ocean countries, through the WMO's Global Telecommunications System (GTS) and the NOAA NWS Emergency Managers Weather Information Network (EMWIN).

The proposed system would allow each country to designate a specific header for national tsunami warnings that would be broadcast by the NMHS and received by local receivers hooked up to EMWIN software. for displaying customer-selected headers.

Such warnings would be broadcast under the RANET system through the Worldspace AfriStar and AsiaStar satellites at high priority. Further dissemination to remote communities would be carried out through HF or community radio-internet, and other sustainable technologies.

EMWIN is a nonproprietary operational dissemination system developed by the NOAA NWS Office of Operational Systems for the emergency management community. It consists of a suite of data access methods that make available a live stream of weather and other critical emergency information through a continuous, dedicated low speed data broadcast using an audio signal from the GOES satellite or terrestrial re-transmitter.

The EMWIN data stream currently includes real-time weather warnings, watches, advisories and forecasts, and has the ability to carry graphical products. End user software provides a friendly environment to, among other things, monitor the weather, set alarms, or auto-print from a personal computer.

Local radio dissemination of information following receipt of e-mail through RANET broadcast.

Refer [3.3.6 - 13 of 19] to* view a WMO Report on the use of EMWIN and RANET for weather- and water-related information dissemination *[PDF] in the CD-ROM

Alerting the public – Sustainable solutions
India Village Knowledge Centres

Since 1992, the MS Swaminathan Research Foundation has been working in Tamil Nadu and Pondicherry to establish Village Knowledge Centres (VKC) as focal points for providing information and knowledge to villagers on various issues such as fish movement, height of waves, weather forecasts, health, education, agriculture and other community activities.

The VKCs provide resources such as computers, printers, telephones, high-frequency radio services, internet access and other communication devices, for villagers to use. Training is provided on basic skills such as operating computers, dissemination of local information to other centres, and transfer of voice from the hub to a Public Address System. Every interested villager may participate and use the technology to build and share knowledge.

An example of how technology is building capacity and empowerment at the community level was provided by the 2004 Indian Ocean tsunami.

In Verampattinam village in Tamil Nadu, India, fishermen who noticed abnormal sea behaviour ran to the Village Knowledge Centre, broke the lock on the door, and without delay used the Public Address System to warn everyone to evacuate and run from the sea. Only five people died from the tsunami. The actions by the fishermen, and the ability to broadcast information through the VKC, were credited for saving many lives.

Information hubs or Focal Centres linking three or four villages along the coast of Tamil Nadu are now being established to build greater awareness of disaster preparedness among community members, and they are an excellent example of how technology and access to information can improve the daily lives of villagers.

Mission 2007 will create a network of information kiosks in 600,000 villages in India by 15th August 2007. View to find out more:

http://www.mission2007.org/

View to find out more about community success stories at

http://www.disasterwatch.net/Best%20Practices/MSSRF.htm

Refer [3.3.6 - 14 of 19] to view Click here to read the article [PDF] in the CD-ROM

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Alerting the public – Other considerations

Communicating alerts to the public can be accomplished in a number of ways and many commercial solutions are available, including radio stations, television, internet and e-mail.

The popular use and widespread availability of cellular mobile voice and text message technology globally also offers an attractive means of reaching many people in a short time.

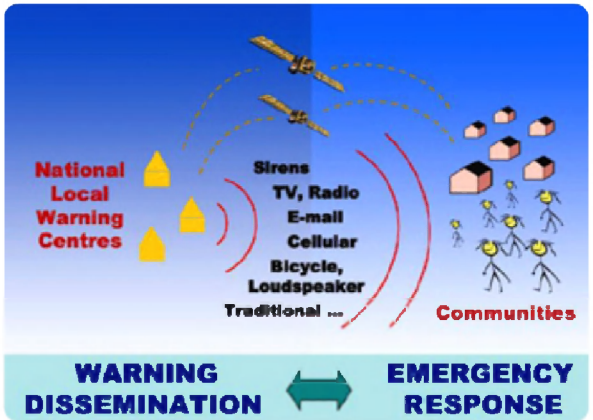
In general, however, governments must be careful to ensure that official alert notifications are robust and reliable – they must reach everyone immediately, always work and be available and ready to broadcast within seconds.

Methods of communication through different media and in different formats need to be implemented. Governments must also make provision to effectively reach populations with special information requirements, such as those who are unable to read, hear or walk.

The ITIC notes particular concern over the use of commercial mobile services for the dissemination of emergency alerts.

Without close cooperation and agreement between an authority and a local service provider for emergency priority of a broadcast, use of dedicated frequencies for transmission, and a means to assure that a message is authorized and authentic, it is easy to imagine that networks will become saturated after initial news of a disaster, and that hoaxes could compromise the integrity of the early warning system.

Additionally, mobile service is often not guaranteed at high signal levels to enable 100 percent coverage, underscoring the importance and necessity of multiple means of alert notification that are complementary in nature.



The dissemination of warnings should be broadcast through a number of different media, and be timely and understandable to ensure that people know what to do when a tsunami emergency occurs.

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Alerting vessels at sea – SOLAS vessels

The Global Maritime Distress and Safety System (GMDSS) is an integrated communications system implemented by the International Maritime Organization (IMO) to ensure that no matter where a commercial ship is in distress, aid can be dispatched.

The System also ensures the provision of Maritime Safety Information (MSI) – both meteorological and navigational – on a global basis at sea.

From 1 February 1999 all SOLAS vessels (passenger and all cargo ships of 300 gross tonnage and upwards) have had to comply with the GMDSS, and be fitted with all applicable GMDSS communications equipment (International NAVTEX and-or SafetyNET Inmarsat), according to the sea areas in which the ship operates.

The Joint IOC-WMO Commission for Oceanography and Marine Meteorology (JCOMM) is responsible for coordinating the provision of meteorological information within this framework. The provision of useful tsunami warnings for ships in ports or in coastal waters (or who may plan to sail in threatened areas), both for SOLAS and non-SOLAS vessels, is clearly needed.

Since February 2005, the IMO has authorized the direct dissemination of tsunami warnings by tsunami warning centres through the SafetyNET communication system. SafetyNET is available to mariners and also, if needed and applicable, to local government offices in regions expected to be affected (COMSAR/Circ 36).

International marine organizations, the IOC, and a number of countries are looking to establish protocols and content standards for tsunami warning bulletins to vessels, and on what training and guidance is needed, to promote vessel safety during tsunamis.

To assure efficiency and consistency in the provision of the information through the GMDSS, coordination with the Issuing Meteorological Services Area will be essential.

Harbor port of Calais, France

Alerting vessels at sea – Recreational boaters

Unlike commercial vessels, recreational boaters and fishermen are usually not required to have navigational and communication equipment aboard, although often at least a minimum means of communication and other safety equipment are carried.

In general, marine broadcasts of sea conditions are issued by official national and local meteorological or weather offices. But there are no official tsunami warnings for boaters.

The International Tsunami Information Centre provides the following advice to people on boats:

- Since tsunami waves cannot be seen in the open ocean, do not return to port if you are at sea and a tsunami warning has been issued. Port facilities may become damaged and hazardous with debris. Listen to mariner radio reports when it is safe to return to port.
- Tsunamis can cause rapid changes in water level and unpredictable dangerous currents that are magnified in ports and harbors. Damaging wave activity can continue for many hours following initial tsunami impact. Contact the harbor authority or listen to mariner radio reports. Make sure that conditions in the harbor are safe for navigation and berthing.
- Boats are safer from tsunami damage while in the deep ocean (>200 fathoms, 1200 ft, 400 m) rather than moored in a harbor. But, do not risk your life and attempt to motor your boat into deep water if it is too close to wave arrival time. Anticipate slowdowns caused by traffic gridlock and hundreds of other boaters heading out to sea.
- For a locally-generated tsunami, there will be no time to motor a boat into deep water because waves can come ashore within minutes. Leave your boat at the pier and physically move to higher ground.
- For a tele-tsunami generated far way, there will be more time (one or more hours) to deploy a boat. Listen for official tsunami wave arrival time estimates and plan accordingly.
- Most large harbors and ports are under the control of a harbor authority and/or a vessel traffic system. These authorities direct operations during periods of increased readiness, including the forced movement of vessels if deemed necessary. Keep in contact with authorities when tsunami warnings are issued.

Harbors often share facilities with both commercial ships and recreational boaters, underscoring the importance of coordination and awareness. Nha Trang, Vietnam.

Refer [3.3.6 - 17 of 19] to view Click here to read TIC's Safety Advice.Sensing a Tsunami [PDF] in the CD-ROM

Refer [3.3.6 - 17 of 19] to view TIC's Safety Advice.Tsunami preparedness [PDF] in the CD-ROM

Refer [3.3.6 - 17 of 19] to view TIC's Safety Advice.Tsunami Safety for boaters [PDF] in the CD-ROM

Refer [3.3.6 - 17 of 19] to view TIC's Safety Advice.Tsunami Safety Rules [PDF] in the CD-ROM

Social Perspectives – Public perceptions of tsunami warnings

Social science plays an important role in ensuring that warnings are understandable to vulnerable communities. Clearly, early warning against attacking tsunamis will save lives – but discussions are still taking place as to the most effective methods of communicating warnings so that people immediately respond by evacuating to safety.

Dr David Johnston of New Zealand, Dr Douglas Paton of Australia, Dr Dennis Mileti of the United States and others have tried to understand how the public responds to warnings using a risk communication model sequence described as "hear-confirm-understand-believe-personalize-respond".

Add caption under photo, "The Pacific Tsunami Museum in Hilo, Hawaii, raises public awareness through photo display of historic tsunami events.

Many factors influence how a person will respond and how fast they will act, including their age, gender, level of education and the perceived threat. This is especially relevant to tsunamis, which are infrequent and thus appear to require further authentification before an individual believes the risk is real enough to act.

In 2003, Dr Paton and his colleagues proposed a social-cognitive model in which four factors influence a person's reaction time and response to a warning:

Refer [3.3.6 - 17 of 19] to view ISDR issues paper on Women, disaster reduction and sustainable development, including early warning [PDF] in the CD-ROM

Perceived responsibility

Given my knowledge and awareness, will the hazard seriously threaten my personal safety, or not?

Response efficacy

Given meaningful information, am I prepared for and do I know how to respond? Are there trusted institutions that will carry out their jobs in a competent manner?

Sense of community

Has there been community-level disaster preparedness so the response is well-known and expected of every citizen?

The timing of the next tsunami or the last tsunami

When was the last time a tsunami hit, and what did it do to my community. The longer the time interval between tsunami, the longer it may take for a person to respond.

3.3.6 Tsunami Mitigation - 3.3.6.4 Tsunami Notification Procedures

Social Perspectives – Public Perceptions on Tsunami Warnings

In a number of studies, surveys and interviews on perceptions of warnings to natural hazards, including tsunamis and volcano eruptions, scientists are finding poor linkages between awareness, risk perception and preparedness.

Put simply, people appear to know what a tsunami is and what tsunami dangers are, but are not willing to respond immediately to alerts from authorities.

In a recent Hawaii study, Dr Chris Gregg and his colleagues focused on whether siren soundings, which are used to alert the population to an emergency, evoke an immediate and appropriate response for tsunamis.

Using surveys and follow-up interviews, they disturbingly found that while awareness of siren tests and test frequency was high, they do not appear to be equated with an increased understanding of the meaning of the siren.

The implication is that much work needs to be done by emergency authorities, even in Hawaii where sirens have been in operation for more 45 years, to increase public understanding of, and effective response to, sirens.

A sign board in a local hotel in Hilo, Hawaii warning against tsunamis.

Refer [3.3.6 - 19 of 19] to access Natural Warning Signs of Tsunamis: Human Sensory Experience and Response to the December 26, 2004 Earthquake and Tsunami, Thailand [PDF] in the CD-ROM

Refer [3.3.6 - 19 of 19] to view* the article Tsunami Warnings: Understanding in Hawai'i *[PDF] in the CD-ROM

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

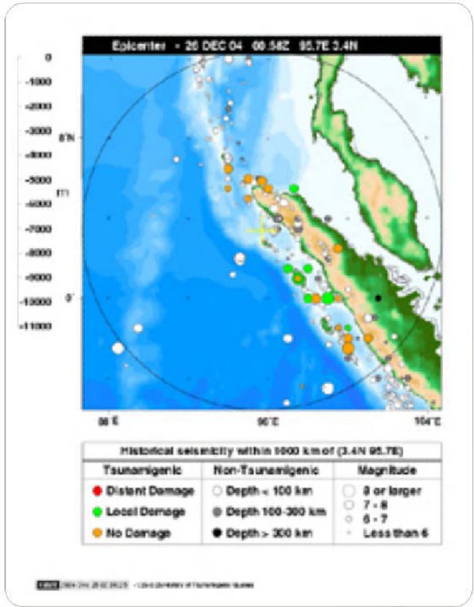
Overview

One of the cornerstones of tsunami mitigation is hazard assessment. Through this process, vulnerable coastal areas are identified and mapped, and the potential risk to the people who live there is understood.

Hazard maps require knowledge of the historical tsunami record in order to estimate the probability that a tsunami will occur in the future. Wherever there is a chance that a large, shallow, undersea earthquake might occur, there is a chance for a tsunami to be generated.

A new science that looks for tsunami sediments in areas where no human documentation exists, is helping to extend the tsunami historical record back in time so that more realistic hazard potentials can be calculated.

Maps outlining tsunami inundation zones – areas likely to be flooded by the great waves – can assist planners and decision makers in designating evacuation zones and routes to safety.



Historical tsunami hazard map for northern Sumatra, Indonesia. Prior to the December 2004 tsunami (earthquake epicenter marked by cross), the region had only experienced locally-damaging tsunamis. Source: PTWC

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

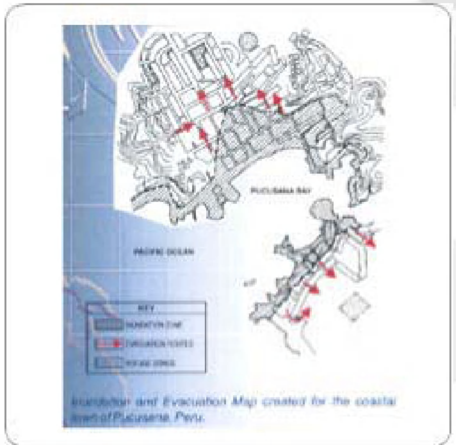
Overview

Tsunami inundation maps are created by scientists who conduct numerical modeling studies to estimate the maximum extent of flooding, based on worst-case scenarios and historical observations of tsunami impact.

Better numerical models and faster computers, combined with the availability of more tsunami observations collected during Post-Tsunami Surveys in the 1990s and 2000s, are allowing scientists to produce more realistic estimates of tsunami inundation and run-up.

Maps outlining tsunami evacuation routes to higher ground can be used to communicate life-saving actions to the public effectively. Evacuation maps are best developed in a cooperative manner involving people who live in affected communities, scientists familiar with the hazard, local geology, inundation maps and local emergency response officials.

At-risk coastal communities in Japan and the United States, including Hawaii, are working hard to achieve these steps in the mitigation process – and they have a lot to offer national and local governments that are looking to develop this crucial aspect of mitigation.



Inundation and Evacuation Map created for the coastal town of Pecusana, Peru.

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Tsunami hazards

In order to reduce the risks from tsunamis, each country must have a good knowledge of its tsunami hazard.

Documentation of the hazard requires identifying known historical and pre-historical tsunamis, and the expected or probable occurrence of tsunamis in the future based on numerical or statistical estimates. A tsunami hazard study should include listings of:

- Tsunami sources, including those from earthquakes, volcanoes and landslides.
- Tsunami impacts caused by the tsunami sources.

Such data can be compiled from

- Historical databases and tsunami catalogues held by the World Data Center for Tsunamis, NOAA National Geophysical Data Center, International Tsunami Information Center, Novosibirsk Tsunami Laboratory, and national data centres.
- Local sources such as archives, newspapers, survey reports, event logs, journals, oral history and personal interviews.
- Paleotsunami research and scientific studies of coastal deposits or evidence of uplift.
- Post-tsunami surveys collecting inundation and run-up data immediately after a tsunami
- Numerical modeling studies using likely tsunami source scenarios to numerically estimate tsunami coastal impacts.

In addition to being used to develop tsunami flooding and evacuation maps as part of a country's tsunami preparedness programmme, this kind of information is crucial to regional and national tsunami warning centres, which base warning alert criteria on the potential tsunami hazard for a coast.

View the NOAA National Geophysical Data Center's Historical Tsunami Database at:

http://www.ngdc.noaa.gov/seg/hazard/tsu_db.shtml

View the Russia's Novosibirsk Tsunami Laboratory's Interactive Tsunami Database at:

http://tsun.sscc.ru/tsulab/On_line_Cat.htm

Thanks to advancements in internet and mapping technology in recent years, data that have been previously available only in textual form are now graphically represented using internet map viewers.

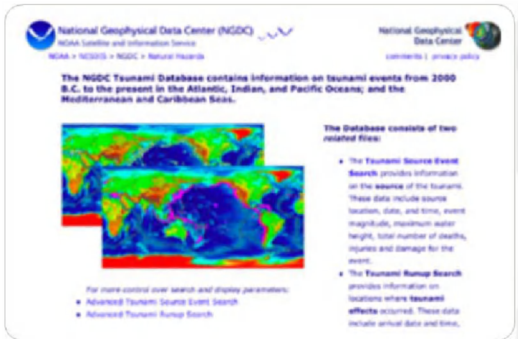
Two examples of internet map viewers focusing on natural hazards:

View NOAA NGDC Natural Hazards Viewer at:

http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml

View the Pacific Disaster Center's Asia Pacific Natural Hazards and Vulnerabilities Atlas viewer at:

http://www.pdc.org/atlas/html/atlas-init.jsp



NOAA National Geophysical Data Center website.

Tsunami hazard assessment

The conduct of a tsunami hazard assessment study involves many activities.

To identify coastal vulnerability, numerical simulation activities for inundation or flood, and run-up maps are often conducted using worst case tsunami source scenarios to determine impact.

Final inundation and run-up maps, which present the results of scientific modeling studies, should reference and be consistent with all observational data collected for the area.

Emergency officials use expected maximum tsunami flooding maps to develop evacuation zone maps to guide public safety following a tsunami warning. Evacuation maps represent the end public product, and are typically developed to cover local jurisdictions.

Refer [3.3.6 - 19 of 19] to view an example of a tsunami modeling study carried out by NOAA's Pacific Marine Environmental Laboratory, and the Joint Institute for the Study of the Atmosphere and Ocean entitled: NOAA TIME Seattle Tsunami Mapping Project: Procedures, Data Sources, and products.[PDF] in the CD-ROM

Activities involved in hazard assessment:

- Compiling a country's complete catalogue of earthquakes and tsunamis.
- Understanding local and regional geology and tectonics that cause tsunamis.
- Identifying hazardous tsunami source areas (local, regional or distant) and their tsunami-generating mechanism (earthquake, landslide or volcanic eruption).
- Identifying vulnerable coastal locations from sources (historical or expected).

Questions that should be answered:

- What is the likelihood of earthquake and tsunami occurrence?
- What is the expected earthquake impact? Local earthquakes, which cause local tsunamis, add to the complexity of risk analysis since the effects of strong seismic shaking on the environment and structures need to be taken into account.
- What is the expected tsunami impact along the coast?

Paleotsunami research extends the tsunami historical record

Tsunamis occur throughout the world's oceans on both human historical and geologic time scales. More than 2,000 tsunamis have been described over that last 4,000 years, and many more prehistoric events are now being inferred from data collected by studying tsunami deposits.

When tsunamis hit the shore, the large waves carry sediments and other debris that are then deposited as distinct stratigraphic layers, visually obvious among soil sedimentary layers deposited during quiescent times. One of the characteristics of tsunami deposits is that the grains within layers are often unsorted by gravity and angular in shape, because of being transported quickly and dropped suddenly by high-energy waves.

Tsunami deposits have been used to extend the tsunami historical record back in time, and their study is especially important for tsunami hazard and risk assessments that seek to quantify the occurrence, recurrence intervals, and size estimates of past events. Deposits have been documented from earthquake, landslide and volcanic eruptions around the world.

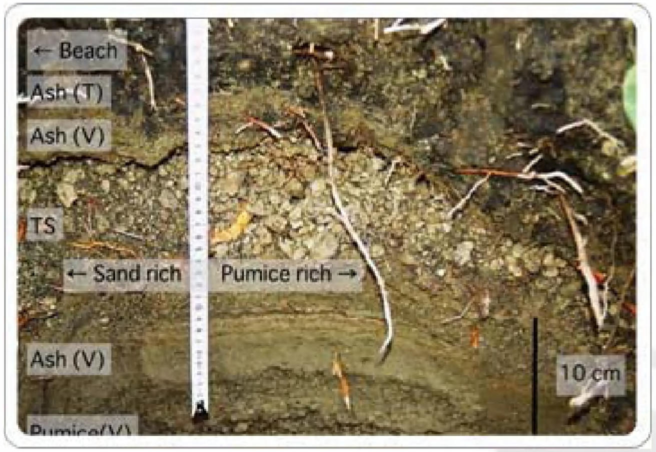
Similarly-dated deposits at different locations, sometimes across ocean basins and far from the tsunami source, are being used to infer and map the distribution of tsunami inundation and impact.

Starting in 1985, geologist Dr Brian Atwater of the US Geological Survey, began finding and mapping sedimentary layers around Puget Sound, Washington, and from British Columbia to northern California in the Pacific Northwest, which suggested that a Cascadia Subduction Zone great earthquake had generated a huge local tsunami.

In collaboration with Dr Kenji Satake, of the Geological Survey of Japan, historical documents in Japanese were found which revealed that a magnitude 9.0 earthquake had occurred on 26 January 1700. Together, they linked the two pieces of evidence to conclude that a Pacific-wide tsunami was generated off the Pacific Northwest coast of North America that left deposits in northern Japan and elsewhere.

Since this landmark study, much work has been carried out to map tsunami deposits along the coasts of South America, northern Japan, the Kuriles and Kamchatka subduction zones, revealing the occurrence of larger tsunamis in pre-history than in known history.

Tsunami deposits also have enormous potential as recorders of flow depth and velocity, which are important to coastal engineers modeling tsunami impact, and sediment transport and scour on coastal structures.



Tsunami sediment layer (TS) can be easily seen, 1994 Rabaul Volcano eruption and tsunami, Papua New Guinea. Credit: Y. Nishimura, Hokkaido University.

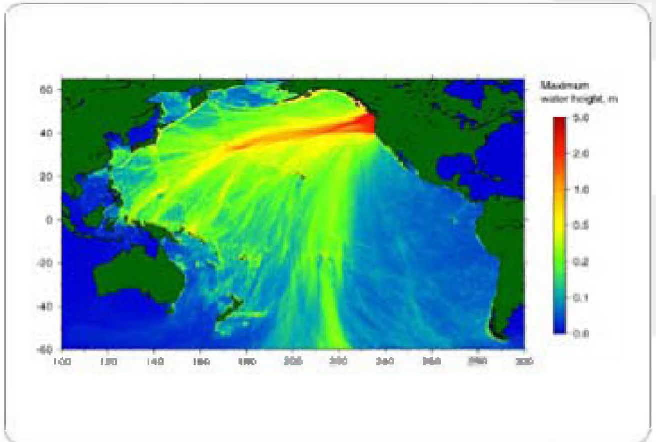
Scientists examining deposits from Mt. Komagatake tsunami, Sapporo, Japan.

Applications and Use of Tsunami Numerical Modeling

A PowerPoint presentation introducing numerical modeling has been compiled by the ITIC from materials presented by Dr Fumihiko Imamura of Tohoku University, Dr Costas Synolakis of the University of Southern California, and Gaye Downes of the Institute of Geological and Nuclear Science, New Zealand. It covers the following topics:

- When modeling is necessary.
- What modeling provides answers to.
- Steps in conducting modeling, for example source parameterization, tsunami propagation, and coastal inundation.
- Different methods for conducting modeling.
- How modeling results are applied to estimate tsunami damage and hazard, and are used in decision making.

Refer [3.3.6 - 6 of 19] to view Applications and Use of Numerical Modeling Part 1,Part 2,Part ,Part4 [PDF] in the CD-ROM



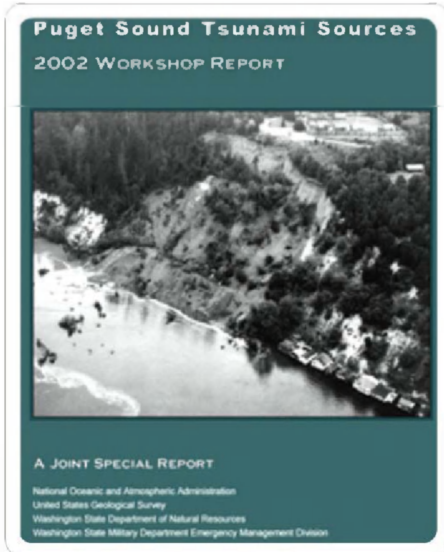
Example of tsunami numerical modeling of Cascadia Subduction Zone.
Credit: K. Satake, Geological Survey of Japan.

Tsunami numerical modeling – Analysis of risk

At the 1st International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean, convened by UNESCO-IOC and held from 3 to 8 March 2005 in Paris, technical delegates identified the key mitigation elements requiring hazard and risk modeling.

They include the needs to:

- Develop maps of extreme or maximum run-up and impact.
- Develop maps of probabilities of different run-ups and impacts.
- Focus initially on earthquake and volcanic source in subduction zones in the ocean.
- Focus initially on identifying regions of higher hazard (such as headlands and bays), which can be done without detailed bathymetry or topography data.
- Develop models to capture impact, as well as uncertainty and variability, in hazard zones and risk to communities.



Credible tsunami scenarios developed by scientists and government officials are needed to prepared tsunami simulations. A team of NOAA, US Geological Survey and State Officials worked to agree on the characteristics of a M9+ Cascadia earthquake and other tsunami sources in the Pacific Northwest.

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Tsunami analysis and simulation

For tsunami analysis and simulation, delegates at the Indian Ocean meeting noted that the two components needed are:

- A base, regional scale model of an ocean basin, developed as a matter of priority.
- A detailed model, incorporating near-shore run-up and inundation, which will evolve as data and models improve.

The delegates made further reference to the model developments noting that:

The base model

- Should be developed using consensus hydrodynamic models such as UNESCO-IOC's TIME, which are valid for deep water to around 200 metres (over 600 feet) in depth.
- Should focus initially on earthquake sources.
- Is limited by lack of detailed bathymetric data and tsunami source information (such as an earthquake, landslide or volcano).
- Needs detailed seismic and bottom surveys in these zones, to help determine the possible source displacement.
- Will need to be expanded to incorporate collateral damage from an earthquake, volcano or landslide.

The detailed model

- Can be developed using existing wave run-up and inundation models (for example, ADCIRC).
- Will enable tsunami impact to be captured as part of the warning process.
- Needs to be interfaced with the base model at the regional and national level.
- Requires better bathymetry (<200 metre depth) and topography data to be acquired at the local level.
- Requires training, expert assistance and guidelines to implement at national or local centres.
- Can be improved by developing new models specifically for tsunami use.

Refer [3.3.6 - 08 of 19] to view the Summary Report of the Tsunami Modeling Working Group at the 1st International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework. [PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Developing national capacities for tsunami numerical modeling

Tsunami evacuation sign, Japan.

Internationally, the Tsunami Inundation Modeling for Exchange (TIME) programme has helped develop national capacities to conduct inundation modeling through long-term, hands-on training programmes conducted through the Disaster Control Research Center at Tohoku University in Japan.

TIME is a joint effort of the International Union of Geophysics and Geodesy and UNESCO-IOC, developed as part of the UN's International Decade for Natural Disaster Reduction. Japan has also developed ISO-compliant signs.

Scientific and Technical Manuals are available to support the software codes that are used. The TIME software has been employed extensively to develop inundation maps for Mexico and South America. As of 2003, the TUNAMI code had been transferred to 19 institutions in 15 countries. In 2005, following the Indian Ocean tsunami, the IOC sponsored a two-week introductory TIME Modeling Course in the Philippines, which was attended by 11 countries from the Indian and Pacific Oceans.

In 2006, to meet increased demand for tsunami inundation maps around the Indian Ocean and globally, the IOC introduced a new two-part Short Course on Tsunami Propagation and Inundation Modeling, to supplement the activities of the TIME programme and to introduce new numerical codes such as MOST and adapted versions of the original TUNAMI codes.

New science manuals are being written, and several modeling software programmes will be available and used to teach the science of tsunami numerical modeling. As before, the course is being designed and taught by practicing experts who are emphasizing understanding of the concepts and the considerations needed to be able to create reliable maps using the best available science and data.

In the US, the National Tsunami Hazard Mitigation Program's Center for Tsunami Inundation Mapping Efforts (also TIME) hosts a website providing contacts and links to other sites that feature examples of hazard maps from Alaska, California, Hawaii, Oregon and Washington. The inundation maps have been developed using several different codes, including MOST, FVWAVE, and other finite difference and finite element models.

View more information on the IOC Short Courses on tsunami sources, propagation, and inundation modeling at:

http://www.tsunamiwave.info/training

Go to the Centre for Tsunami Inundating Mapping Efforts at:

http://nctr.pmel.noaa.gov/time/resources/.

Refer [3.3.6 - 09 of 19] to view the most recently updated IOC TIME Project Manual[PDF] in the CD-ROM .

Tsunami Model Visualization for Suva, Fiji

In 2003 the Pacific Disaster Center in Hawaii produced a Tsunami Model Visualization for Suva, Fiji. It demonstrates the use of computer modeling, data and information resources, and visualization techniques to simulate the evolution of a tsunami wave on Suva, based on the 1953 tsunami that struck the city.

The visualization is featured in the Tsunami Awareness Kit developed cooperatively for Pacific island by the Pacific Disaster Center, SOPAC, the ITIC, the PTWC and SOPAC member countries in 2005.

Tsunami model visualization, Suva, Fiji.

According to the Pacific Disaster Center, the visualization "is intended to demonstrate to decision makers the use of science and technology in assessing potential risk and vulnerability to the tsunami hazard for the population and infrastructure in the Suva Harbour area."

The Method of Splitting Tsunami (MOST) model developed by Dr Vasily Titov of NOAA's Pacific Marine Environmental Laboratory, was used to simulate tsunami wave evolution and estimate the maximum inundation in the harbour area. GIS analysis tools were then applied to build a three-dimensional view of the harbour area, to enable viewers to gain understanding of the impact of a tsunami on today's built environment:

"Visualizations such as this can be effective tools for communicating risk and identifying potential impacts of the tsunami hazard."

Refer [3.3.6 -10 of 19] view a description of the Tsunami Model Visualization for Suva, Fiji, including system requirements necessary to run the visualization.[Video] in the CD-ROM .

Refer [3.3.6 -10 of 19] view the Tsunami Model Visualization for Suva, Fiji,[PDF] in the CD-ROM .

Evacuation maps – Communities work together

The Asian Disaster Reduction Center has contributed greatly to the development of community-based processes for building tsunami awareness and preparedness, including the creation useful evacuation maps.

In the end, it is the community itself that has to evacuate following a tsunami warning, and so it makes sense for all stakeholders to help to design their means of evacuation.

George Crawford, Earthquake and Tsunami Program Manager for the Emergency Management Division of the State of Washington in the United States, has championed these same principles, stating simply that:

"Local tsunami evacuation maps [are] developed based on modeling, maps and local oral history"

The principles include:

- Identifying and including all stakeholders, including scientists, local leaders and emergency officials, community groups and non-profit organizations, and citizens.
- Conducting community workshops to inform and educate, and to design and evaluate evacuation plans and maps.
- Identifying and walking potential evacuation routes, taking in account single access roads, assembly areas and signage requirements

Refer [3.3.6 -11 of 19] to view ADRC's: Japan Tsunami Warning and Mitigation System – Preparedness 1 and 2[PDF] in the CD-ROM .

Refer [3.3.6 -11 of 19] to view an article by George Crawford, Washington State Earthquake and Tsunami Program Manager, on Developing TsunamiReady Communities,[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Oahu Civil Defense Agency Evacuation Maps

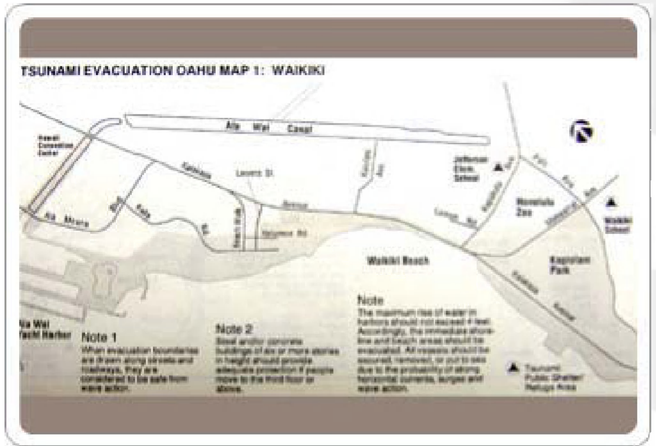
The Oahu Civil Defense Agency in Honolulu, Hawaii, developed a set of tsunami evacuation maps that were first published in the Hawaiian telephone white pages in 1991.

They have subsequently also been carried as a public service by Verizon Hawai'i Super Pages State-wide, ensuring that all citizens and visitors have quick and easy access to clear evacuation information.

Produced by George Curtis, the maps were developed using "one dimensional modeling," based on 100 years of historical and scientific data including six tsunami events. People are informed that:

"If they live, work or spend time in any of the mapped grey areas, they must know that some time in the past 100 years those zones have been impacted by tsunami wave action. If they live in a grey zone they must evacuate if ordered to do so. If they live outside the zone, they must stay away from the shoreline – and not tie up traffic."

All state schools in the zones have evacuation plans, and exercise them annually.



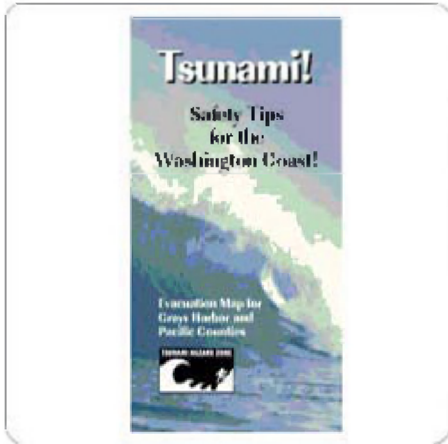
3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Tsunami! Safety Tips for the Washington Coast

A good example of a tsunami evacuation map was produced in the form of a brochure by the Washington Military Department at Camp Murray in the northwestern United States.

Tsunami! Safety Tips for the Washington Coast provides a map with evacuation routes for Grays Harbour and the Pacific Counties, clearly showing residents what roads to take and in which direction to head if a tsunami is approaching.

It also provides basic information on tsunamis, how people can protect themselves against earthquakes and tsunamis, what to include in an emergency supply kit, radio channels to tune into for emergency information, and contact details for emergency services.



Refer [3.3.6 -14 of 19] to view Tsunami! Safety Tips for the Washington Coast [PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Honolulu, Hawaii – Tsunami Evacuation and Sheltering

In 1991 a *City and County of Honolulu Emergency Operations Plan* was published with a Tsunami Evacuation and Sheltering annex that provides a useful example to planners and emergency managers of evacuation operations, responsibilities and maps.

The document supplements the Honolulu City Emergency Operations Plan, and its purpose is to describe:

"…tsunami evacuation process and to identify public shelters and-or refuge areas so that city response forces, residents and visitors can, when required, accomplish a coordinated and timely evacuation."

The plan contains definitions, examples of Pacific Tsunami Warning Center bulletins, operations concepts, roles and responsibilities, hazard-specific response procedures, sheltering analysis and guidance on warning, evacuation, direction and control, roles and responsibilities, public information and Plan maintenance.

Refer [3.3.6 -14 of 19] to view Annex S, Appendix 2, City and County of Honolulu Emergency Operations Plan: Tsunami Evacuation and Sheltering,[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Post-Tsunami Survey Field Guide

Post-tsunami field surveys, involving teams of experts and local stakeholders who visit areas struck by tsunamis to gather a range of information, have become an important source of data with which to improve tsunami risk mapping.

In 1998 UNESCO-IOC's Intergovernmental Oceanographic Commission published a *Post-Tsunami Survey Field Guide* to assist Member States, scientists, authorities and community leaders to organize and conduct post-tsunami field survey reconnaissance investigations.

While earlier guides had been produced, an international process for setting agreed standards for survey measurements of tsunami run-up and damage was undertaken by the IOC, culminating in the 1998 Guide, which was published as one of the IOC's series of Manuals and Guides. It describes the purposes of post-tsunami surveys as being to:

"Observe and document the effects of tsunamis, collecting readily available and perishable data as soon as possible, so as to learn about the nature and impact of the phenomenon, and be able to make recommendations on the need for further research, planning and preparedness."

The purposes of the *Field Guide* are to:

"Establish guidelines to conduct post-tsunami field reconnaissance investigations, and the standards for the observations, measurements, and assessments, so as to properly collect the data in a consistent and timely manner, and be able to decide on the specific type of data to be collected."

The subjects examined in the Guide are grouped as:

- Procedures before the field survey: this deals with recommendations for the make-up of the team, pre-travel arrangements and co-ordination, and basic equipment, documents, personal effects and supplies to be gathered.
- Procedures while in the field: this deals with logistics in the field, the type of information to be collected and the way to do it.
- Procedures after the field survey: this deals with gathering, distributing and reporting post- tsunami data.

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping


Intergovernmental Oceanographic Commission — Manuals and Guides 37

POST-TSUNAMI SURVEY FIELD GUIDE
(First Edition)

1998 UNESCO

Intergovernmental ... Manuals and Guides

The survey involves: gathering existing maps, charts, and tidal records among other things; actual measurement of physical parameters; graphic depictions and audiovisual recording; and interviews with eyewitnesses.

It also contains annexes with a prototype eyewitness interview questionnaire, and suggested formats for field survey forms to be filled out during the survey.

Refer [3.3.6 -14 of 19] to view the UNESCO-IOC Post-Tsunami Survey Field Guide (First Edition), Manuals and Guides – No 37 ,[PDF] in the CD-ROM .

Refer [3.3.6 -14 of 19] to view how field data collected after tsunamis since the 1990s have furthered our understanding of tsunamis, Synolakis and Okal, 2005.[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Post-Tsunami Survey Field Guide – Hawaii Tsunami Plan

While the UNESCO-IOC publication provides excellent overall guidance on post-tsunami surveys, successful rapid surveys to collect data that is perishable will be most successful if they have been planned and organized in advance.

In Hawaii, a team of dedicated tsunami scientists developed the Hawaii Tsunami Observation Plan in 2002 to establish and maintain a system.

The plan focuses on conducting safe and competent operations, in coordination with emergency responders involved in search and rescue operations and under the direction of Hawaii State Civil Defense, for the efficient and accurate measurement of tsunami run-ups and inundations throughout the State.

This Plan will:

- Record arriving tsunami waves at key locations around the islands.
- Record the effects of the waves on all significant coastal areas, especially the run-up values.
- Preserve these records in a retrievable fashion for tsunami researchers and emergency managers

Key components of the Plan include:

- A Field Guide for measuring tsunami run-ups and inundations.
- Volunteer trained tsunami observers, pre-cleared for tsunami event emergency access.
- Survey equipment and supplies caches consisting of basic information materials, maps showing historical run-ups, and pre-assigned survey areas.

Refer [3.3.6 -16 of 19] to view the Hawaii Tsunami Observer Plan,[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Reinforcing preparedness – Tsunami signage, United States

Once risk areas are defined, the most visible way to educate the public about tsunami hazard zones, evacuation routes and safe zones, is to post signs.

In 2003 the State of Oregon Department of Geology and Mineral Industries published *Tsunami Sign Placement Guidelines*, by Mark Darienzo.

In Oregon, tsunami waves from a local subduction zone arrive at the coast around 15 to 30 minutes after an earthquake, and so people are advised to move inland and to high ground immediately when ground shaking stops:

"It is critical that residents and tourists know where the tsunami hazard zones, evacuation routes and safe zones are located along the coast."

The 11-page manual describes the types of tsunami signs available – tsunami hazard zone, tsunami evacuation route, tsunami evacuation site, and entering or leaving a tsunami hazard zone – and, for the purposes of consistency in sign placement, it outlines placement guidelines for Oregon that comply with State laws.

The signs, created in Oregon, were adopted for use by the five Pacific states of the National Tsunami Hazard Mitigation Program: Alaska, California, Hawaii, Oregon, and Washington. Other Pacific Rim countries have also either adopted or adapted the signs for their use.

Refer [3.3.6 -17 of 19] to view Oregon Tsunami Sign Placement Guidelines,[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Reinforcing preparedness – Tsunami signage, Sri Lanka

In the Indian Ocean region Sri Lanka, Thailand and Indonesia have developed signage to assist tsunami emergency evacuations.

As part of a national tsunami community preparedness programme, the government of Sri Lanka has developed detailed guidance for sign use and placement in coastal communities. Community-based preparedness activities are being facilitated by the Disaster Management Centre, Geological Survey and Mines Bureau, and the Meteorological Department.

Communities are identifying tsunami hazard zones, evacuation routes, safe shelters, emergency helicopter landing sites, and appropriate multi-lingual signage to support local response plans that are immediately put into action upon receiving an evacuation advisory from the National Disaster Management Centre and a warning from the Meteorological Department, which acts as the National Tsunami Warning Centre for Sri Lanka.

Among the innovative signs developed is signage that will be placed outside homes of disabled people who need assistance during an emergency. In its community response, groups of pre-identified, trained volunteers will help to transport these individuals to shelters outside the inundation zone.

The development of emergency response plans through collective discussion and understanding of the tsunami hazard, and of actions to reduce the risk, as well as exercising the plans through drills, is helping to build tsunami resilient communities in many villages.

Refer [3.3.6 -18 of 19] to view Sri Lanka Tsunami Sign Placement Guidelines ,[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.5 Tsunami hazard and risk mapping

Reinforcing preparedness – Tsunami signage

In 2003 the Pacific-based International Coordination Group for the Tsunami Warning System in the Pacific, at its XIX Session, endorsed two signs developed by the United States NTHMP for tsunami hazard and tsunami evacuation.

The signs, originally in blue-and-white, were modified to meet the signage criteria, colours and shape standards of the International Standards Organization (ISO). These include the use of yellow and black in a triangle shape for a hazard sign, and green and white in a rectangle shape for an evacuation sign. Japan has also developed ISO-compliant signs.

While ISO-guided international signs are recommended for use, they are not required. What is most important is that the public clearly understand the meaning of signage along coasts. Many communities use text along with symbols to properly convey the message of a sign.

Interpretive roadside signage has also been developed to educate and build awareness of tsunami hazards along coasts. In some places heavily affected by tsunamis, memorials and explanatory information are displayed to remind people of the devastating impacts of historical events and to reinforce tsunami safety practices.

Examples of ISO-compliant signs for tsunami hazard.

3.3.6 Tsunami Mitigation - 3.3.6.6 Mitigating the tsunami hazard

Overview

Much work has been done to develop emergency response and mitigation plans and systems in countries with long and devastating experience of natural disasters such as tsunamis, including in the United States and Japan.

As seen in previous sections, tsunami warnings, public notification, and inundation and hazard mapping are crucial to a comprehensive warning and mitigation system that is multi-faceted and also involves a range of other activities, such as emergency response planning, exercises and drills, developing land use and building guidelines, and public education.

The following pages describe a range of tsunami response and mitigation activities and resources that will be of interest to government officials, businesses and community groups.

Tsunamis can be generated by subaerial landslides that enter the water, or submarine landslides.

Overview

The National Tsunami Hazard Mitigation Program in the United States stresses the need for tsunami mitigation efforts to be part of a sustained, multi-hazard, institutionalized project at the state, regional and local levels.

Local and regional tsunami work groups and stake-holder coordination committees can effectively provide the framework for coastal constituencies "to participate in developing priorities and strategies and to gain a stake in the results of hazard mitigation", according to the NTHMP's 1998 strategic *Implementation Plan*.

For their part, national tsunami work groups enable coastal communities to exchange information and keep state organizations up to date on local mitigation efforts.

The December 26, 2004 Sumatra tsunami stripped forested hills of vegetation in Banda Aceh, leaving a clear marker of where maximum runup occurred. Photo courtesy of Yuichi Nishimura, Hokkaido University.

> *"Long-term planning also involves consideration of post-tsunami recovery. After a tsunami strikes, a community may have unique opportunities to take long term mitigation actions which are not currently available."*
>
> *"These may include large post-disaster funding sources, political support for major legislative and land use planning changes, and damaged coastal areas which can be more easily set aside from future development."*

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors
3.3.6 Tsunami Mitigation - 3.3.6.6 Mitigating the tsunami hazard

Local Planning Guidance on Tsunami Response – 2nd Edition

By the late 1990s, even though at-risk coastal communities in the United states were aware of the tsunami threat, most had done little tsunami-specific evacuation, mitigation, preparedness, response or recovery planning.

In 1997 a Tsunami Hazard Mitigation Work-shop convened by the California Governor's Office of Emergency Services identified a critical need for up-to-date inundation maps for communities at risk, and for guidance on how to use the maps for local government.

Tsunami evacuation map, Barangay Buhatan, Albay Province, Philippines, developed in consultation with the community. An evacaution drill was conducted during the Pacific-wide Exercise Pacific Wave 06 in May 2006.

Subsequently, at-risk areas along the California coastline were identified and, with funding from the National Tsunami Hazard Mitigation Program of NOAA, Professor Costas Synolakis of the University of Southern California produced inundation projections for selected areas.

A 206-page guidance manual was also produced, as a *Supplement to the Emergency Planning Guidance for Local Governments*, to assist "in the initial development of a tsunami response plan and the procedures necessary to deal with a tsunami's impact on their communities."

The useful guidance covers three main areas: use of model inundation maps; development of tsunami-specific plans including evacuation procedures; and explanation of warning procedures. The manual is designed for local officials, but may also be used for planning purposes by regional or national agencies that support local government disaster activities.

Refer [3.3.6 -03 of 10] to view Local Planning Guidance on Tsunami Response -- 2nd Edition,[PDF] in the CD-ROM .

Tsunami Planning

As part of its *Local Planning Guidance on Tsunami Response – 2nd Edition*, the California Office of Emergency Services produced a series of questions and checklists to assist emergency managers in developing a comprehensive response plan for the tsunami hazard.

Tsunami Sample Planning Template

In the California OES Local Planning Guidance, Appendix 3 - Tsunami Planning, the Tsunami Sample Planning Template first asks:

- Organizational structure.
- Coordination of various disciplines.
- Inclusion of non-profit organizations or private businesses in the response process.
- Public information concerns.
- Safety and security.
- Information sharing among the key players.

Under an “Operations” section it then considers issues that might surface during tsunami response planning for operations branches such as the fire department, hazardous materials, law enforcement, the coroner, medical and health, care and shelter, and public works and utilities.

There are further sections considering issues such as: “Planning and intelligence,” which covers threat analysis and shortfalls in plans and procedures; “Logistics,” considering support requirements and resource data bases; “Finance and administration,” covering issues of operational continuity and cost tracking; and “Training and exercises,” which considers tsunami response training, awareness programmes and first responder training.

Refer [3.3.6 -04 of 10] to view the Local Planning Guidance on Tsunami Response.

Model Community Emergency Response Plan

Disaster response flow charts, checklists, and standard operating procedures are contained in an emergency response plan produced by Elise G DeCola and Tim L Robertson in 2002 for the Yukon River Inter-Tribal Watershed Council, United States.

Excerpts of *Model Community Emergency Response Plan* are featured in a resource included in the Tsunami Awareness Kit developed cooperatively for Pacific island countries by the Pacific Disaster Center, the South Pacific Applied Geoscience Commission (SOPAC), ITIC, PTWC, and SOPAC member countries in 2005.

It includes a Sample Tsunami Response Flow Chart, Sample Response Checklist, and Tsunami Alert, Warning and Evacuation Procedures, and provides guidance, among other things, on initiating an emergency response, siren alert and warning systems, disaster assistance, incident management, and shelter operations.

View the chapters of the Model Community Emergency Response Plan at:

http://www.yritwc.com/emergencyresponse.htm

Emergency response plans from around the world

Several countries have developed comprehensive Tsunami Emergency Response Plans that are closely integrated with Tsunami Warning Centre warning and information bulletins. Four are featured here as excellent examples.

One is for Chile, written by the Chilean Navy (Servicio Hidrográfico y Oceanográfico de la Armada (SHOA) de Chile), as its national Tsunami Warning Centre.

A second is for French Polynesia, written by the Centre Polynésien de Prévention des Tsunamis (Commissariat à l 'Energie Atomique/ Département d 'Analyse et Surveillance de l 'Environnement, Laboratoire de Géophysique), as its regional tsunami warning centre.

A third is for Japan, compiled by its Cabinet Agency responsible for disaster preparedness, and a fourth is for Hawaii, United States, developed by Hawaii State Civil Defense as the agency responsible for public safety in the State.

Refer [3.3.6 -04 of 10] to view Chile’s Tsunami Emergency Response Plan[PDF] in the CD-ROM .

Refer [3.3.6 -04 of 10] to view France’s Tsunami Emergency Response Plan for French Polynesia [PDF] in the CD-ROM .

Refer [3.3.6 -04 of 10] to view Hawaii Tsunami Emergency Response Plan [PDF] in the CD-ROM .

Sharing Japan's Experience in Natural Disasters: Anthology of Good Practices

The Japanese government's Asian Disaster Reduction Centre shares a wealth of disaster-related policy, planning and mitigation experience, in its aim "to create a global culture of prevention."

There are links on its website to a rich array of background information and resources under the following headings:

- Establishing a culture of prevention: Natural disasters cannot be eradicated, but their impact can be reduced.
- Promoting effective measures against disasters, incorporating disaster reduction into government initiatives.
- Investing in disaster reduction.
- Information as a key to reducing the damage of disasters.
- Passing on experiences to the next generations to improve disaster reduction capability.
- Strengthening Partnerships.
- Building a Network and Strengthening International Cooperation.

View the Sharing Japan's Experience in Natural Disasters: Anthology of Good Practices at:

http://web.adrc.or.jp/publications/Japan_Good_Practices/index.htm

Special Paper 31 – Mitigating Geologic hazards in Oregon

In 1999 the Oregon Department of Geology and Mineral Industries produced a *Special Paper on Mitigating Geologic Hazards in Oregon: A Technical Reference Manual*, by John D Beaulieu and Dennis L Olmstead.

The Premise

In the manual, directed at policy makers, they argue that:

"With proper information, the risks posed by geologic hazards can be managed so that benefits gained by strategies to reduce risk are acceptable in terms of costs. The keys to risk management are to have enough information about the hazard and to take the proper steps in risk reduction."

Steps to Reduce Risks

Reducing risks from geologic hazards includes several steps:

1. Properly characterizing the hazard.
2. Constructing a team to develop strategies.
3. Considering a range of strategies to address the risk.
4. Making an informed selection of strategies from a broad range of choices.
5. Permanently integrating the strategies to assure ongoing success.

Why Risk Reduction Strategies Fail

Risk reduction strategies can fail for many reasons and community efforts may not be fully effective, the authors state, if they do not encompass a broad effort.

"Available information may be adequate, but devised strategies may not be acceptable. Alternatively, strategies may be acceptable, but may not be effective in actually reducing risk, because the hazard was poorly characterized."

Basic Elements

The manual describes the basic elements that should be present in any effective regulatory or decision making process. It presents insights and information on how hazards can best be understood and managed, from a technical and risk-management point of view.

Oregon landslide.

Refer [3.3.6 -06 of 10] Special Paper 31 – Mitigating Geologic hazards in Oregon,[PDF] in the CD-ROM .

Refer [3.3.6 -06 of 10] Special Paper 32 – Geologic Hazards: Reducing Oregon's Losses, a technical reference manual that summarizes Special Paper 31, can be found at:,[PDF] in the CD-ROM .

Hawaii, USA – Emergency Response and Tsunami Preparedness

As the agency responsible for public safety in the State, Hawaii State Civil Defense has developed a comprehensive Tsunami Emergency Response Plan that is closely integrated with the Pacific Tsunami Warning Centre warning and information bulletins. The plan featured here discusses tsunami response at the state and county level.

Hawaii State Civil Defense has also produced a useful PowerPoint presentation entitled, *Case Study: Hawaii, USA – Emergency Response and Tsunami Preparedness,* describing how the State's tsunami warning and response is organized and operates, and briefly outlines mitigation efforts including:

- Hazard and risk analysis.
- National disaster facilities in Hawaii.
- The State Civil Defense system.
- Maximum tsunami run-ups.
- Mitigation, preparedness, response and recovery efforts.
- Public notification following tsunami warnings.
- Major disasters coordination procedures.
- Emergency management data systems.
- Evacuation maps and traffic control.
- Conducting tsunami exercises and "tsunami month" activities.

Refer [3.3.6 -07 of 10] to view the PowerPoint Case Study: Hawaii, USA – Emergency Response and Tsunami Preparedness,[PDF] in the CD-ROM .

Refer [3.3.6 -07 of 10] to view the Tsunami Emergency Response Plan for Hawaii, United States ,[PDF] in the CD-ROM .

Tsunami mitigation for the City of Suva, Fiji

A Suva Earthquake Risk Management Scenario Pilot Project (SERMP) was produced for the government of Fiji, considering mitigation measures for both earthquakes and tsunamis striking Suva, based on the real experience of the 1953 Suva earthquake and tsunami.

A tsunami mitigation methodology was developed, using a multidisciplinary approach with multi-agency cooperation, and an article titled "Tsunami Mitigation for the City of Suva, Fiji," was published in the *Science of Tsunami Hazards* journal, Volume 18, Number 1 (2000).

The article describes how hazard and vulnerability assessments were integrated to provide a risk assessment, which was then considered in terms of Fiji's emergency management requirements. The outcomes include hazard, vulnerability and risk zone maps, estimates of relevant tsunami parameters and possible damage situations.

Practical applications of the results, in terms of community vulnerability and reduction of potential losses, and including a simulated tsunami exercise, were a major part of the project, which concluded that there was a significant tsunami risk to the city.

The project recommendations are being implemented by Fiji's National Disaster Management Office in terms of disaster planning, response actions, training and community education. Fiji continues to develop its own local tsunami warning system, which will further prepare the city for future tsunamis.

Tsunami Evacuation Route sign in Viña del Mar, Chile.

Refer [3.3.6 -08 of 10] to view Tsunami Mitigation for the City of Suva, Fiji,[PDF] in the CD-ROM .

Exercises and drills

The purpose of tsunami exercises and drills is to rehearse, often with public participation, emergency response, evacuation and recovery plans to ensure their proper execution when a real event occurs. They also highlight operational strengths and weaknesses that need to be corrected.

An exercise can be conducted so that various scales of effort and sophistication are required. They can include exercise orientations or briefings, targeted organizational drills (such as school or business evacuation drills), "tabletop" exercises involving coordination among various agencies carried out in a room, and conducting a full-scale field exercise.

The scope and frequency of tsunami exercises should be determined by participants in each country, region, province, city or community. Both the public and the private sectors should consider exercising their response plans regularly, to be prepared for an actual emergency.

Exercise development processes include management, control, simulation and evaluation. Constructing an exercise requires the development of planning documents, staffing and training team leaders who will take responsibility, developing expected player actions and points of review, and identifying administration and logistics that will be coordinated among participating agencies.

Refer [3.3.6 -09 of 10] to view a video of a Community Evacuation Drill in SriLanka in 2005, [Video] in the CD-ROM .

Refer [3.3.6 -09 of 10] to view a Summary of a Tsunami Drill carried out in the Marquesas in 2004, [PDF] in the CD-ROM .

Refer [3.3.6 -09 of 10] to view a Overview of the Pacific-wide Drill carried out in May 2006, [Word doc] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.6 Mitigating the tsunami hazard

TsunamiReady communities

In the United States, NOAA's National Weather Service had by early 2006 designated over two dozen at-risk coastal communities as "TsunamiReady", in an initiative aimed at improving public safety during tsunami emergencies.

The project promotes tsunami preparedness as, in its words:

"…an active collaboration among federal, state and local emergency management agencies, the public, and the National Weather Service tsunami warning system. This collaboration supports better and more consistent tsunami awareness and mitigation efforts among communities at risk."

TsunamiReady brochure, NOAA NWS.

Coastal communities in several US States have developed tsunami hazard plans with evacuation routes to shelters outside hazard zones, as well as plans and drills for schools in hazard zones. Communities were also required to establish an Emergency Operations Centre, disseminate tsunami warnings using sirens and local media, set up a community awareness programme, and multiple ways of receiving National Weather Service warnings.

Benefits to the communities, it is argued, include that they become more prepared to save lives, increase contacts with emergency experts, identify community readiness needs and enhance their core infrastructure to support other community concerns.

Refer [3.3.6 -09 of 10] to view Click here to view a summary of TsunamiReady,[PDF] in the CD-ROM .

The TsunamiReady website is at:

http://www.tsunamiready.noaa.gov/

3.3.6 Tsunami Mitigation - 3.3.6.7 Environmental and engineering considerations

The United Nations International Strategy for Disaster Reduction (ISDR) has investigated links between environmental management and disaster reduction, and its findings are outlined in *Living with Risk: A global review of disaster reduction initiatives* – a publication for government officials at all levels, who deal with disaster issues.

"Chapter Five: A section of disaster reduction applications," discusses a range of ways to reduce disaster risk, and a selection of disaster reduction applications illustrate the scope of activities taking place and highlights their strengths and weaknesses.

The ISDR publication argues that a healthy environment enhances the capacity of societies to reduce impacts of natural and human-induced disasters, "a fact largely underestimated." There is a compelling need to explore how environmental mismanagement changes hazard and vulnerability patterns.

> "Knowledge about natural resources and the wise use of environmental management should be promoted as a strategy for reducing risks. Environmental actions that reduce vulnerability need to be identified and applied by disaster reduction practitioners. Quantitative measurements of these actions will determine their acceptance and application in political and economic arenas."
>
> - The United Nations International Strategy for Disaster Reduction (ISDR)

Refer [3.3.6 -02 of 11] to Read an issue paper on Environmental Degradation and Disaster Risk that looks for synergies between environmental and disaster management 2004.[PDF] in the CD-ROM .

Living with Risk: A global review of disaster reduction initiatives

The *Living with Risk* chapter argues that integrating environmental management within existing disaster reduction policy frameworks and international strategies "will build a safer world." Also, "instilling disaster reduction thinking into environmental performance is a positive proposition.

The chapter outlines:

- Links between environmental management and disaster reduction.
- Environmental legislation.
- Environmental policies and planning.
- Institutional and organizational arrangements.
- Environmental impact assessments.
- Reporting on the state of the environment.
- Ecological and environmental economics.
- Environmental codes and standards.

Refer [3.3.6 -02 of 11] to view Chapter Five of Living with Risk: A global review of disaster reduction initiatives can be found here:,[PDF] in the CD-ROM .

Living with Risk points out that while the environment and disasters are inherently linked, and the relationship between disaster reduction and environmental management are recognized, little research and policy work has been undertaken on the subject and the concept of using environmental tools for disaster reduction has not been widely applied.

"Environmental management can become a cost-effective tool for disaster reduction while serving many other objectives including conservation of biodiversity, mitigation of adverse global environmental changes and poverty alleviation."

- Living with Risk

The homepage of Living at Risk is at:

http://www.unisdr.org/eng/about_isdr/bd-lwr-2004-eng-p.htm

Environmental policy considerations

The natural environment can provide protection against tsunamis, while environmental destruction to make way for development can raise the tsunami risk of coastal communities. Following the 2004 tsunami, the World Wildlife Fund called for environmental issues to be considered essential to coastal protection, and to tsunami planning and mitigation efforts.

Tropical coastal ecosystems, it argued, have sophisticated natural insurance mechanisms to help them survive the storm waves of typhoons and tsunamis.

Environmental policy planning should be considered for protection of coastal populations and ecosystems.

"Coral reefs are the equivalent of natural breakwaters, providing a physical barrier that reaches the sea surface, causing waves to break offshore and allowing them to dissipate most of their destructive energy before reaching the shore."

Mangrove forests also act as natural shock absorbers, "soaking up destructive wave energy and buffering against erosion." Systems of marshes, tidal inlets and mangrove channels also help limit the extent of inundation by floodwaters and enable flood waters to drain quickly.

But there has been extensive destruction of natural coastal habitats to make way for urban development, population growth, industry, aquaculture, agriculture and tourism in the Asia Pacific Region and elsewhere. The WWF recommends that tsunami mitigation strategies take into account:

- Rehabilitation and restoration of degraded coastal ecosystems that help protect from storm waves, especially coastal marshes and forests, mangroves and coral reefs;
- Adoption of integrated coastal zone management, including zoning and mandatory coastal set-back. For example, hotels should not be built within a hazard zone.
- Strict enforcement of land and coastal-use planning and policies, including natural disaster risk assessments.
- Incentives to ensure sensitive facilities are built away from high risk areas.
- Risk assessment that helps reduce the vulnerability of coastal development.

Examples of tsunami land use mitigation practices

In the Second Edition of TSUNAMI!, a 1998 book published by University of Hawaii Press, authors Walter C Dudley and Min Lee assert that natural environmental barriers or relocation can be more practical options than structural solutions. This is an excerpt from the book:

> *"In Hilo following the devastation of the 1946 tsunami, the idea of protective walls and breakwaters was considered as a possible defense against tsunamis. Cost estimates indicated that to be effective, such a wall would cost more than the valued of all the buildings in Hilo, and the ideas was quickly abandoned."*
>
> *"But tsunami walls are used extensively in Japan. Following the 1896 Meiji tsunami, a protective wall was planned for the village of Tarou, but it took the galvanizing effect of the 1933 Showa era tsunami to actually get construction underway. The wall was completed following World War II and now stands 33 feet high and 4,500 feet long. It is known as," "The Great Wall" and tourists come from all over Japan to gaze on the massive structure. The cost was enormous and no one is quite sure what will happen if a tsunami wave higher than 33 feet strikes the wall."*
>
> *"Less expensive measures, such as planting thick rows of low trees, have been tried with some success. Trees appear to be effective in absorbing at least some of the energy of an advancing tsunami wave, and they do make a rather pleasant green border for a seaside community."*
>
> *"When all else fails, relocation may be the only option. Following tsunami devastation on the Kamchatka Peninsula of Russia, many parts of the city of Petropavlosk were moved to higher ground to avoid future destruction."*
>
> *"In Hilo, after being almost totally destroyed twice in 14 years, much of the downtown business district was rebuilt farther inland. The inundation zone is now largely soccer fields and public parkland. Many an admiring tourist has commented on the city fathers' fine town planning to have left so much precious coastal land as green open space for recreational use. Little do they realize the real reason and true cost behind the open space."*

Tsunami water gate which is closed after tsunami warning is issued in Japan

Vegetative bank for the protection from tsunami constructed in 1857 in Japan after two giant tsunamis attacked in 1854.

Building and land use considerations

The impacts of tsunami waves and flooding are greatly influenced not only by off-coast topography and natural environmental barriers, but also by the methods used and materials of construction in tsunami inundation zones.

The US National Tsunami Hazard Mitigation Program points out that while wood-frame structures perform well when earthquakes shake the ground, they easily collapse when hit by powerful waves. Reinforced concrete buildings may be safe havens for vertical evacuation when a tsunami strikes. The *Implementation Plan for Tsunami Mitigation Projects*, a guide produced for the NTHMP, argues that:

"Consideration of both the effects of moving water and strong ground shaking need to be included in construction codes. Vegetation may dampen the water velocity in some cases, but in others, add to the debris and projectile force of the flow. No guidelines addressing these issues are available to coastal communities."

It argues that local authorities and planners need the following in order for land use and construction considerations to form part of local tsunami mitigation strategies:

- Construction guidelines.
- Coastal land use guidance such as siting of structures, open space, and interactions of uses.
- Infrastructure guidance such as issues facing utilities, bridges, and road embankments.
- Vegetation guidance.

A two-story wooden school building that stood near the church at Sissano Mission was carried 65 m by the wave until caught by a grove of coconut palms. The lower floor of the building collapsed, but the upper floor class rooms were preserved. Schoolwork was still hanging on the wall. (Photo credit: Hugh Davies, University of PNG.)

Designing for Tsunamis

In the United States NOAA's National Tsunami Hazard Mitigation Program led a multi-state project that in 2001 published *Designing for Tsunamis: Seven Principles for Planning and Designing for Tsunami Hazards*.

The document presents tsunami mitigation guidelines as they relate to land use, site planning and building design and construction, and its purpose is to help communities in the five high-risk Pacific states to:

"…understand their tsunami hazards, exposure and vulnerability, and to mitigate the resulting risk through land us planning, site planning, and building design.

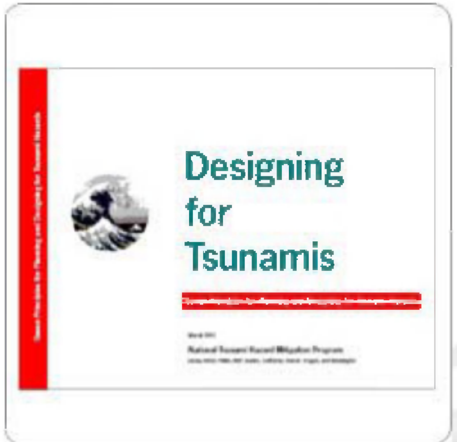
The guidelines are intended for use by officials involved in planning, zoning, building regulation, community development and related land use and development functions in coastal communities. While designed for US coastal communities, *Designing for Tsunamis* is highly accessible and comprehensive, and can be adapted for use anywhere in the world.

For each of *Designing for Tsunami's* seven principles, there is background information on the topic, recommended process steps for implementing the principle, specific "how to" strategies, and case studies that illustrate how communities are tackling tsunami hazards.

The seven principles are:

1. Know your community's tsunami risk: hazard, vulnerability and exposure.
2. Avoid new development in tsunami run-up areas to minimize future tsunami losses.
3. Locate and configure new development that occurs in tsunami run-up areas to minimize future tsu nami losses.
4. Design and construct new buildings to minimize tsunami damage.
5. Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects.
6. Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage.
7. Plan for evacuation.

The document also contains a bibliography and list of resources, websites and videos that provide leads to further materials.



Refer [3.3.6 -07 of 06] to view Designing for Tsunamis,[PDF] in the CD-ROM .

Surviving a Tsunami By Vertical Evacuation – Engineering Studies

Many people have survived tsunamis by sheltering in the upper floors of sturdy buildings that have been able to withstand the immense forces of the waves, including during the 2004 Indian Ocean tsunami. But much depends on the building's construction and on the size and power of the great waves.

Whether buildings can be used as tsunami shelters, and if so which buildings, is a critical question for cities that cannot be evacuated quickly and where loss of life could be immense, or for when tsunamis strike with no time for warnings.

The US National Tsunami Hazard Mitigation Program (NTHMP), with funding primarily from Federal Emergency Management Agency (FEMA), has led an effort to identify construction and coastal land use guidance in areas of both strong ground shaking and tsunami hazard. Two studies were commissioned.

In Phase I, in 2005, a study by Oregon State University, the University of Hawaii, and Planwest Partners concluded that tsunamis loads were far too great for conventional buildings to be expected to withstand, and that it would be economically unfeasible to construct tsunami-proof average buildings.

However, it appeared possible to conduct "vertical evacuation" to structures built to resist at least specific tsunami loads, and to identify the sturdy construction requirements for high-occupancy buildings, like large seaside resorts.

In Phase II, design and siting specifications, a manual for field data collections, and an outreach program consisting of the creation of databases and workshops to train design professionals, are being produced.

An ATC-64 study "Development of Design and Construction Guidance for Special Facilities for Vertical Evacuation from Tsunami", is being carried out by the Applied Technology Council (ATC) in the US, and is expected to be completed in 2007.

At the same time, the US National Science Foundation has funded a multi-disciplinary tsunami engineering study to develop methodology and engineering tools for use in the analysis, evaluation, design and retrofit of coastal structures and facilities.

One of the main goals of the project, to be completed in 2010, is to provide professional building code and design tools to enable the construction of buildings that can withstand tsunami-induced forces. The project is significant because it will provide experimentally-validated tools to benefit the ATC-64 project.

A Phase III Project has also been funded under the NTHMP to develop a companion document to the Vertical Evacuation Tsunami Shelter Guidelines. The document will provide planning information for States and local communities on how tsunami shelter design guidance can be applied at the local level, and will be of special interest to low-lying communities that lack evacuation access to high ground following an local earthquake, and may have to rely on vertical evacuation.

Elevated platform used for tsunami evacuation that also serves as a high-elevation scenic vista point for tourism. Okushiri Island, Japan. Photo courtesy of ITIC.

Refer [3.3.6 -07 of 06] to view the Summary of the activities,[PDF] in the CD-ROM .

Phase I: Structural Response to Tsunami Loading

The NTHMP Phase I Study, conducted by Harry Yeh of Oregon State University, Ian Robertson of University of Hawaii, and Jane Preuss of Planwest Partners, reviewed a range of current building codes for tsunami loading provisions, evaluated prototype seismic-tsunami design structures, and reviewed past tsunami damage.

Their design considerations include hydraulic lateral forces, surge forces, breaking wave forces, impact forces, floating debris, hydrodynamics and others. The study concluded that:

- US building codes do not adequately address the flow velocity and subsequent structural loading during a tsunami. Experimental validation of the velocity, flow depth and loading expressions is needed.
- Tsunami forces often exceed design forces based on wind and seismic conditions.
- However, a review of three typical prototype buildings indicated that the as-built capacity of individual members is often adequate for the tsunami loads.
- A structure must resist both the initial earthquake ground shaking and subsequent tsunami-induced loads, including the impact of water-borne missiles, so that vertical evacuation can be recommended to levels above the expected maximum flow.

They also made recommendations concerning tsunami shelter design, noting that shelters:

- Must be evaluated for resistance to structural and foundation failure and, additionally, must be evaluated for tsunami-induced scour around the shelter's foundation.
- Must provide sufficient floor space for evacuees above the base flood elevation.
- Must be fire resistant since tsunamis often trigger fires.

The scientists also recommended, among other things, that analytical modeling and experimental verification of tsunami flow depth and velocity be performed using a large-scale tsunami wave tank, and that wave tank studies should be undertaken to verify hydrodynamic loading due to tsunami flow, and impact due to waterborne debris.

Based on these studies, it was proposed that tsunami loading equations be revised. They concluded that vertical evacuation in multi-story reinforced concrete (and structural steel) buildings is an appropriate policy for all near-source tsunamis, and "remote-source tsunamis in densely populated areas where horizontal evacuation is not feasible."

Refer [3.3.6 -08 of 11] to view the PowerPoint Structural Response to Tsunami Loading in the CD-ROM .

Refer [3.3.6 -08 of 11] to view the Report "Development of Design Guidelines for Structures that Serve as Tsunami Vertical Evacuation Sites" by Harry Yeh, Oregon State University, Ian Robertson, University of Hawaii, and Jane Preuss, Planwest Partners,[PDF] in the CD-ROM .

This structure in Sumatra survived the 2004 Indonesian earthquake and Indian Ocean tsunami.

Phase II: Design and Siting Specifications for Vertical Evacuation

Traditional tsunami coastal evacuation routes direct people to rapidly move inland to higher ground, to avoid the arrival of destructive waves. However, horizontal inland evacuation may not be feasible in some coastal communities because:

- There is the potential for a local tsunami striking within minutes from a near shore earthquake or landslide.
- The coastal area is a flat terrain that affords no high ground protection.
- The evacuation area is too densely populated for rapid inland evacuation.

In such communities, it is essential that existing buildings, or new emergency centres,be evaluated or designed for vertical evacuation options.

Vertical evacuation to the upper floors of strong buildings may be possible if there is no time to evacuate inland.

The NTHMP, using funds from FEMA, is sponsoring a study, "Development of Design and Construction Guidance for Special Facilities for Vertical Evacuation from Tsunami", to respond to the recommendations of the Phase I study for vertical evacuation guidance to the upper floors of buildings specifically designed for tsunami loads.

Several coastal communities along the US west coast are vulnerable to local-source tsunamis triggered by earthquakes along the Cascadia Subduction Zone, and Alaska and Hawaii communities are also prone to near-source tsunami hazards.

The ATC-64 project is being undertaken by the Applied Technology Council (ATC) under the broader contract "Seismic and Multi-Hazard Technical Guidance Development and Support" (HSFEHQ-04-D-0641), and is expected to be completed in 2007.

The ATC is a US non-profit organization whose mission is to develop and promote state-of-the-art, user-friendly engineering resources and applications for use in mitigating the effects of natural and other hazards on the built environment.

Refer [3.3.6 -09 of 11] to view for an overview of the Development of Design and Construction Guidance for Special Facilities for Vertical Evacuation from Tsunami Project,[PDF] in the CD-ROM .

Design and Construction of Buildings for Vertical Evacuation

There is a worldwide lack of research on the effects of tsunami waves on coastal infrastructure such as buildings, bridges and harbour facilities. In the wake of the 2004 tsunami, a number of researchers began working to improve the ability of structures to survive tsunami impacts.

Their challenge is to develop realistic design guidelines and simple but effective methods for designing, analyzing and verifying the design of structures, so that buildings reliably meet performance objectives when exposed to tsunami wave loading,

Among the research is a four-year collaborative effort, starting in 2006 and funded by the US National Science Foundation, involving the University of Hawaii at Manoa, Oregon State University and Princeton University.

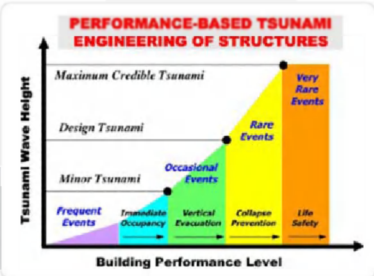
The project brings together numerical modelers, structural and ocean engineers, and laboratory scientists, and makes use of a newly constructed tsunami wave basin to perform experiments and make numerical measurements.

The data, along with actual tsunami observations, will be used to develop methodology and tools for implementing site-specific Performance Based Tsunami Engineering (PBTE) for use in the analysis, evaluation, design and retrofit of coastal structures and facilities.

The project represents a system-driven approach to the development of Performance Based Tsunami Engineering for building code implementation. The code guidelines will be proposed for adoption in all US jurisdictions subject to tsunami inundation.

The PBTE Project will contribute experimentally-validated design procedures and tools for evaluating tsunami loading on coastal structures, significantly enhancing the NTHMP- FEMA funded ATC-64 *Development of Design and Construction Guidance for Special Facilities for Vertical Evacuation from Tsunami* project.

Efforts are now being made to design buildings according to their expected safety performance level. In the ideal case, engineers would build most structures to be safe against a design tsunami defined as one which occurs occasionally; for these, vertical evacuation should be possible. On the other hand, critical lifeline structures such as transportation or energy facilities, or hospitals, should be built to withstand the maximum credible tsunami since these structures provide life safety services.



Refer [3.3.6 -10 of 11] for an overview of the Performance Based Tsunami Engineering Project , [PDF] in the CD-ROM .

FEMA National Flood Insurance Program

The United States National Flood Insurance Program is managed by the Federal Emergency Management Agency (FEMA), which also oversees flood mitigation programmes.

FEMA views mitigation as one of the cornerstones of emergency management:

"Aspects of mitigation include effective floodplain management, engineering of buildings and infrastructures to withstand earthquakes, and the implementation of building codes designed to protect property from natural hazards."

"The National Flood Insurance Program encourages the building of safe structures within flood-plains and in some cases the removal of those that are the most vulnerable. Mitigation is an essential element in reducing the impact of natural disasters on communities and their residents throughout the nation."

The Agency is involved in a range of flood insurance and mitigation activities, and much of the information is useful to tsunami planners, managers and communities.

Visit the FEMA National Flood Insurance Program website at:

http://www.fema.gov/plan/prevent/floodplain/How_the_NFIP_works.shtm

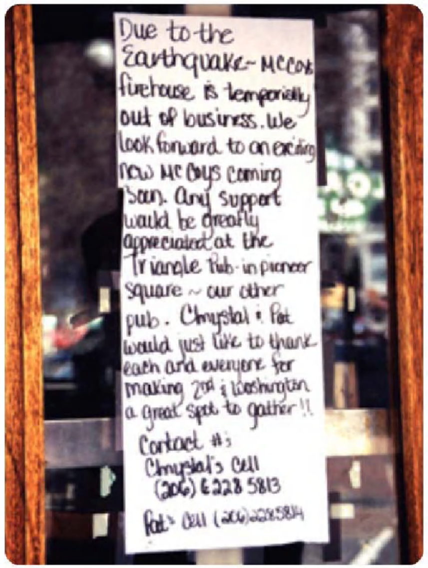
3.3.6 Tsunami Mitigation - 3.3.6.8 Guidance for Businesses

Studies in many countries have indicated that businesses are in general poorly prepared for most disasters.

But businesses have public safety responsibilities. And private sector losses from disasters such as tsunamis can be enormous, and not only in terms of property destruction, and staff and client disruptions.

For weeks afterwards businesses might need to operate in very difficult circumstances, sometimes with lack of the support infrastructure upon which they depend, such as a reliable water supply or telecommunications system.

The following pages offer some guidance to public and private sector businesses on how they might prepare for risks and losses from disasters, such as tsunamis.



Sign posted on window of business after the M6.8 Nisqually, Washington, USA earthquake in February, 2001.
Credit: US FEMA

3.3.6 Tsunami Mitigation - 3.3.6.8 Guidance for Businesses

Emergency Planning Manuals for Businesses

A set of three guides to emergency planning for businesses, produced by Auckland City Civil Defence in New Zealand, assists company owners and operators to improve the emergency preparedness of their businesses.

The guides point out that every building and operation has individual conditions, and so businesses must tailor their plans to actual needs and operating styles.

The manuals outline the nature of a range of hazards but are applicable to tsunamis, and provide checklists for business preparedness, emergency response capacity, resources and a range of other factors as well as evaluation suggestions and safety advice.

Produced for the Ministry of Civil Defence's Public Education Advisory Committee, and sponsored by New Zealand Safety Limited, the three manuals are:

Refer [3.3.6 -02 of 05] to view the Manual #1-Hazard Assessment for Businesses, [PDF] in the CD-ROM .

Refer [3.3.6 -02 of 05] to view the Manual #2 - Planning and Preparedness for Businesses,[PDF] in the CD-ROM .

Refer [3.3.6 -02 of 05] to view the Manual #3 - Emergency Management Audit for Businesses,[PDF] in the CD-ROM .

The manuals also target all sectors and industries. Thus they are intended:

"...as a primer to assist business managers with a range of questions that will aid in the preparation of their own specific preparedness needs."

Risk Identification and Analysis: A Guide for Small Public Entities

The Public Entity Risk Institute in Fairfax, United States, produced a 12-page free-use booklet to provide small public entities with a "user-friendly process to identify and analyze their risks on an enterprise-wide basis". It is just as useful for businesses.

The booklet looks at why risk is important, and how public entities can identify and address them. It contains forms and potential loss and impact summaries that, writes author Claire Lee Reiss, may help make risk identification and analysis more easily manageable.

It suggests and elaborates on nine steps: establish risk as a priority for every employee; designate a risk team leader; define the scope and goals of the risk team's activities; establish an analytical framework; recruit team members; identify and evaluate risks; plot a risk map; create an action plan; implement and monitor the action plan.

Reiss stresses that every entity is different and the outlined process is suggestive and flexible, and concludes that what is important is not so much how the process is undertaken, but that it is undertaken and systematically continued:

"Public entities that successfully integrate risk concerns into their organizational structures and daily operations, protect their ability to deliver services to citizens and strengthen their ability to fulfill their mission."

Hilo, Hawaii after 1960 M9.5 Chilean earthquake and ocean-wide destructive tsunami.

Refer [3.3.6 -03 of 05] to view Risk Identification and Analysis: A Guide for Small Public Entities , [PDF] in the CD-ROM .
Introduction
Appendix_A
Appendix_B
Appendix_C
Appendix_D

The Tsunami Risks Project

Two British universities collaborated to create the Tsunami Risks Project, a comprehensive website that introduces businesses and the insurance industry to the complexity of tsunamis and the wide range of phenomena that can cause them.

It explores estimations of tsunami hazards, events, physics, consequences, mitigation, risk assessment, and frequency-magnitude distributions and evaluations of the direct and indirect insurance risks that tsunamis present.

The Tsunami Risks Project also looks at means by which disaster planning can reduce economic losses that result from tsunamis, and sources of post-disaster information and mapping that can be consulted to validate tsunami-related insurance claims.

The Tsunami Risks Project is sponsored by The Tsunami Initiative and Britain's Health and Safety Executive. Research has been conducted by the Benfield Greig Hazard Research Centre at University College, London, and the Centre for Quaternary Science and Coventry Centre for Disaster Management at Coventry University.

Businesses must anticipate loss of essential infrastructure to support their operations.

Visit the Tsunami Risks Project website at:

http://www.nerc-bas.ac.uk/tsunami-risks/index.html

3.3.6 Tsunami Mitigation - 3.3.6.8 Guidance for Businesses

Business Survival Kit for Earthquakes and Other Disasters – to order

This 2003 film uses the Seattle 2001 earthquake to highlight lessons learned by large and small businesses. It is not freely available, and must be ordered.

Among the video topics are hazard planning and safety, protection of personnel and assets, evacuation and business continuity.

The kit also includes a Disaster Planning Toolkit CD with worksheets and emergency checklists by the Institute for Business and Home Safety (IBHS).

Sponsored by the Cascadia Regional Earthquake Workgroup (CREW), it was produced by Global Net Productions, Inc.

Tel: +1 800 862 6247

Website: www.globalnetproductions.com

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Overview

Knowledge can be life-saving in an emergency.

Learning about tsunamis is not only knowing the golden rule of response – if there is warning, the sea drains away from the beach or the ground shakes, move to higher ground. It is also about knowing safe evacuation routes, how long the danger might last and a wealth of other potentially critical information.

In the words of Markku Niskala, secretary-general of the International Federation of Red Cross and Red Crescent Societies:

"…in the face of disaster, the difference between life and death can be as simple as possessing the right information – and acting on it."

The life-saving role of indigenous knowledge was highlighted by Simeulue islanders, who lost only seven of their 78,000 inhabitants even though the 2004 Indian Ocean tsunami struck them just eight minutes after the earthquake. Populations of other coastal areas were decimated.

The Simeulue islanders have kept alive, through oral history, the lessons of a tsunami that struck in 1907, and knew exactly what to do when the tsunami attacked. They even have a word for the 1907 tsunami – "smong".

The tsunami claimed the lives of more women and children than men – the ratio was three to one.

Read about how traditional knowledge passed down through oral tradition as "Smong" helped Simeulue Island people on December 26, 2004.

http://www.ifrc.org/docs/News/05/05121901/index.asp

Read about the seafaring Moken people who knew about tsunamis and what to do when they knew one was approaching

http://www.cbsnews.com/stories/2005/03/18/60minutes/main681558.shtml

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Overview

The value of information was dramatically illustrated during the Indian Ocean tsunami. Many victims of the tsunami received no warning – but thousands of lives were saved in cases where tsunami knowledge existed and was used.

One spectacular example was provided by Tilly Smith, aged 10, a British schoolgirl who was on holiday in Thailand on 26 December 2004. She saved over 100 people by recalling, from a recent geography lesson, that water rapidly receding from the beach meant that great waves were on the way.

When his observation tower on the remote Indian island of Tarasa Dwip started shaking, port official Abdul Razzak recalled a *National Geographic* programme on tsunamis and knew he needed to act. He rushed through villages screaming "Go to the hills!" and sent colleagues on his motorcycle to alert as many others as possible. Razzak saved 1,500 lives.

Read Tilly Smith's story in *National Geographic* at:

http://news.nationalgeographic.com/news/2005/01/0118_050118_tsunami_geography_lesson.html

Read Abdul Razzak's story at:

http://news.nationalgeographic.com/news/2005/01/0107_050107_tsunami_natgeo.html

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Overview

Community education and awareness is key to the success of any tsunami mitigation effort – and particularly when tsunamis strike with no warning, when individuals must be able to take quick and appropriate action with no official guidance.

Tsunami education can, however, be complicated – often, information needs to reach audiences that are diverse and, in many cases, technical information is inadequate or not easily accessible to emergency managers, local decision makers and the public.

NOAA's National Tsunami Hazard Mitigation Program identifies a set of activities that provide a framework for public education programmes.

Education efforts have been proven to be more effective if spread across as many channels and groups as possible, encompassing the electronic and print media, posters and signs, school curricula, museums and information centers, and workshops and other public forums.

According to the NTHMP's Strategic Implementation Plan, a tsunami education campaign needs to:

- Define the audiences.
- Determine what the audience needs to know.
- Define how to convey the message.
- Assess existing materials and resources.
- Select appropriate vehicles to reach targeted audiences.
- Develop needed materials.
- Define a dissemination mechanism.
- Define a strategy for sustained support.

Refer [3.3.6 -03 of 05] to view Users who are interested in education curricula aimed at children and young adults can to access the Schools Module in the CD-ROM .

Tsunami Awareness Kit

Most communities must work from the ground up to expand their knowledge, and establish procedures and programmes aimed at minimizing risks from tsunamis.

Recognizing the role that public awareness and education play in reducing vulnerability, the Pacific Disaster Center, South Pacific Applied Geoscience Commission (SOPAC), the ITIC, Pacific Tsunami Warning Centre and SOPAC member countries collaborated in 2005 to develop a Tsunami Awareness Kit. It is one of many hazard awareness efforts underway in the global community to help protect lives and property from future catastrophes.

The kit is a collection of resources that form the basis of a public awareness programme aimed at strengthening mechanisms for sharing information, knowledge, experiences and sound practices.

The resources can be used to brief stakeholders, government officials and communities on the potential impacts and hazards that result from tsunamis. The kit provides information that communities can use to respond to tsunamis, and to reduce their vulnerability.

For additional information about the Tsunami Awareness Kit, visit:

http://www.pdc.org/PDCNewsWebArticles/2005TAK/index.html

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors
3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Risk Communication Guide for State and Local Agencies

The US California Offices of Emergency Services produced a *Risk Communication Guide for State and Local Agencies* in 2001.

The 18-page guide provides basic information for emergency management professionals in regional and local emergency agencies, to assist them in developing a risk communication strategy to effectively communicate risk issues with the community.

It is designed to help the emergency management community to respond to media and public inquiries, and comprises checklists against which communication strategies can be devised, and guidelines for dealing with the media.

Tsunami meeting, July, 2005, Japan

Refer [3.3.6 -05 of 15] The Risk Communication Guide for State and Local Agencies can be found at: [PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Tsunami awareness resources

The International Tsunami Information Centre and a range of other organizations and authorities have produced public awareness, education and safety guides and brochures aimed at informing people how to respond to tsunamis and other types of disasters.

The following pages present different types of easy-to read, practical tsunami information and safety tips that can be disseminated among local communities to raise people's awareness of natural hazards – and, mostly importantly – what they can do to survive them.

They range from a booklet of eye witness accounts of the 1960 Chile tsunami and a Disaster Preparation Booklet to ITIC safety rules, brochures providing multi-hazard advice to local people and travelers, and a booklet on how to survive the aftermath of a disaster.

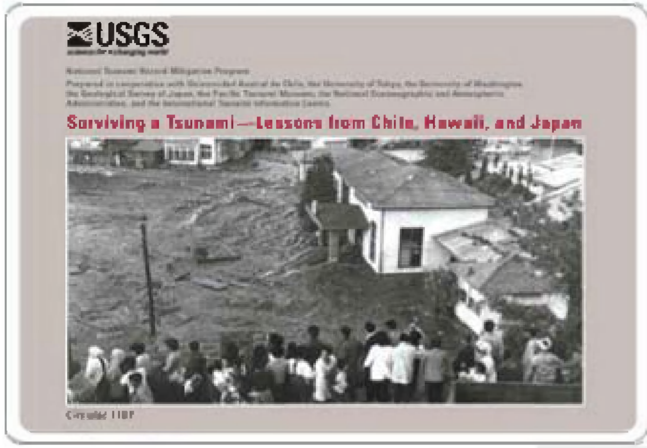
The ideas and information contained in the resources can be adapted to local contexts, or if they are already appropriate, reproduced for use as community awareness and education materials.

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan

True stories of how people survived – or did not survive – the great Pacific-wide tsunami of 1960 are told in an 18-page illustrated booklet. It contains interesting and valuable first-hand accounts by eye-witnesses that illustrate how to survive a tsunami, and is aimed at people who live, work or play along coasts where tsunamis might strike.

Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan was produced in 1999 by the United States Geological Survey and National Tsunami Hazard Mitigation Programme in cooperation with Universidad Austral de Chile, University of Tokyo, University of Washington, the Geological Survey of Japan and the Pacific Tsunami Museum.



Refer [3.3.6 -07 of 15] to view Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan,[PDF] in the CD-ROM .

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

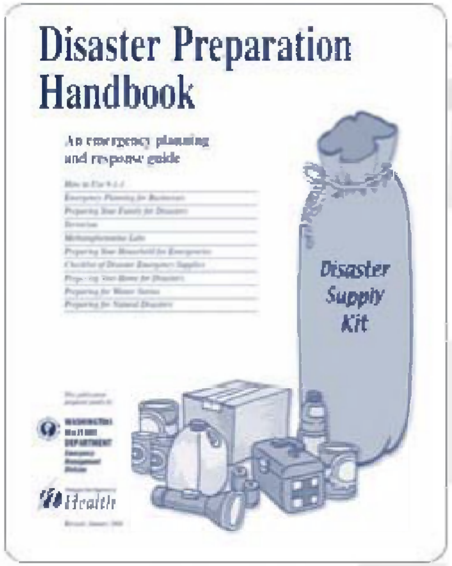
Disaster Preparation Handbook

The Washington Military Department Emergency Management Division produced a very practical and succinct illustrated *Disaster Preparation Handbook* as an emergency planning and response guide.

Not all of the booklet is applicable to tsunamis but much of it is. (There are non-applicable sections on terrorism and methamphetamine laboratories, and on winter storms.)

The *Disaster Preparation Handbook* has suggestions on how to use emergency phone lines, emergency planning for business, preparing families for disasters and households for emergencies, how to prepare a home for disasters, preparing for natural disasters, and a checklist of disaster emergency supplies.

Refer [3.3.6 -08 of 15] to view the Disaster Preparation Handbook,[PDF] in the CD-ROM .



3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

The International Tsunami Information Centre has compiled clear and pithy safety and "What to do" advice for people before and during a tsunami.

Refer [3.3.6 -07 of 06] to view learn what to do before a tsunami tsunami_preparedness.pdf, [PDF] in the CD-ROM .

Refer [3.3.6 -07 of 06] to view learn about warning signs – "Sensing a Tsunami" sensing_a_tsunami.pdf,[PDF] in the CD-ROM .

Refer [3.3.6 -07 of 06] to view the International Tsunami Information Centre safety rules tsunami_safety_rules.pdf,[PDF] in the CD-ROM .

Refer [3.3.6 -07 of 06] to view guidance to mariners tsunami_safety_for_boaters.pdf,[PDF] in the CD-ROM .

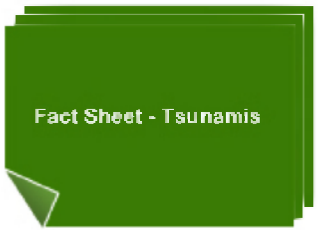
Fact Sheet – Tsunamis

The United States government's Federal Emergency Management Agency (FEMA) has a comprehensive disaster website with easy-to-read information for the public on what to do before, during and after a disaster strikes.

Its "before a tsunami" information ranges from people knowing whether their home is in a hazard zone and learning tsunami signs to making evacuation plans, teaching children what to do and packing a disaster kit with essential supplies.

There is advice on how to be safe and to stay informed during a tsunami, and what to do afterward, including what might be damaged and dangerous at home.

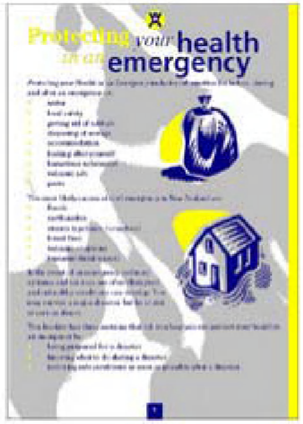
Additional information is provided regarding flooding – a lingering result of tsunami inundation.



The FEMA tsunami web page is at:

http://www.fema.gov/hazard/tsunami/index.shtm

Protecting your Health in an Emergency



Emergencies often arrive with little or no warning and they can cause extensive damage. After surviving a disaster, people often find themselves facing fresh threats to their safety such as lack of drinking water, unhygienic conditions that can lead to illness, lack of health services for the injured and of medical supplies, and lack of food and livelihoods.

Protecting your Health in an Emergency, a booklet produced in New Zealand, contains a comprehensive set of tips for the public on being prepared for a disaster, knowing what to do during a disaster, and restoring safe conditions as soon as possible after a disaster.

While there are small aspects of the booklet that might not be applicable to developing country conditions, it provides a wealth of practical tips ranging from basic hygiene to what common household goods can be hazardous if damaged, dealing with pets, how to dispose of sewerage, and how to make a temporary toilet.

The information can be adapted to local circumstances and disseminated to the public in a variety of ways, including via media supplements and programmes, school lessons, or leaflets produced by authorities, community groups or businesses.

Refer [3.3.6 -11 of 15] to view Protecting your Health in an Emergency ,[PDF] in the CD-ROM .

Refer [3.3.6 -11 of 15] to view Natural Hazards, Household Emergency and Survival Kit guidance from NZ Ministry of Civil Defense and EM,[PDF] in the CD-ROM .

Visit the NZ Ministry of Civil Defense and EM website and its Get Ready - Get Thru National Education Programme

http://www.civildefence.govt.nz/memwebsite.nsf

3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

The following are recommended tsunami resources that can be ordered to support learning and training on tsunamis by authorities, businesses or communities.

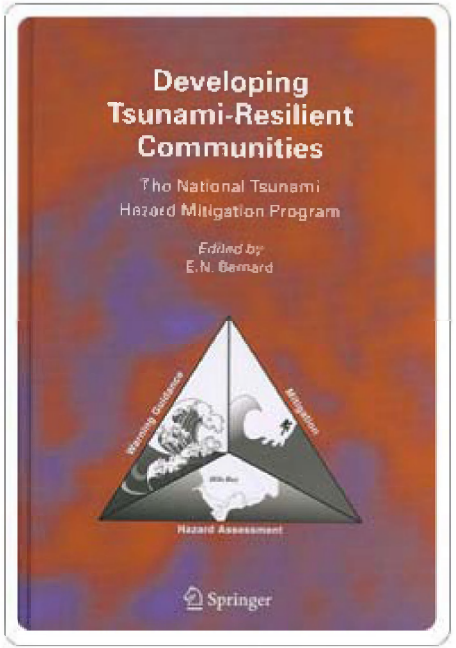
Developing Tsunami-Resilient Communities – to order

Developing Tsunami-Resilient Communities is a 184-page book, edited by EN Bernard.

The book is a compilation of journal articles outlining the development and accomplishments of the National Tsunami Hazard Mitigation Program in the United States, and it provides guidance and tools for emergency managers, planners, and responders.

It is available through:

Springer, PO Box 322, 3300 AH Dordrecht, The Netherlands



3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Tsunami: Waves of Destruction

Tsunami: Waves of Destruction is a 17 minute film – with a longer 28-minute version also available – on video and on DVD and highlights tsunamis in Hawaii, United States.

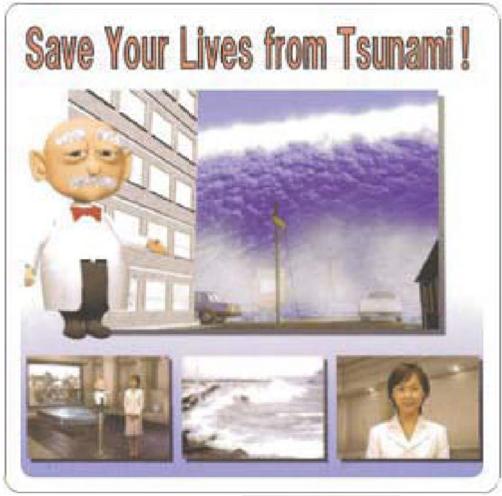
Produced in 2000, the film defines tsunamis and their causes, types and different impacts, and contains narratives of the 1946 and 1960 tsunamis in Hawaii as well as sections on tsunami public awareness and what to do during a tsunami warning. It can be used on any island or coast, with local examples added.

Tsunami: Waves of Destruction is a production of Hawaii State Civil Defense and Hawaii Public Television, and is a Charlotte Simmons Production.

Permission (v) has been obtained to duplicate the DVD for educational purposes, from Ray Lovell of Hawaii State Civil Defense. It is also available from VideoLab, Honolulu. Tel: +1 808 5930400

Refer [3.3.6 -13 of 15]   to view Tsunami: Waves of Destruction,[Video] in the CD-ROM .

Save Your Lives from Tsunami!



Save Your Lives from Tsunami! is a 17 minute film on CD planned and produced by the Japan Meteorological Agency in cooperation with NHK Enterprises 21, Inc.

Produced in 2004 in Japanese and English, the film defines tsunamis, the characteristics of tsunami waves, and their generation mechanisms. The film introduces Professor Tsunami who teaches the viewer about tsunamis, how to prepare for one, and what to do one a tsunami hits. Film recordings of tsunami waves and the damage that they caused in and around Japan is shown. Finally, the film describes the operation of the Japan National Tsunami Warning System by the Japan Meteorological Agency to immediately warn people against tsunamis.

The film uses animations to illustrate the earthquake and tsunami generation process, and shows actual footage of the waves striking coastal towns in Japan.

The CD is freely available from JMA and the ITIC.
Japan Meteorological Agency
Earthquake and Tsunami Observations Division
Seismological and Volcanological Department

Address:
1-3-4 Otemachi, Chiyoda-ku, Tokyo 100 8122, Japan
Tel: +81 3 3212 8341
Fax: +81 3 3215 2963
Website: http://www.jma.go.jp/en/tsunami/

International Tsunami Information Centre

Address: Suite 2200, 737 Bishop Street, Honolulu HI 96813-3213, United States
Tel: +1 808 532 6422
Fax: + 1 808 532 5576
Website: http://www.tsunamiwave.info/

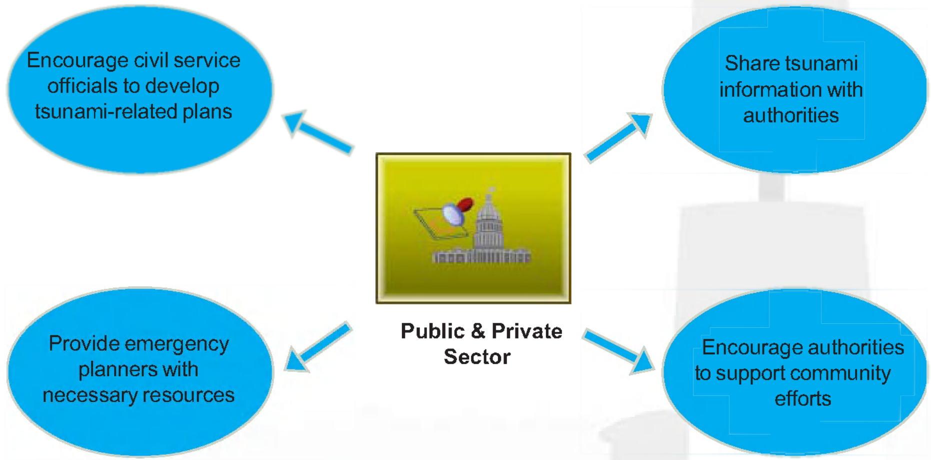
Refer [3.3.6 -13 of 15] *to view Save your lives from Tsunami!* ,[Video] in the CD-ROM .

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Training modules - 3.3 Public and Private Sectors
3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

You have now reached the end of the Public and Private sectors module.of the *TsunamiTeacher* resource kit. The learning objectives for authorities, community stakeholders and the private sector were to:

Authorities

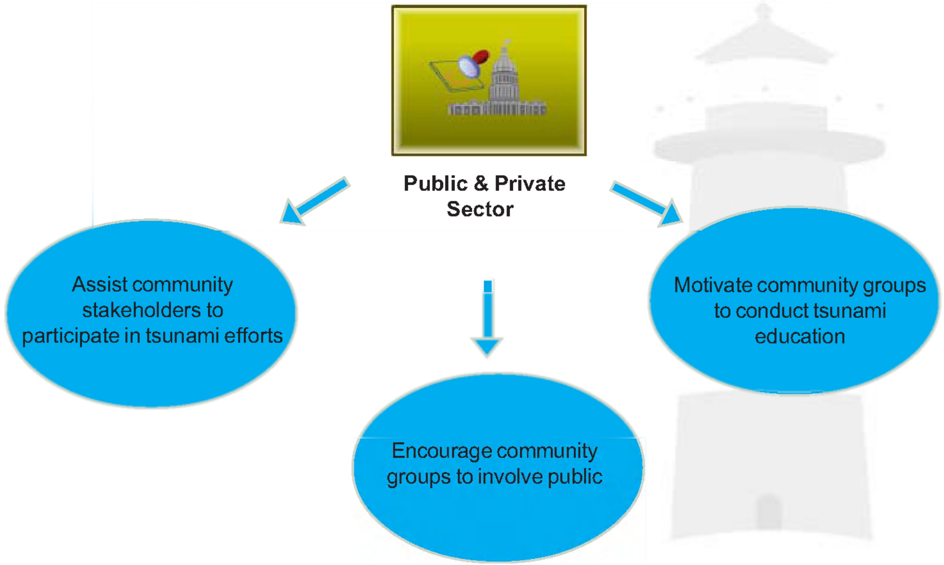
- Encourage elected and senior civil service officials to support the development of tsunami emergency response, public awareness and mitigation policies and plans.
- Provide hands-on emergency planners and managers with the resources they need to develop integrated tsunami warning, emergency and mitigation systems.
- Share with authorities the rich body of information and materials developed around the world on all aspects of tsunami warning, planning and preparedness that can be adapted appropriately to local contexts.
- Encourage national and local authorities to support coastal community groups and businesses with efforts to promote public tsunami awareness and preparedness.



3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Community stakeholders

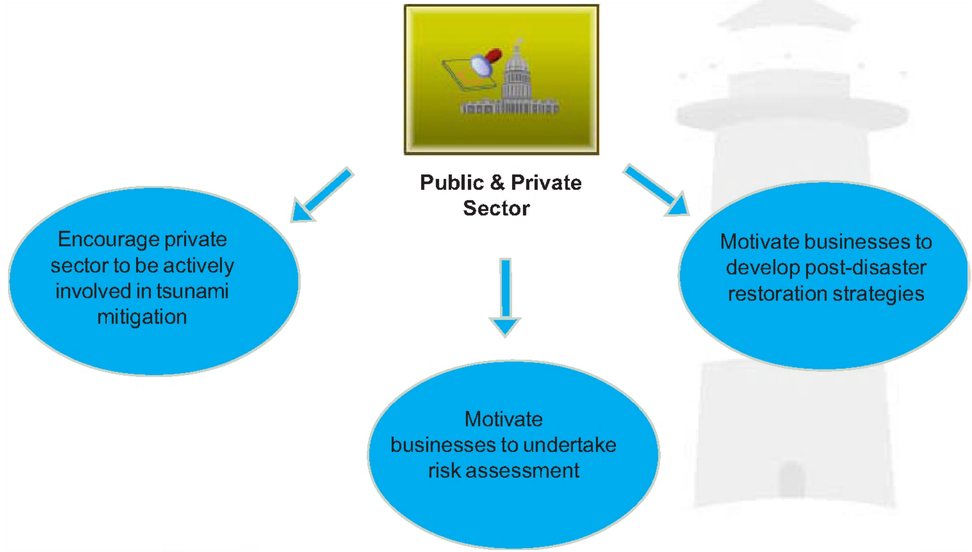
- Motivate and assist community stakeholders to become an integral part of local tsunami emergency response, preparedness and recovery planning and efforts.
- Encourage community groups to involve the people they reach in tsunami response exercises such as evacuation drills.
- Motivate and assist community groups to conduct public tsunami education.



3.3.6 Tsunami Mitigation - 3.3.6.9 Public awareness and education

Private sector

- Encourage the private sector to become actively involved in tsunami mitigation, preparedness, emergency response and recovery planning efforts.
- Motivate public and private businesses in coastal areas to undertake tsunami risk assessments, and to plan and implement emergency strategies that include tsunami events.
- Encourage public and private businesses to develop strategies that will enable services and opera tions to be restored as quickly as possible after disaster strikes.



Hopefully, these have been achieved. If you need additional information, please go back to the other training modules.

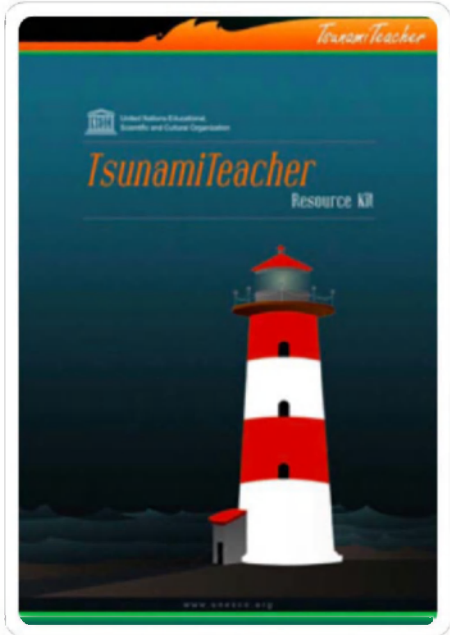
4 Workshops and Evaluation

4.1 Introduction

The overarching aim of *TsunamiTeacher* is to help build the capacity of people, communities and governments to prepare for tsunamis, to respond effectively when tsunamis strike, and to recover rapidly afterwards.

Access to a consolidated global source of quality tsunami information and experience, with training modules aimed at key stakeholder groups who could help raise the tsunami awareness and preparedness of coastal communities, could greatly support capacity-building efforts at all levels across all regions.

TsunamiTeacher can be used for self-learning, and as library of tsunami information and resources upon which media professionals, teachers, government officials, disaster response planners and managers, businesses and community groups can draw at any point.



4 Workshops and Evaluation

4.1 Introduction

It is recommended, however, that workshops be held to introduce *TsunamiTeacher's* target audiences to the contents of the kit, to enable people to engage intensively with its resources and to brainstorm ways in which the materials could assist tsunami-related activities. This section of *TsunamiTeacher* is geared to support workshop training efforts.

Drawing on the tsunami experiences of communities around the world, and on the studies of experts, it has been shown again and again that information and education are critical to saving lives during a tsunami and to the emergency preparedness of communities.

TsunamiTeacher's target audiences, and especially those in coastal communities and in high-risk tsunami regions, have key roles to play in raising public awareness and understanding of tsunamis, and in helping communities to prepare for tsunamis.

IOC-USGS Seismology and Tsunami Warning Training, Thailand, 2005.

4 Workshops and Evaluation

4.1 Introduction

By keeping the tsunami threat in the public eye, the media can assist efforts to promote public awareness of tsunamis. Schools can include tsunami learning in their curricula so that children learn to understand the great waves, the threat that they pose and how to respond.

National and local authorities, and businesses and community groups in coastal areas, can work together to develop tsunami emergency response plans and processes within a multi-hazard framework, and to promote public education on tsunamis.

The overall aim of *TsunamiTeacher* workshops is to advance the kit's intended outcomes, which are to enable people, groups and governments to:

- Share the valuable body of information gathered, and research and good practice undertaken, on tsunamis
- Adapt high quality generic materials appropriately to local contexts
- Grow stakeholder and public awareness of and preparedness for tsunamis
- Develop responses that have the potential to save lives and to mitigate the impacts of tsunamis

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher

4 Workshops and Evaluation
4.1 Introduction

A secondary purpose of workshops is to help evaluate *TsunamiTeacher*, so that the kit can be improved in future editions. Further, evaluations of workshops themselves will provide useful input into how future workshops might most successfully be organized.

To fulfill the important roles that they can play in tsunami awareness and preparedness, key stakeholders need to learn as much as possible about tsunamis and to become familiar with the resources available to assist them.

TsunamiTeacher's target audiences are busy people, but it is highly recommended that formal time be set aside for training workshops that fully familiarize people with the kit's rich information and resources – and save them a great deal of time afterwards when they use it.

IOC-ISDR Hawaii Study Tour, July 2005.

4 Workshops and Evaluation

4.1 Introduction

Workshop facilitators do not have to be qualified trainers. They can be middle level or senior personnel in the media, education, or in the public or private sectors who know their field well and would be able to identify aspects of *TsunamiTeacher* that are most appropriate to particular workshop participant groups.

There are plenty of materials, including films, power-point presentations, articles, brochures, documents and manuals that workshop trainers can extract from *TsunamiTeacher* to support workshop activities and training.

The proposed workshop frameworks in the following section are intended only as a broad guide to trainers conducting *TsunamiTeacher* courses.

Global Future Search workshop on disaster risk reduction,
UN Development Training Programme, February, 2006.

4 Workshops and Evaluation

4.1 Introduction

The Workshop frameworks suggest how time might be allocated during one-day or three-day workshops, especially between participants' working through the *TsunamiTeacher* kit or engaging in group work, and are a source of ideas for discussions and exercises.

TsunamiTeacher's target audiences have significantly different needs, and there are groups – for example, emergency response planners and managers – who would need workshops designed to suit their specialist requirements.

Trainers are entirely free to alter the workshop frameworks or to design workshops from scratch, depending on the time available, the needs of participants and the content most appropriate to different participant groups.

University of Puerto Rico scientist briefing the public on tsunamis at a local shopping mall.

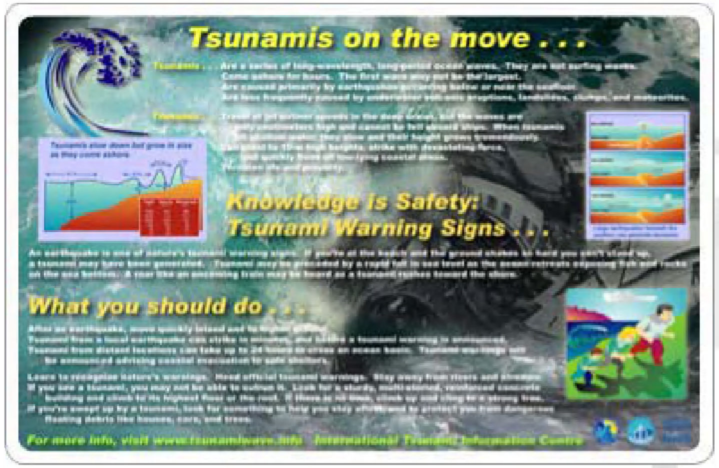
4 Workshops and Evaluation

4.1 Introduction

There are two evaluation forms: one asks workshop participants to rate the effectiveness of a range of editorial and design aspects of *TsunamiTeacher;* the other seeks feedback on workshops themselves.

The evaluation forms target workshop participants, but all users of *TsunamiTeacher* are invited to complete the kit evaluation questionnaire and send it by e-mail, fax or post to UNESCO's International Tsunami Information Centre (ITIC).

Contact details can be found in the "Links and Contacts" section of the kit.



4 Workshops and Evaluation

4.2 Trainer Notes

One suggested objective of *TsunamiTeacher* workshops is to persuade target audiences of the importance of raising awareness of and preparedness for tsunamis, and to encourage stakeholder groups to consider ways in which they might contribute to this goal.

Another objective is to introduce target audiences to the rich resources that *TsunamiTeacher* contains, and to guide workshop participants to materials that could assist them in getting tsunami messages out to the public and helping communities prepare for tsunamis.

Much of *TsunamiTeacher's* content is shared by the different target audiences – the media, schools, and the public and private sectors – and all workshop participants will spend some time on common content.

However, there are separate training modules for each of the groups, and so workshops for different audiences will have quite distinctive content. Even within key audiences, workshop focuses will be different (for instance, between national and local government officials).

Thus, trainers will need to fully familiarize themselves with content and materials appropriate to the particular groups of participants, and identity materials and formulate discussion topics and exercises to support different participant needs.

Rather than being a series of lectures, the workshops are divided between face-to-face sessions and time spent on computers working through the *TsunamiTeacher.*

The idea is for *TsunamiTeacher* users to complete workshops having:

- Been introduced to the appropriate body of information, resources, links and contacts contained in *TsunamiTeacher*.
- Deepened their knowledge and understanding of tsunamis.
- Generated ideas for ways to promote community awareness of and preparedness for tsunamis.
- Developed plans for mitigation-related activities to be pursued after the workshop, such as media reports, tsunami lessons in schools or developing emergency plans.
- Improved their ability to access and use tsunami information, resources and documents, including where possible via the Internet.
- Considered ways of adapting *TsunamiTeacher's* generic materials appropriately to local contexts.

4.2 Trainer Notes

The proposed workshop timetable is for eight hours a day, over one or three days. It can start and end at whatever time is appropriate locally and convenient for the trainer and participants. Each day is broken into four sessions of varying length, and they could be separated by two 30-minute tea-coffee breaks and a one-hour meal break.

The face-to-face sessions are interspersed with tsunami-related discussions, group activities and exercises that should be relevant to participants, their fields of work and their countries. For the three-day workshop, it is suggested that there are talks by experts and field visits.

The one-day workshop framework is designed as an introduction to *TsunamiTeacher*, aimed at familiarizing participants with the kit's organization and resources but not in-depth with its content, and at enthusing them with interest in tsunamis and persuading them to use *TsunamiTeacher* afterwards.

The three-day workshop does all of this, and also goes in-depth into *TsunamiTeacher's* content, grapples with issues around tsunami awareness and preparedness, and suggests that participants begin working towards tsunami mitigation activities. For ease of use, different kinds of activities are presented in texts of different colours.

These are:

Group discussions

Computer work

Exercises

It should be stressed again that the following frameworks are intended only as suggestions and ideas. Final workshop plans should be developed according to participant group needs.

4.2 Trainer Notes

One-day Workshop framework

First session: one hour

Introduction to TsunamiTeacher

The trainer welcomes and introduces the participants, and describes the *TsunamiTeacher* kit, and why and by whom it was produced. S/he then outlines the workshop programme, and its aims and intended outcomes.

The participants watch the 30-minute film *Asian Tsunami: Disaster of the Century*, produced by the Asia Pacific Broadcasting Union (ABU). It needs to be emphasized that the ABU holds copyright to the film, which may only be used for educational purposes (unless permission for commercial screening is negotiated with the ABU).

Group discussion

- Participants recall how they experienced the 2004 tsunami or how they felt when they watched television coverage of the event.
- With guidance from the trainer, participants discuss how more lives could have been saved and possible ways that coastal communities can protect themselves from tsunamis.

4.2 Trainer Notes

Second session: 1.5 hours

Tsunami awareness and preparedness roles

Computer work

Exercise

Group Discussion

Computer work

- Participants start up the *TsunamiTeacher* CD. The trainer briefly introduces participants to the "Glossary" and "Links and contacts" sections of the kit, and explains what their functions are.
- Participants then read through the whole of the "Getting started" section, including the click-through resources.
- Participants proceed to the relevant training module, and read through the first pages and the "Intro duction" section.

Exercise:

- Participants break into groups and brainstorm ideas around the possible roles that their sector (media, schools, or the public or private sectors) might play in promoting tsunami awareness and preparedness among the people they reach. This should not take up more than 20 to 25 minutes.

Group Discussion

- Participants discuss whether they have come across any further roles that their sector might play in tsunami awareness and preparedness, and whether some of the roles they thrashed out earlier are not contained in *TsunamiTeacher* – and if not, why not.

4.2 Trainer Notes

Third session: 1.5 hours

The great waves

The trainer explains to participants that the third session is aimed at imparting must-know information about tsunamis, and familiarizing them with the training modules.

Computer work

Group Discussion

Computer work

Participants of all workshops continue reading through the module. The trainer stresses that participants should merely read as much as they have time for in one hour and 15 minutes:

- Media Module: read "The great waves". Then proceed to "Tsunamis down the years".
- Schools Module: read "Teacher guide". When the section "*TsunamiTeacher* background resources" is reached, click through to and read "The great waves" and then "Tsunamis down the years" – but only the first section "A short history".
- Public and Private Sectors Module: read the "Key challenges" and "Tsunami science and history" sections, including the background materials considered appropriate to the participants.

Group Discussion

Participants discuss what they have learned about the basic science and causes of tsunamis, their history and tsunami research, and how that knowledge might be useful to tsunami mitigation efforts in their community and country.

4.2 Trainer Notes

Fourth session: two hours

Being prepared

Computer work

Exercise

Group Discussion

Computer work

Participants take a look at the remaining resources that are available in the training modules, spending one hour on this task.

- Media Module: read through the final "Being prepared" section of the module.
- Schools Module: take a look at the curriculum materials and classroom resources available in the final two sections of the module.
- Public and Private Sectors Module: read through section most relevant to the participants – "Strate gies to reduce risk – Policies and legal frameworks", "Tsunami warning systems" or "Tsunami mitiga tion – Planning and preparedness".

Exercise

Participants divide into groups and prepare plans for post-workshop tsunami-related activities, referring back to the Modules when necessary to suggest *TsunamiTeacher* resources that they might use.

- Media Module: groups brainstorm story or programme ideas or tsunami awareness campaigns, what they might contain and the resources and contacts they could use.
- Schools Module: groups design a two-lesson tsunami curriculum, including learning objectives, content and activities, and list the *TsunamiTeacher* or internet resources they would use.
- Public and Private Sectors Module: groups focus on an aspect of tsunami mitigation appropriate to their sector, and draft an early implementation plan.

Group Discussion

The groups report back on their projects, and participants are invited to comment and to discuss ways of taking forward tsunami-related activities after the workshop.

The trainer draws the workshop to a conclusion, and encourages the participants to use *TsunamiTeacher* in the future and to share the kit with their colleagues

4.2 Trainer Notes

Three-day Workshop framework

Day one: An introduction

First session: one hour

Introduction to TsunamiTeacher

The trainer welcomes and introduces the participants, and describes the *TsunamiTeacher* kit, and why and by whom it was produced. S/he then outlines the workshop programme, and its aims and intended outcomes.

The participants watch the 30-minute film *Asian Tsunami: Disaster of the Century*, produced by the Asia Pacific Broadcasting Union (ABU). It needs to be emphasized that the ABU holds copyright to the film, which may only be used for educational purposes (unless permission for commercial screening is negoti-ated with the ABU).

Group discussion

Group discussion

- Participants recall how they experienced the 2004 tsunami or how they felt when they watched television coverage of the event.
- With guidance from the trainer, participants discuss how more lives could have been saved and possible ways that coastal communities can protect themselves from tsunamis.

4.2 Trainer Notes

Second session: 1.5 hours

Tsunami awareness and preparedness roles

Computer work

Exercise

Discussion

Computer work

- Participants start up the *TsunamiTeacher* CD. The trainer briefly introduces participants to the "Glossary" and "Links and contacts" sections of the kit, and explains what their functions are.
- Participants then read through the whole of the "Getting started" section, including the click-through resources.
- Participants proceed to the relevant training module, and read through the first pages and the "Intro duction" section.

Exercise

- Participants break into groups and brainstorm ideas around the possible roles that their sector (media, education, or the public or private sectors) might play in promoting tsunami understanding and preparedness among the people they reach. Each group reports back on their findings, followed by a general discussion on all of the inputs.

Group Discussion

- Participants discuss whether they have come across any further roles that their sector might play in tsunami awareness and preparedness, and whether some of the roles they thrashed out earlier are not contained in *TsunamiTeacher* – and if not, why not.

4.2 Trainer Notes

Third session: 1.5 hours

An expert speaks

An expert visits to talk about the role of the relevant sector in promoting awareness of and preparedness for disasters generally, and how tsunami-readiness could fit into a local community and country's multi-hazard disaster framework. The kind of expert would depend on the nature of the participants' work but could, for instance, be the local director of emergency services, a politician who heads up a safety committee or a specialist in disaster planning or general safety issues.

Group Discussion

Participants have the opportunity to question the speaker discuss the issues that s/he has raised.

4.2 Trainer Notes

Fourth session: two hours

The great waves

The trainer explains to participants that the fourth session is aimed at imparting must-know information about the science of tsunamis, and starting to familiarize them with the training modules.

Computer work

Exercise

Computer work

Participants continue reading through their module. The trainer stresses that participants should read as much as they have time for in an hour and 15 minutes:

- Media Module: read "3.1.2: The great waves", including the click-through resources.
- Schools Module: read "Teacher guide". When the section "*TsunamiTeacher* background resources" is reached, click through to and read "The great waves".
- Public and Private Sectors Module: read the "Key challenges" and "Tsunami science and history" sections, including the background materials considered appropriate to the participants.

Exercise

Participants break into groups and discuss what they have learned about the science and causes of tsunamis, and how they might use this knowledge to either promote public awareness of, or community preparedness for, the tsunami threat. The groups report back on their findings, followed by a group discussion on the various inputs.

4.2 Trainer Notes

Day two: Knowledge is key

First session: 1.5 hours

Tsunamis down the years

The trainer informs participants that this session is dedicated to the history of tsunamis and the 2004 Indian Ocean tsunami, and what they have meant to the world.

Computer work

Exercise

Computer work

Participants in all workshops start where they left off the day before, and proceed to read the "Tsunamis down the years" section of *TsunamiTeacher*.

Exercise

Participants break into groups and work up ideas on how research into tsunamis, and experiences of past tsunamis – especially the 2004 Indian Ocean tsunami – can be used to enrich work they may do on tsunamis. For instance: media groups might look at interesting ways of covering a future 2004 tsunami anniversary; teachers may design a lesson on amazing tsunamis; and officials, businesses or community groups might consider how they might apply lessons learned from past tsunamis to future mitigation efforts.

4.2 Trainer Notes

Second session: 1.5 hours

Being prepared

Computer work

Group Discussion

Computer work

Participants begin to look at ways of mitigating tsunamis.

- Media and Schools Modules: participants read through the "Being prepared" section of the kit. This is the third and final section of the Media Module, and the last suggested read in the Schools Module Teachers Guide.
- Public and Private Sectors Module: depending on what is most relevant to them, participants work through the "Strategies to reduce risk – Policies and legal frameworks", "Tsunami warning systems" and-or the "Tsunami mitigation – Planning and preparedness" sections.

Discussion

Participants discuss what they have learned, and how the resources that they have found might feed into tsunami awareness and preparedness activities that they might undertake.

4.2 Trainer Notes

Third and fourth sessions: three hours

Field trip

Participants go into the field.

If the workshop is held in a coastal area, participants accompany a geologist or geographer on a tour of the coast, learning about how the physical features of their area would influence the impact of a tsunami. They learn where reefs may slow down the great waves, where harbour and river mouths might funnel and increase the impact of tsunamis, and where people might seek refuge when a tsunami strikes.

If the workshop is held inland, participants visit a scientist and-or a facility with experts who have a good geological overview of their country and its coast, and who can identify what areas are most vulnerable to tsunamis, why, and what can be done to mitigate future tsunamis in particular areas.

Day three: Being prepared

First session: 1.5 hours

Resources and plans

The final day encourages participants to focus on materials in *TsunamiTeacher* that are most relevant to them, and to select and engage with resources that will support post-workshop tsunami-related activities. Participants who feel they need more time to read through the kit's contents, should be given time to do this.

First, however, the trainer should introduce participants to the "Resource collection", and explain how this library of resources is organized and could be used by them in future.

Computer work

- The media: participants return to a section of the Media Module that is of interest to them and their readers or viewers. They read through the background materials, and conduct internet research and telephone interviews to learn more about this particular aspect of tsunamis, searching for information and thoughts that might feed into a article or programme or a series of articles or programme. They also explore the "Links and contacts" section for additional information sources.
- Schools: educators investigate the tsunami curricula and support materials featured in their module, and begin to select out resources they might want to use in the classroom.
- Public and private sectors: participants revisit the section of their module that is most relevant to their work or responsibilities, and begin to select background resources that might be useful to future tsunami-related activities.

Second and third sessions: three hours

Practicalities

The workshop should break half way through this session.

Exercise

Exercise

For these two practical sessions, participants choose to work individually or in groups to plan and work on future tsunami activities:

- The media: participants either write the content for an article or programme on a chosen tsunami topic and select images or film to accompany it, or draft an outline and proposal for a series of articles or programmes on tsunamis or for a media public awareness campaign.
- Schools: educators design a multi-lesson tsunami curriculum geared at pre-primary, primary or secondary school pupils, including learning objectives and content and activities, and listing the *TsunamiTeacher* or internet resources they would use.
- Public and private sectors: participants focus on one important aspect of tsunami mitigation that they might be involved in or could be appropriate to their work, and draft an outline of how it might effec tively be implemented .

4.2 Trainer Notes

Final sessions: 1.5 hours

In conclusion

Group Discussion

Exercise

Group Discussion

Participants present, individually or in groups, the practical outcomes of the past two sessions, and brainstorm how their plans might be improved and-or implemented.

Discussion: Participants express what they have learned during the three-day workshop, and how this new knowledge might help to further tsunami awareness and preparedness in their community, region or country.

Exercise

Participants complete the *TsunamiTeacher* evaluation forms.

The trainer brings the workshop to a conclusion, and encourages the participants to use *TsunamiTeacher* in the future and to share the kit with their colleagues.

4.3 Evaluation guide

Evaluation guide

Another purpose of *TsunamiTeacher* workshops is to evaluate the usefulness of the resource to stake-holders across the world, and to come up with suggestions for the kit's improvement.

As *TsunamiTeacher* workshops have their own set of goals – such as introducing audiences to tsunami information, improving participants' knowledge and understanding of tsunamis, and enhancing their capacity to promote tsunami awareness and preparedness – how effectively these were achieved during the workshop will also be evaluated.

Serious account will be taken of the views and suggestions made by workshop participants, expressed anonymously through questionnaires. It is suggested that trainers analyse the responses of participants contained in the completed questionnaires, describe the results in a workshop report, and submit the report to the International Tsunami Information Centre.

4.3 Evaluation guide

The evaluation forms draw heavily on questions and ideas developed for previous UNESCO workshop evaluations, and in the CD section on the Eductra: Human System Design's *Evaluation of the Information Management Resource Kit – Module A* (www.eductra.it) .

The questionnaires are divided into sections that deal with various aspects of the *TsunamiTeacher* kit and the training workshop. Workshop participants should be encouraged to be frank in answering the anonymous questionnaires, in the interest of improving *TsunamiTeacher* and future UNESCO workshops.

Questions should be answered by placing a tick or a cross in the box that best represents their opinion, on a scale ranging from “Very poor” to “Poor”, “Average”, “Good” and “Very good”. There are also open-ended questions that ask for comments.

TsunamiTeacher questionnaire

Workshop questionnaire

TsunamiTeacher questionnaire

The *TsunamiTeacher* questionnaire is divided into two sections: The first determines how successfully the kit achieved its objectives. The second evaluates the CD kit's content and design.

Workshop questionnaire

This questionnaire evaluates *TsunamiTeacher* workshops in a general way.

Because workshops will be of different length and will cater for different audiences, it is not possible to frame questions for specific sessions or aspects of workshops. However, trainers are free to add in questions that deal with individual sessions, presentations or activities.

Glossary

The International Tsunami Information Centre in Hawaii, part of the Intergovernmental Oceanographic Commission of UNESCO, publishes an illustrated *Tsunami Glossary* that explains tsunami-related terms and organizations. The Glossary is divided into six sections:

- Tsunami classification, which describes different kinds of tsunamis.
- General tsunami terms used in tsunami mitigation, and in generation and modeling.
- Surveys and measurements: terms used to measure and describe tsunamis.
- Tide, mareograph (tide gauge) and sea level terms.
- Acronyms and organization: describing tsunami-related organizations and products.
- Bibliography.

There is also an alphabetical index at the end, to enable users to locate terms rapidly.

The 36-page full-colour ITIC *Tsunami Glossary* is free to be reproduced for educational purposes. *TsunamiTeacher* users can print out the Glossary and use it to learn about tsunamis, or as a reference document.

There is also an alphabetical list below of the terms, acronyms and organizations contained in the *Tsunami Glossary*, divided into two sections “Glossary of tsunami terms” and “Acronyms and organization”.

While working through *TsunamiTeacher*, users can at any point click on the “Glossary” button in the top bar of the screen frame, find a term, acronym or organization they would like described, and access its definition by clicking on the relevant word or words.

Refer [Glossary] to access the ITIC Tsunami Glossary [PDF] in the CD-ROM .

Longer and more scientific tsunami terms can also be found on the ITIC website at:

http://www.tsunamiwave.info

A

Air-coupled tsunami

Synonym for atmospheric tsunami.

Arrival time

Time of the first maximum of the tsunami waves.

Atmospheric tsunami

Tsunami-like waves generated by a rapidly moving atmospheric pressure front moving over a shallow sea at about the same speed as the waves, allowing them to couple.

B

Breaker

A sea-surface wave that has become so steep (wave steepness of 1/7) that the crest outraces the body of the wave and it collapses into a turbulent mass on shore or over a reef. Breaking usually occurs when the water depth is less than 1.28 times the wave height. Roughly, three kinds of breakers can be distinguished, depending primarily on the gradient of the bottom:

- Spilling breakers (over a nearly flat bottom) which form a foamy patch at the crest and break gradually over a considerable distance.
- Plunging breakers (over fairly steep bottom gradients) which peak up curl over with a tremendous overhanging mass and then break with a crash.
- Surging breakers (over very steep bottom gradients) which do not spill or plunge but surge up the beach face.

Waves also break in deep water if they build too high while being generated by the wind, but these are usually short-crested and are termed whitecaps.

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Breakwater

An offshore or onshore structure, such as a wall, water gate, or other in-water wave-dissipating object that is used to protect a harbour or beach from the force of waves.

Sea wall with stairway evacuation route used to protect a coastal town against tsunami inundation in Japan. Photo courtesy of River Bureau, Ministry of Land, Infrastructure and Transport, Japan.

Water gate used to protect against tsunami waves on Okushiri Island, Japan. The gate begins to automatically close within seconds after earthquake shaking triggers its seismic sensors. Photo courtesy of ITIC.

C

Cotidal

Indicating equality with the tides or a coincidence with the time of high or low tide.

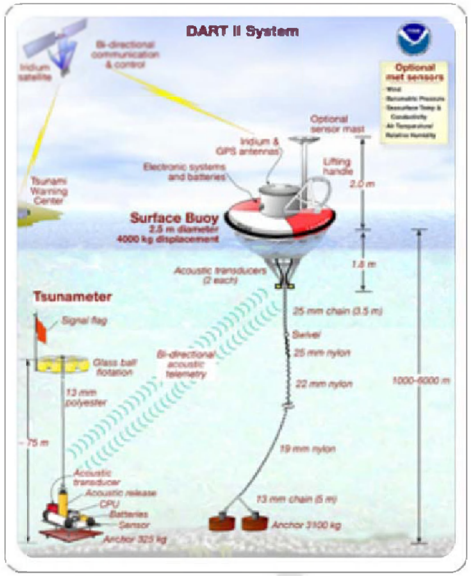
Crest length

The length of a wave along its crest. Sometimes called crest width.

D

Deep-ocean Assessment and Reporting of Tsunamis (DART)

An instrument for the early detection, measurement, and real-time reporting of tsunamis in the open ocean. Developed by the US NOAA Pacific Marine Environmental Laboratory, the DART system consists of a seafloor bottom pressure recording system capable of detecting tsunamis as small as one cm, and a moored surface buoy for real-time communications. An acoustic link is used to transmit data from the seafloor to the surface buoy. The data are then relayed via a satellite link to ground stations, which demodulate the signals for immediate dissemination to the NOAA tsunami warning centres. The DART data, along with state-of-the-art numerical modelling technology, are part of a tsunami forecasting system package that will provide site-specific predications of tsunami impact on the coast.



Drop

The downward change or depression in sea level associated with a tsunami, a tide or some longterm climatic effect.

E

Eddy

By analogy with a molecule, a “glob” of fluid within a fluid mass that has a certain integrity and life history of its own; the activities of the bulk fluid being the net result of the motion of the eddies.

Eddies generated by the interactions of tsunami waves as they hit the coast of Sri Lanka, 26 December 2004. Photo courtesy of Digital Globe.

Elapsed time

Time between the maximum level arrival time and the arrival time of the first wave.

Estimated time of arrival (ETA)

Time of tsunami arrival at some fixed location, as estimated from modelling the speed and refraction of the tsunami waves as they travel from the source. ETA is estimated with very good precision if the bathymetry and source are well known (less than a couple of minutes).

Evacuation map

A drawing or representation that outlines danger zones and designates limits beyond which people must be evacuated to avoid harm from tsunami waves. Evacuation routes are sometimes designated to ensure the efficient movement of people out of the evacuation zone to evacuation shelters.

Inundation and Evacuation Map created for the coastal town of Pucusana, Peru.

Elevated platform used for tsunami evacuation that also serves as a high-elevation scenic vista point for tourist. Okushiri Island, Japan. Photo courtesy of ITIC.

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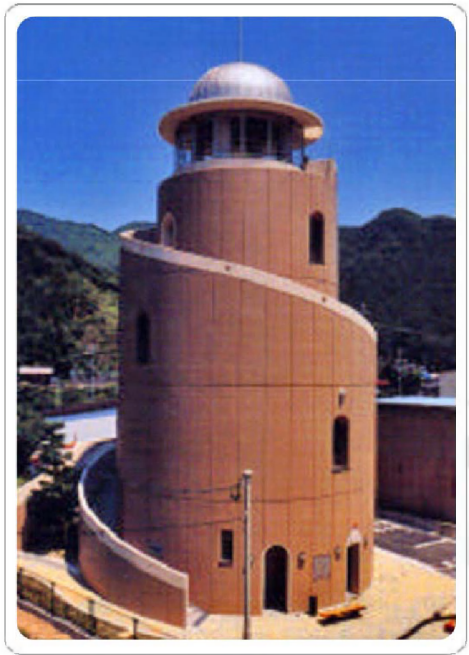


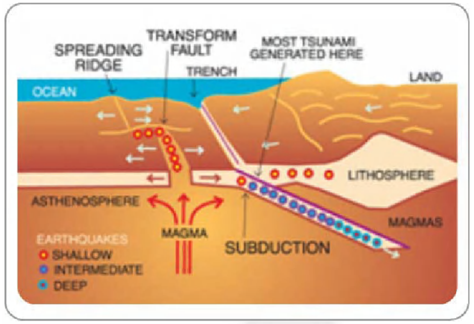
Emergency shelter building that also acts as community centre and Museum for Disaster Prevention. Kisei, Mie Prefecture, Japan. The building is 22-m high, has five floors covering 320 m2 , and holds 500 persons. Info courtesy of http://www.webmie.or.jp.

Epicentre

This is the point on the Earth's surface directly above the focus.

Earthquake(Magnitude)

This is a measure of the relative size of an earthquake. A number of different magnitude scales exist besides the Richter scale, including the moment magnitude, which measures the energy released and gives the most reliable estimate for large earthquakes.



Credit: IOC-ITIC

Because the scale is logarithmic, an increase in one unit of magnitude corresponds to a 10-fold increase in seismic wave amplitude and a 30-fold increase in released energy. And a change of 0.3 units equals a three-fold increase in intensity.

In other words, the 9.3 Sumatra earthquake that generated the 2004 Indian Ocean tsunami was three times more powerful than the 9.0 earthquake it was originally thought to be.
Moment magnitude is measurable nearly immediately thanks to the advent of modern seismometres, digital recording, and real-time communication links. It allows warning centres to provide initial tsunami advisories within minutes of an earthquake occurrence. In Japan, earthquake warnings get broadcast to the public within 30 seconds of them happening.

F

Focus

This is the point on the Earth where a rupture first occurs and where the first seismic waves originate.

H

Historical tsunami

A tsunami documented to occur through eyewitness or instrumental observation within the historical record.

Historical tsunami data

Historical data are available in many forms and at many locations. These forms include published and unpublished catalogs of tsunami occurrences, personal narratives, marigraphs, tsunami amplitude, runup and inundation zone measurements, field investigation reports, newspaper accounts, film, or video records.

I

Initial rise

Time of the first minimum of the tsunami waves.

Intensity

Extreme strength, force, or energy.

Inundation

The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline.

Tsunami inundation generated by the earthquake of 26 May 1983, at Oga aquarium in Japan. Photo courtesy of Takaaki Uda, Public Works Research Institute, Japan.

Inundation (maximum)

Maximum horizontal penetration of the tsunami from the shoreline. A maximum inundation is measured for each different coast or harbour affected by the tsunami.

Inundation area

Area flooded with water by the tsunami.

Dark area shows inundation area from the 1964 Alaska tsunami. Photo courtesy of NGDC.

Inundation line

Inland limit of wetting, measured horizontally from the mean sea level (MSL) line. The line between living and dead vegetation is sometimes used as a reference. In tsunami science, the landward limit of tsunami runup.

L

Leading wave

First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in sea level, and in other cases, an elevation or rise in sea level. When a drop in sea level occurs, sea level recession is observed.

Local tsunami

A tsunami from a nearby source for which its destructive effects are confined to coasts within 100 km of the source. A local tsunami is usually generated by an earthquake, but can also be caused by a landslide or a pyroclastic flow from a volcanic eruption.

Low water

The lowest water level reached during a tide cycle. The accepted popular term is low tide.

M

Magnitude

A number assigned to a quantity by means of which the quantity may be compared with other quantities of the same class.

Maremoto

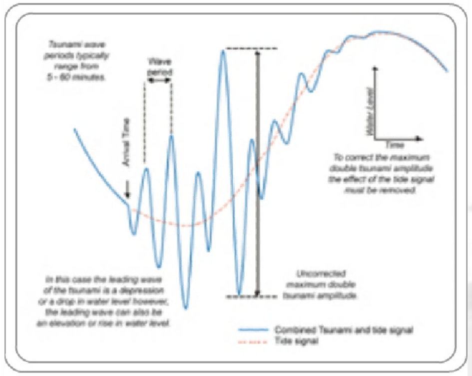
Spanish term for tsunami.

Damage caused by the 22 May 1960 Chilean tsunami. Photo courtesy of Ilustre Municipalidad de Maullin, USGS Circular 1187.

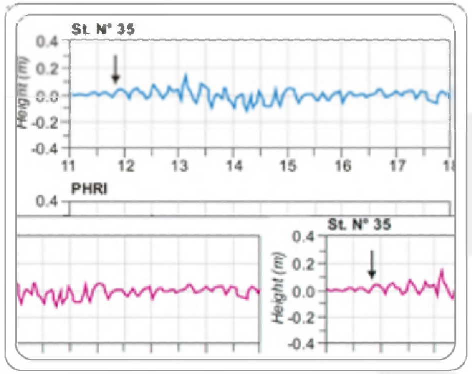
Mareogram or Marigram

1) Record made by a mareograph.

2) Any graphic representation of the rise and fall of the sea level, with time as abscissa and height as ordinate, usually used to measure tides, may also show tsunamis.



Mareogram (sea level) record of a tsunami.



Mareograms of tsunami signals measured by an underwater gauge located 50 km outside the entrance to Tokyo Bay in about 50 m of water (upper trace), and another gauge located at the shore (lower trace). The tsunami is detected on the outside gauge about 40 minutes before it reaches shore (arrows). The offshore gauge was developed by Japan's Port and Harbours Research Institute.

Mareograph

A recording sea level gauge. Also known as a marigraph or tide gauge.

Mean height

Average height of a tsunami measured from the trough to the crest after removing the tidal variation.

Mean sea level

The average height of the sea surface, based upon hourly observation of tide height on the open coast or in adjacent waters which have free access to the sea. These observations are to have been made over a "considerable" period of time. In the United States, mean sea level is defined as the average height of the surface of the sea for all stages of the tide over a 19-year period. Selected values of mean sea level serve as the sea level datum for all elevation surveys in the United States. Along with mean high water, mean low water, and mean lower low water, mean sea level is a type of tidal datum.

Microtsunami

A tsunami of such small amplitude that it must be observed instrumentally and is not easily detected visually.

O

Ocean-wide tsunami

A tsunami capable of widespread destruction, not only in the immediate region of its generation but across an entire ocean. All ocean-wide tsunamis have been generated by major earthquakes. Synonym for teletsunami or distant tsunami.

Overflow

A flowing over, inundation.

p

Paleotsunami

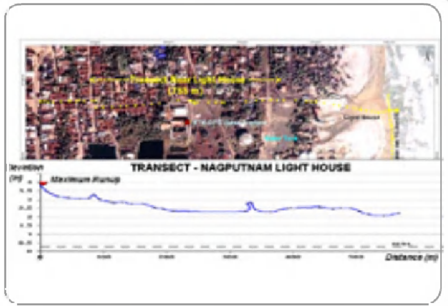
Tsunami occurring prior to the historical record or for which there are no written observations. Paleotsunami research is based primarily on the identification, mapping, and dating of tsunami deposits found in coastal areas, and their correlation with similar sediments found elsewhere locally, regionally, or across ocean basins. In one instance, the research has led to a new concern for the possible future occurrence of great earthquakes and tsunamis along the northwest coast of North America. In another instance, the record of tsunamis in the Kuril-Kamchatka region is being extended much further back in time. As work in this field continues it may provide a significant amount of new information about past tsunamis to aid in the assessment of the tsunami hazard.

Post-tsunami survey

Tsunamis are relatively rare events and most of their evidence is perishable. Therefore, it is very important that reconnaissance surveys be organized and carried out quickly and thoroughly after each tsunami occurs, to collect detailed data valuable for hazard assessment, model validation, and other aspects of tsunami mitigation.

In recent years, following each major destructive tsunami, a post-tsunami reconnaissance survey has been organized to make measurements of runups and inundation limits and to collect associated data from eyewitnesses such as the number of waves, arrival time of waves and which wave was the largest. The surveys have been organized primarily on an ad-hoc basis by international academic tsunami researchers. A Post-Tsunami Survey Field Guide (http://ioc3.unesco.org/itic/contents.php?id=28) has been prepared by the PTWS to help with preparations of surveys, to identify measurements and observations to be taken, and to standardize data collections. The Tsunami Bulletin Board e-mail service has also been used for quickly organizing international surveys and for sharing of the observations from impacted areas.

After a major tsunami, physical oceanographers, social scientists and engineers conduct post-tsunami surveys to collect information. These data, including runup and inundation, deformation, scour, building and structural impact, wave arrival descriptions, and social impact, are important for designing better mitigation to reduce the impacts of tsunami on life and property.
Photo courtesy of Philip Liu, Cornell University.



Post-tsunami survey measuring runup along a transect inland from the coast. Courtesy of ICMAM, Chennai, DOD, India.

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Probable maximum water level

A hypothetical water level (exclusive of wave run-up from normal wind-generated waves) that might result from the most severe combination of hydrometeorological, geoseismic and other geophysical factors that are considered reasonably possible in the region involved, with each of these factors considered as affecting the locality in a maximum manner.

This level represents the physical response of a body of water to maximum applied phenomena such as hurricanes, moving squall lines, other cyclonic meteorological events, tsunamis, and astronomical tide combined with maximum probable ambient hydrological conditions such as wave level with virtually no risk of being exceeded.

R

Recession

Drawdown of sea level prior to tsunami flooding. The shoreline moves seaward, sometimes by a kilometre or more, exposing the sea bottom, rocks, and fish. The recession of the sea is a natural warning sign that a tsunami is approaching.

North Shore, Oahu, Hawaii. During the 9 March 1957 Aleutian Island tsunami, people foolishly explored the exposed reef, unaware that tsunami waves would return in minutes to inundate the shoreline. Photo by A. Yamauchi, courtesy of Honolulu Star-Bulletin.

Reference sea level

The observed elevation differences between geodetic benchmarks are processed through least-squares adjustments to determine orthometric heights referred to a common vertical reference surface, which is the reference sea level. In this way, height values of all benchmarks in the vertical control portion of a surveying agency are made consistent and can be compared directly to determine differences of elevation between benchmarks in a geodetic reference system that may not be directly connected by lines of geodetic leveling.

The vertical reference surface in use in the United States, as in most parts of the world, approximates the geoid. The geoid was assumed to be coincident with local mean sea level at 26 tidal stations to obtain the Sea Level Datum of 1929 (SLD 290). National Geodetic Vertical Datum of 1929 (NGVD 29) became a name change only, the same vertical reference system has been in use in the United States since 1929. This important vertical geodetic control system is made possible by a universally accepted, reference sea level.

Refraction diagrams

Models using water depths, direction of wave, separation angle, and ray separation between two adjacent rays as input, produce the path of wave orthogonals, refraction coefficients, wave heights, and travel times.

Regional tsunami

A tsunami capable of destruction in a particular geographic region, generally within about 1,000 kilometres (625 miles) of its source. Regional tsunamis also occasionally have very limited and localized effects outside the region.

Most destructive tsunami can be classified as local or regional, meaning their destructive effects are confined to coasts within a 100 km, or up to a 1,000 km, respectively, of the source — usually an earthquake. It follows many tsunami related casualties and considerable property damage also comes from these tsunamis. Between 1975 and 2005 there were 22 local or regional tsunamis in the Pacific and adjacent seas that resulted in deaths and property damage.

For example, a regional tsunami in 1983 in the Sea of Japan or East Sea, severely damaged coastal areas of Japan, Korea, and Russia, causing more than $800 million in damage, and more than 100 deaths. Then, after nine years without an event, 11 locally destructive tsunamis occurred in just a seven-year period from 1992 to 1998, resulting in over 4,200 deaths and hundreds of millions of dollars in property damage. In most of these cases, tsunami mitigation efforts in place at the time were unable to prevent significant damage and loss of life. However, losses from future local or regional tsunamis can be reduced if a denser network of warning centres, seismic and water-level reporting stations, and better communications are established to provide a timely warning, and if better programmes of tsunami preparedness and education can be put in place.

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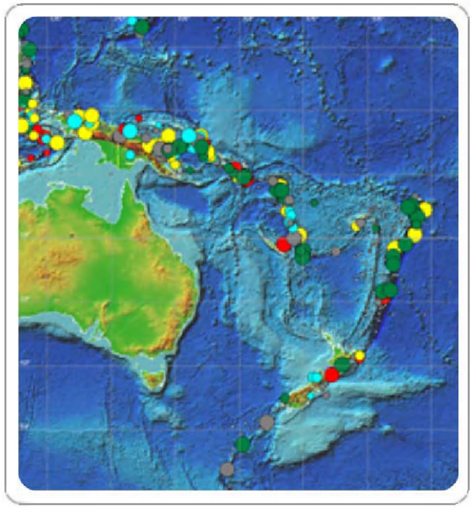
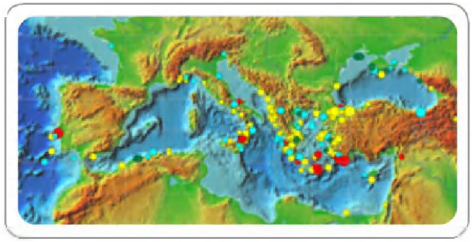
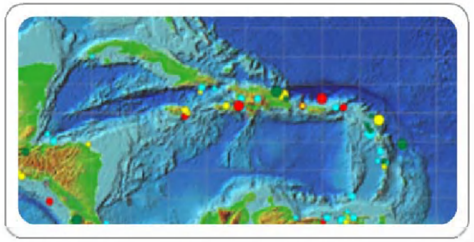


Earthquakes generating tsunamis in the Southwest Pacific. Source: ITDB, 2005. Red circles show tsunamis causing greatest damage according to the Imamura-Soloviev tsunami intensity scale. Grey circles are non-tsunamigenic earthquakes. The size of the circle is scaled to the magnitude of the earthquake.



Earthquakes generating tsunamis in the Mediterranean and connected seas. Source: ITDB, 2005.



Earthquakes generating tsunamis in the Caribbean and adjacent seas. Source: ITDB, 2005.

Rise

The upward change or elevation in sea level associated with a tsunami, a tropical cyclone, storm surge, the tide, or other long term climatic effect.

Runup

1- Difference between the elevation of maximum tsunami penetration (the inundation line) and the sea level at the time of the tsunami.

2- Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami attack, etc., and measured ideally at a point that is the local maximum of the horizontal inundation.

3- In practical terms, runup is only measured where there is clear evidence of the inundation limit on the shore.

Tsunami stripped forested hills of vegetation leaving clear marker of tsunami runup, Banda Aceh, 26 December 2004 Sumutra tsunami. Photo courtesy of Yuichi Nishimura, Hokkaido University.

Runup distribution

Set of tsunami runup values measured or observed along a coastline.

S

Sea level

The height of the sea at a given time measured relative to some datum, such as mean sea level

Sea level station

A system consisting of a device such as a tide gauge for measuring the height of sea level, a data collection platform (DCP) for acquiring, digitizing, and archiving the sea level information digitally, and often a transmission system for delivering the data from the field station to a central data collection centre. The specific requirements of data sampling and data transmission are dependent on the application. The GLOSS programme maintains a core network of sea level stations. For local tsunami monitoring, one-second sampled data streams available in real-time are required. For distant tsunamis, warning centres may be able to provide adequate warnings using data acquired in near-real time (one-minute sampled data transmitted every 15 minutes). Sea level stations are also used for sea level rise and climate change studies, where an important requirement is for the very accurate location of the station as acquired through surveying techniques.

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Rarotonga sea level station, Avarua Harbor, Cook Islands. The fiberglass electronics package (a), antenna (b), solar panel (c) were installed on a pier. Conduit (d) containing cables connecting the sensor, located at a depth of five feet below low-tide water level, to the data collection platform containing the electronics above, was externally attached to the tube containing the sensor (e).

GLOSS sea level stations employ a number of instruments to measure sea level, including down-looking radars to measure sea level. Port Louis, Mauritius. Photo courtesy of University of Hawaii Sea Level Center.

Seiche

A seiche may be initiated by a standing wave oscillating in a partially or fully enclosed body of water. It may be initiated by long period seismic waves (an earthquake), wind and water waves, or a tsunami.

Seismic sea wave

Tsunamis are sometimes referred to as seismic sea waves because they are most often generated by earthquakes.

Sieberg tsunami intensity scale

A descriptive tsunami intensity scale, which was later modified into the Sieberg-Ambraseys tsunami intensity scale described below (Ambraseys 1962).

Modified Sieberg Sea-wave Intensity Scale

1) Very light. Wave so weak as to be perceptible only on tide-gauge records.

2) Light. Wave noticed by those living along the shore and familiar with the sea. On very flat shores generally noticed.

3) Rather strong. Generally noticed. Flooding of gently sloping coasts. Light sailing vessels or small boats carried away on shore. Slight damage to light structures situated near the coast. In estuaries reversal of the river flow some distance upstream.

4) Strong. Flooding of the shore to some depth. Light scouring on man-made ground. Embankments and dikes damaged. Light structures near the coasts damaged. Solid structures on the coast injured. Big sailing vessels and small ships drifted inland or carried out to sea. Coasts littered with floating debris.

5) Very strong. General flooding of the shore to some depth. Breakwater walls and solid structures near the sea damaged. Light structures destroyed. Severe scouring of cultivated land and littering of the coast with floating items and sea animals. With the exception of big ships, all other type of vessels carried inland or out to sea. Big bores in estuary rivers. Harbour works damaged. People drowned. Wave accompanied by strong roar.

6) Disastrous. Partial or complete destruction of man-made structures for some distance from the shore. Flooding of coasts to great depths. Big ships severely damaged. Trees uprooted or broken. Many casualties.

Significant wave height

The average height of the one-third highest waves of a given wave group. Note that the composition of the highest waves depends on the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period. Also called characteristic wave height.

Spreading

When referring to tsunami waves, it is the spreading of the wave energy over a wider geographical area as the waves propagate away from the source region. The reason for this geographical spreading and reduction of wave energy with distance traveled, is the sphericity of the earth. The tsunami energy will begin converging again at a distance of 90 degrees from the source. Tsunami waves propagating across a large ocean undergo other changes in configuration primarily due to refraction, but geographical spreading is also very important depending on the orientation, dimensions, and geometry of the tsunami source.

Subsidence (uplift)

The permanent movement of land down (subsidence) or up (uplift) due to geologic processes, such as during an earthquake.

The 26 December 2004 earthquake resulted in 1.2 m of land subsidence in the Car Nicobar, Nicobar Islands, India leaving houses that were once above sea level now permanently submerged. Photo courtesy of ICMAM, Chennai, DOD, India.

T

Teletsunami or distant tsunami

A tsunami originating from a far away source, generally more than 1,000 km away.

Less frequent, but more hazardous than regional tsunamis, are ocean-wide or distant tsunamis. Usually starting as a local tsunami that causes extensive destruction near the source, these waves continue to travel across an entire ocean basin with sufficient energy to cause additional casualties and destruction on shores more than 1,000 kilometres from the source. In the last 200 years, there have been at least 21 destructive ocean-wide tsunamis.

The most destructive Pacific-wide tsunami of recent history was generated by a massive earthquake off the coast of Chile on 22 May 1960. All Chilean coastal towns between the 36th and 44th parallels were destroyed or heavily damaged by the action of the tsunami and the quake. The combined tsunami and earthquake toll included 2,000 killed, 3,000 injured, two million homeless and $550 million damage. Off the coast of Corral, Chile, the waves were estimated to be 20 metres (67 feet) high. The tsunami caused 61 deaths in Hawaii, 20 in the Philippines and 138 in Japan. Estimated damages were US $50 million in Japan, US $24 million in Hawaii and several millions of dollars along the west coast of the United States and Canada. Distant wave heights varied from slight oscillations in some areas to 12 metres (40 feet) at Pitcairn Island, 11 metres (37 feet) at Hilo, Hawaii, and six metres (20 feet) at some places in Japan.

The worst tsunami catastrophe in history occurred in the Indian Ocean on 26 December 2004, when a M9.3 earthquake off the northwest coast of Sumatra, Indonesia, produced an ocean-wide tsunami that hit Thailand and Malaysia to the east, and Sri Lanka, India, the Maldives, and Africa to the west as it traversed across the Indian Ocean. Nearly 250,000 people lost their lives and more than a million people were displaced, losing their homes, property, and livelihoods. The magnitude of death and destructiveness caused immediate response by the world's leaders and led to the development of the Indian Ocean tsunami warning and mitigation system in 2005. The event also raised awareness of tsunami hazards globally, and new systems were established in the Caribbean, the Mediterranean, and Atlantic.

The tsunami of 26 December 2004 destroyed the nearby city of Banda Aceh leaving only a few structures standing. Photo courtesy of Yuichi Nishimura, Hokkaido University.

Tidal wave

1) The wave motion of the tides.

2) Often incorrectly used to describe a tsunami, storm surge, or other unusually high and therefore destructive water levels along a shore that are unrelated to the tides.

Tide

The rhythmic, alternate rise and fall of the surface (or water level) of the ocean, and of bodies of water connected with the ocean such as estuaries and gulfs, occurring twice a day over most of the Earth and resulting from the gravitational attraction of the moon (and, in lesser degrees, of the sun) acting unequally on different parts of the rotating Earth.

Tide amplitude

One-half of the difference in height between consecutive high water and low water; hence, half of the tidal range.

Tide gauge

A device for measuring the height (rise and fall) of the tide. Especially an instrument for automatically making a continuous graphic record of tide height versus time.

Tide station

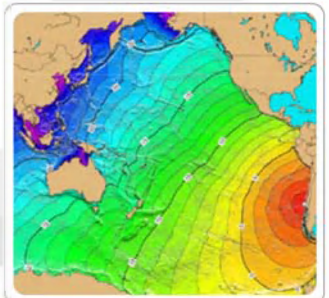
A place where tide observations are obtained.

Travel time

Time required for the first tsunami wave to propagate from its source to a given point on a coastline.

Travel time map

Map showing isochrons or lines of equal tsunami travel time calculated from the source outwards toward terminal points on distant coastlines.



Travel times (in hours) for the 22 May 1960 Chile tsunami crossing the Pacific basin. This tsunami was extremely destructive along the nearby coast of Chile, and the tsunami also caused significant destruction and casualties as far away as Hawaii and Japan. The awareness and concern raised by this Pacific-wide tsunami ultimately led to the formation of the PTWS.

Tsunameter

An instrument for the early detection, measurement, and real-time reporting of tsunamis in the open ocean. Also known as a tsunamimeter. The DART system is a tsunameter.

Tsunami

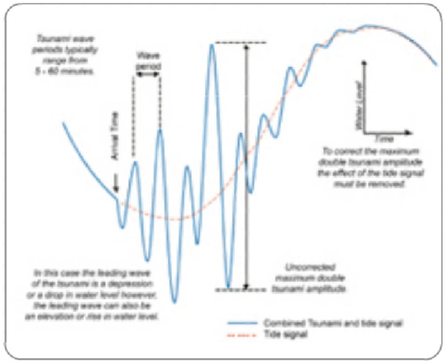
Japanese term meaning wave ("nami") in a harbour ("tsu"). A series of traveling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor. (Also called a seismic sea wave and, incorrectly, tidal wave). Volcanic eruptions, submarine landslides, and coastal rockfalls can also generate tsunamis, as can a large meteorite impacting the ocean. These waves may reach enormous dimensions and travel across entire ocean basins with little loss of energy. They proceed as ordinary gravity waves with a typical period of between 10 and 60 minutes. Tsunamis steepen and increase in height on approaching shallow water, inundating low- lying areas, and where local submarine topography causes the waves to steepen, they may break and cause great damage. Tsunamis have no connection with tides; the popular name, tidal wave, is entirely misleading.

Tsunami generated by 26 May 1983, Japan Sea earthquake approaching Okushiri Island, Japan. Photo courtesy of Tokai University.

Tsunami amplitude

Usually measured on a sea level record, it is:

1) the absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed sea level at the time,
2) half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often an amplitude modified in some way by the tide gauge response.



Mareogram (sea level) record of a tsunami.

Tsunami bore

A steep, turbulent, rapidly moving tsunami wave front, typically occurring in a river mouth or estuary.

Tsunami bore entering Wailua River, Hawaii during the 1946 Aleutian Island tsunami. Photo courtesy of Pacific Tsunami Museum.

Tsunami damage

Loss or harm caused by a destructive tsunami. More specifically, the damage caused directly by tsunamis can be summarized into the following:

1) Deaths and injuries.
2) Houses destroyed, partially destroyed, inundated, flooded, or burned.
3) Other property damage and loss.
4) Boats washed away, damaged or destroyed.
5) Lumber washed away.
6) Marine installations, destroyed.
7) Damage to public utilities such as railroads, roads, electric power plants, water supply installations etc.

Indirect secondary tsunami damage can be:

1) Damage by fire of houses, boats, oil tanks, gas stations, and other facilities.
2) Environmental pollution caused by drifting materials, oil, or other substances.
3) Outbreak of disease of epidemic proportions, which may be serious in densely populated areas.

Banda Aceh, Sumatra, Indonesia. The tsunami of 26 December 2004 completely razed coastal towns and villages, leaving behind only sand, mud, and water where once there had been thriving communities of homes, offices, and green space. Photo courtesy of DigitalGlobe.

Tsunami dispersion

Redistribution of tsunami energy, particularly as a function of its period, as it travels across a body of water.

Tsunami earthquake

An earthquake that produces an unusually large tsunami relative to the earthquake magnitude (Kanamori, 1972). Tsunami earthquakes are characterized by a very shallow focus, fault dislocations greater than several metres, and fault surfaces smaller than those for normal earthquakes. They are also slow earth-quakes, with slippage along their faults occurring more slowly than in normal earthquakes. The last events of this type were in 1992 (Nicaragua) and 1996 (Chimbote, Peru).

Focus

This is the point on the Earth where a rupture first occurs and where the first seismic waves originate.

Epicentre

This is the point on the Earth's surface directly above the focus.

Magnitude

This is a measure of the relative size of an earthquake. A number of different magnitude scales exist besides the Richter scale, including the moment magnitude, which measures the energy released and gives the most reliable estimate for large earthquakes.

Because the scale is logarithmic, an increase in one unit of magnitude corresponds to a 10-fold increase in seismic wave amplitude and a 30-fold increase in released energy. And a change of 0.3 units equals a three-fold increase in intensity.

In other words, the 9.3 Sumatra earthquake that generated the 2004 Indian Ocean tsunami was three times more powerful than the 9.0 earthquake it was originally thought to be.

Moment magnitude is measurable nearly immediately thanks to the advent of modern seismometres, digital recording, and real-time communication links. It allows warning centres to provide initial tsunami advisories within minutes of an earthquake occurrence. In Japan, earthquake warnings get broadcast to the public within 30 seconds of them happening.

Tsunami edge wave

Wave generated by a tsunami that travels along the coast.

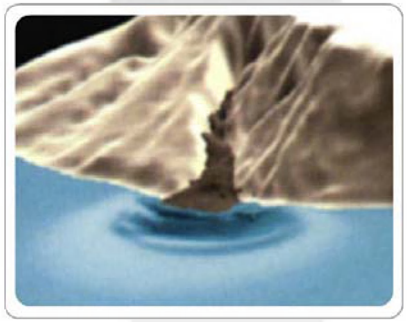
Tsunami forerunner

A series of oscillations of the water level preceding the arrival of the main tsunami waves, mainly due to the resonance in bays and shelves that could occur before the arrival of the main tsunami.

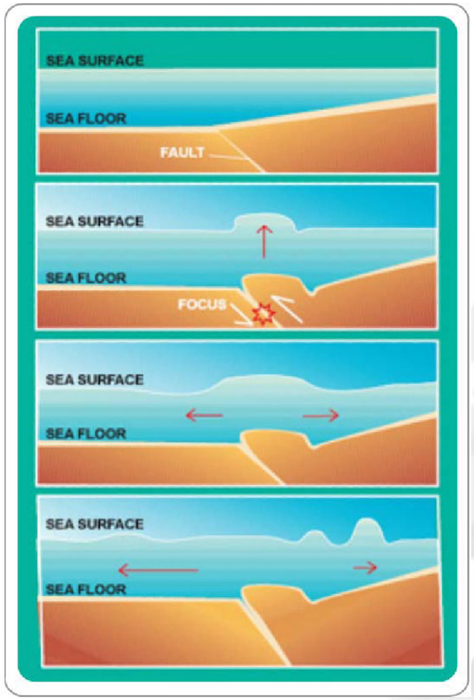
Tsunami generation

Tsunamis are most frequently caused by earthquakes, but can also result from landslides, volcanic eruptions, and very infrequently by meteorites or other impacts upon the ocean surface. Tsunamis are generated primarily by tectonic dislocations under the sea which are caused by shallow focus earthquakes along areas of subduction. The upthrusted and downthrusted crustal blocks impart potential energy into the overlying water mass with drastic changes in the sea level over the affected region. The energy imparted into the water mass results in tsunami generation, i.e. energy radiating away from the source region in the form of long period waves.

Tsunamis can be generated by submarine landslides, or by subaerial landslides that enter the water. Photo courtesy of LDG-France.



Tsunamis can be generated by pyroclastic flows associated with volcanic eruptions. Photo courtesy of LDG-France.



Tsunamis are most often generated by shallow earthquakes.

Tsunami generation theory

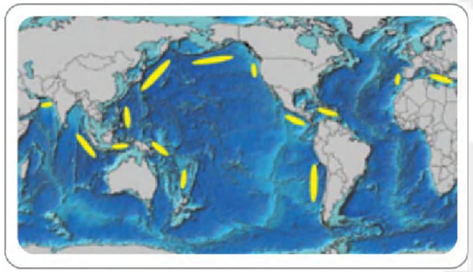
The theoretical problem of generation of the gravity wave (tsunami) in the layer of elastic liquid (an ocean) occurring on the surface of elastic solid half-space (the crust) in the gravity field can be studied with methods developed in the dynamic theory of elasticity. The source representing an earthquake focus is a discontinuity in the tangent component of the displacement on some element of area within the crust.

For conditions representative of the Earth's oceans, the solution of the problem differs very little from the joint solution of two more simple problems: the problem of generation of the displacement field by the given source in the solid elastic half-space with the free boundary (the bottom) considered quasi-static and the problem of the propagation of gravity wave in the layer of heavy incompressible liquid generated by the known (from the solution of the previous problem) motion of the solid bottom.

There is the theoretical dependence of the gravity wave parameters on the source parameters (depth and orientation). One can roughly estimate the quantity of energy transferred to the gravity wave by the source. In general, it corresponds to the estimates obtained with empirical data. Also, tsunamis can be generated by other different mechanisms such as volcanic or nuclear explosions, landslides, rock falls, and submarine slumps.

Tsunami hazard

The probability that a tsunami of a particular size will strike a particular section of coast.



Global tsunami source zones. Tsunami hazards exist in all oceans and basins, but occur most frequently in the Pacific Ocean. Tsunamis can occur anywhere and at any time because earthquakes cannot be accurately predicted.

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Glossary

Tsunami hazard assessment

Documentation of tsunami hazards for a coastal community is needed to identify populations and assets at risk, and the level of that risk. This assessment requires knowledge of probable tsunami sources (such as earthquakes, landslides and volcanic eruptions), their likelihood of occurrence, and the characteristics of tsunamis from those sources at different places along the coast. For those communities, data on earlier (historical and paleotsunamis) tsunamis may help quantify these factors. For most communities, however, only very limited or no past data exist. For these coasts, numerical models of tsunami inundation can provide estimates of areas that will be flooded in the event of a local or distant tsunamigenic earthquake or a local landslide.

Tsunami impact

Although infrequent, tsunamis are among the most terrifying and complex physical phenomena and have been responsible for great loss of life and extensive destruction to property. Because of their destructiveness, tsunamis have important impacts on the human, social and economic sectors of societies. Historical records show that enormous destruction of coastal communities throughout the world has taken place and that the socio-economic impact of tsunamis in the past has been enormous. In the Pacific Ocean where the majority of these waves have been generated, the historic record shows tremendous destruction with extensive loss of life and property.

In Japan, which has one of the most populated coastal regions in the world and a long history of earthquake activity, tsunamis have destroyed entire coastal populations. There is also a history of severe tsunami destruction in Alaska, the Hawaiian Islands, and South America, although records for these areas are not as extensive. The last major Pacific-wide tsunami occurred in 1960. Many other local and regional destructive tsunamis have occurred with more localized effects.

Tsunami intensity

Size of a tsunami based on the macroscopic observation of a tsunami's effect on humans, objects including various sizes of marine vessels and buildings.

The original scale for tsunamis was published by Sieberg (1923), and later modified by Ambraseys (1962) to create a six-category scale. Papadopoulus and Imamura (2001) proposed a new 12-grade intensity scale which is independent of the need to measure physical parameters like wave amplitude, sensitive to the small differences in tsunami effects, and detailed enough for each grade to cover the many possible types of tsunami impact on the human and natural environment. The scale has 12 categories, similar to the Modified Mercalli Intensity Scale used for macroseismic descriptions of Earthquake intensity.

Tsunami magnitude

Size of a tsunami based on the measurement of the tsunami wave on sea level gauges and other instruments.

The scale, originally descriptive and more similar to an intensity, quantifies the size by using measurements of wave height or tsunami runup. Iida et al. (1972) described the magnitude (m) as dependent in logarithmic base 2 on the maximum wave height measured in the field, and corresponding to a magnitude range from -1 to 4:

$$m = \log_2 H_{max}$$

Hatori (1979) subsequently extended this so-called Imamura-Iida scale for far-field tsunamis by including distance in the formulation. Soloviev (1970) suggested that the mean tsunami height may be another good indicator of tsunami size, so that the mean tsunami height is equal to 1/square root (Hmax), and the maximum intensity would be that measured nearest to the tsunami source. A variation on this is the Imamura-Soloviev intensity scale I (Soloviev, 1972). Shuto (1993) has suggested the measurement of H as the height where specific types of impact or damage occur, thus proposing a scale which can be used as a predictive quantitative tool for macroscopic effects.

Tsunami magnitudes have also been proposed that are similar in form to those used to calculate earthquake magnitudes. These include the original formula proposed by Abe (1979) for tsunami magnitude, M_t:

$$M_t = \log H + B$$

where H is the maximum single crest or trough amplitude of the tsunami waves (in metres) and B is a constant, and the far-field application proposed by Hatori (1986) which adds a distance factor into the calculation.

Tsunami numerical modelling

Mathematical descriptions that seek to describe the observed tsunami and its effects.

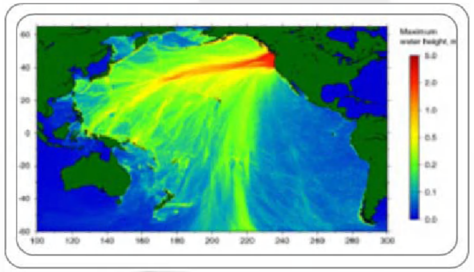
Often the only way to determine the potential runups and inundation from a local or distant tsunami is to use numerical modelling, since data from past tsunamis is usually insufficient. Models can be initialized with potential worst case scenarios for the tsunami sources or for the waves just offshore to determine corresponding worst case scenarios for runup and inundation. Models can also be initialized with smaller sources to understand the severity of the hazard for less extreme but more frequent events. The information is the basis for creating tsunami evacuation maps and procedures.

At present, numerical modeling has only been carried out for a small fraction of coastal areas at risk. Sufficiently accurate modelling techniques have only been available in recent years, and the models require training to understand and use correctly, as well as input of detailed bathymetric and topographic data in the area being modeled.

Numerical models have been used in recent years to simulate tsunami propagation and interaction with land masses. Such models usually solve similar equations but often employ different numerical techniques and are applied to different segments of the total problem of tsunami propagation from generation regions to distant areas of runup.

For example, several numerical models have been used to simulate the interaction of tsunamis with islands. These models have used finite difference, finite element, and boundary integral methods to solve the linear long wave equations. The models solve these relatively simple equations and provide reasonable simulations of tsunamis for engineering purposes.

Historical data are often very limited for most coastlines. Consequently, numerical modeling may be the only way to estimate potential risk. Techniques now exist to carry out this assessment. Computer software and the training necessary to conduct this modeling are available through programmes such as the IOC Tsunami Inundation Modeling Exchange (Time) Programme.



Calculated maximum tsunami wave heights for a M9.0 Cascadia subduction zone earthquake. The model was calculated after tsunami deposits found in Japan and elsewhere suggested that a repeat of the 1700 Cascadia great earthquake would generate a destructive teletsunami. Courtesy of Kenji Satake, Geological Survey of Japan.

Tsunami observation

Notice, observation or measurement at a particular point in time of sea level fluctuation caused by the incidence of a tsunami on a specific point.

Tsunami period

Amount of time that a tsunami wave takes to complete a cycle. Tsunami periods typically range from five minutes to two hours.

Tsunami period (dominant)

Difference between the arrival time of the highest peak and the next one measured on a water level record.

1946 Aleutian Islands tsunami rushing ashore in Hilo,Hawaii. Photo courtesy of Pacific Tsunami Museum.

Tsunami preparedness

Readiness of plans, methods, procedures, and actions taken by government officials and the general public for the purpose of minimizing potential risk and mitigating the effects of future tsunamis. The appropriate preparedness for a warning of impending danger from a tsunami requires knowledge of areas that could be flooded (tsunami inundation maps) and knowledge of the warning system to know when to evacuate and when it is safe to return.

Tsunami propagation

Tsunamis travel outward in all directions from the generating area, with the direction of the main energy propagation generally being orthogonal to the direction of the earthquake fracture zone. Their speed depends on the depth of water, so that the waves undergo accelerations and decelerations in passing over an ocean bottom of varying depth. In the deep and open ocean, they travel at speeds of 500 to 1,000 km per hour (300 to 600 miles per hour). The distance between successive crests can be as much as 500 to 650 km (300 to 400 miles). However, in the open ocean, the height of the waves is generally less than a meter (three feet) even for the most destructive teletsunamis, and the waves pass unnoticed. Variations in tsunami propagation result when the propagation impulse is stronger in one direction than in others because of the orientation or dimensions of the generating area and where regional bathy metric and topographic features modify both the waveform and rate of advance. Specifically, tsunami waves undergo a process of wave refraction and reflection throughout their travel. Tsunamis are unique in that the energy extends through the entire water column from sea surface to the ocean bottom. It is this characteristic that accounts for the great amount of energy propagated by a tsunami.

Model of tsunami propagation in the southeast Pacific, nine hours after generation. Source: Antofagasta, Chile (30 July 1995). Courtesy of LDG-France.

Tsunami resonance

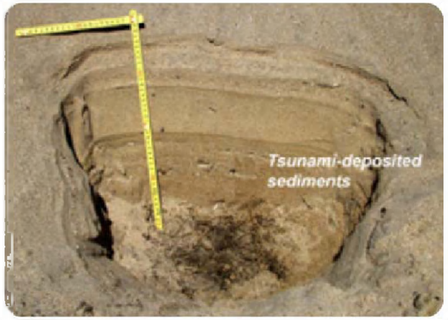
The continued reflection and interference of tsunami waves from the edge of a harbour or narrow bay which can cause amplification of the wave heights, and extend the duration of wave activity from a tsunami.

Tsunami risk

The probability of a particular coastline being struck by a tsunami multiplied by the likely destructive effects of the tsunami and by the number of potential victims. In general terms, risk is the hazard multiplied by the exposure.

Tsunami sediments

Sediments deposited by a tsunami. Finding tsunami sediment deposits within stratigraphic soil layers provides information on the occurrence of historical paleotsunamis. The discovery of similarly dated deposits at different locations, sometimes across ocean basins and far from the tsunami source, can be used to map and infer the distribution of tsunami inundation and impact.



Sediment layers deposited from successive waves of 26 December 2004 Indian Ocean tsunami, as observed in Banda Aceh, Indonesia. Photo courtesy of Yuichi Nishimura, Hokkaido University.

Tsunami simulation

Numerical model of tsunami generation, propagation and inundation.

Tsunami source

Point or area of tsunami origin, usually the site of an earthquake, volcanic eruption, or landslide that caused large-scale rapid displacement of the water to initiate the tsunami waves.

Tsunami velocity (or shallow water velocity)

The velocity of an ocean wave whose length is sufficiently large compared to the water depth (i.e., 25 or more times the depth) can be approximated by the following expression:

c = √ (gh)

Where:

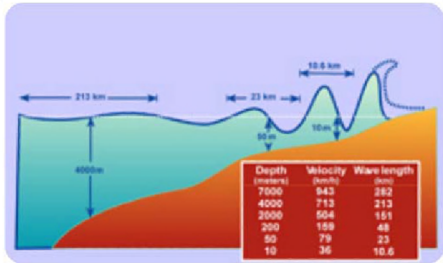
c: is the wave velocity

g: the acceleration of gravity

h: the water depth.

Thus, the velocity of shallow-water waves is independent of wave length **L**. In water depths between ½ **L** and 1/25 **L** it is necessary to use a more precise expression:

c = √((gL/2p)[tanh(2 p h/L)])



Wave height and water depth. In the open ocean, a tsunami is often only a tens of centimeters high, but its wave height grows rapidly in shallow water. Tsunami wave energy extends from the surface to the bottom in the deepest waters. As the tsunami attacks the coastline, the wave energy is compressed into a much shorter distance creating destructive, life threatening waves.

Tsunami wave length

The horizontal distance between similar points on two successive waves measured perpendicular to the crest. The wave length and the tsunami period give information on the tsunami source. For tsunamis generated by earthquakes, the typical wave length ranges from 20 to 300 km. For tsunamis generated by landslide, the wave length is much shorter, ranging from hundreds of metres to tens of kilometres.

Tsunami zonation (tsunami zoning)

Designation of distinctive zones along coastal areas with varying degrees of tsunami risk and vulnerability for the purpose of disaster preparedness, planning, construction codes or public evacuation.

Tsunamic

Having features analogous to those of a tsunami or descriptive of a tsunami.

Tsunamigenic

Having generated a tsunami; a tsunamigenic earthquake, a tsunamigenic landslide.

W

Water level (maximum)

Difference between the elevation of the highest local water mark and the elevation of the sealevel at the time of the tsunami. This is different from maximum runup because the water mark is often not observed at the inundation line, but maybe halfway up the side of a building or on a tree trunk.

Wave crest

1) The highest part of a wave.

2) That part of the wave above still water level.

Wave trough

The lowest part of a wave.

Acronyms and Organizations

The Intergovernmental Oceanographic Commission of UNESCO's Global Tsunami Warning and Mitigation Systems work in partnership with a number of organizations and use acronyms to describe system governance and different tsunami information products. These are listed below, in alphabetical order.

Communications Plan for the Tsunami Warning System

The operations manual for the Tsunami Warning System in various regions. The Plan provides a general overview of the operational procedures and of the nature of tsunamis. It lists the seismographic and sea level stations participating in the warning system, the methods of communication between the stations and the Warning Centre, the criteria for the reporting and issuing of tsunami information messages by the Warning Centre, the recipients of the information, and the methods by which the messages are sent. Official contact information for emergency communications is included.

Forecast Point

The location where the Tsunami Warning Centre may provide estimates of tsunami arrival time or wave height.

GLOSS

Global Sea-Level Observing System. A component of the Global Ocean Observing System (GOOS). The UNESCO IOC established GLOSS in 1985 originally to improve the quality of sea level data as input to studies of long term sealevel change. It consists of a core network of approximately 300 stations distributed along continental coastlines and throughout each of the world's island groups. The GLOSS network also supports sea level monitoring for tsunami warning with minimum operational standards of 15-minute data transmissions of one-minute sampled data.

GOOS

Global Ocean Observing System. GOOS is a permanent global system for observations, modeling, and analysis of marine and ocean variables to support operational ocean services worldwide. The GOOS Project aims to provide accurate descriptions of the present state of the oceans, including living resources; continuous forecasts of the future conditions of the sea for as far ahead as possible; and the basis for forecasts of climate change. The GOOS Project Office, located at the IOC headquarters in Paris since 1992, provides assistance in the implementation of GOOS.

GTS

Global Telecommunications System of the World Meteorological Organization (WMO) that directly connects national meteorological and hydrological services worldwide. The GTS is widely used for the near real-time transmission of sea level data for tsunami monitoring. The GTS and other robust communications methods are used for the transmission of tsunami warnings.

ICG

Intergovernmental Coordination Group. As subsidiary bodies of the UNESCO IOC, the ICG meets to promote, organize, and coordinate regional tsunami mitigation activities, including the issuance of timely tsunami warnings. The ICG is composed of National Contacts from Member States in the region. Currently, there are ICGs for tsunami warning and mitigation systems in the Pacific, Indian Ocean, Caribbean and adjacent regions, and the north-eastern Atlantic, the Mediterranean and connected seas.

ICG/CARIBE-EWS

Intergovernmental Coordination Group for Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions established by Resolution XXIII-14 of the 23rd Session of the IOC General Assembly in 2005. The ICG is comprised principally of IOC Member States and regional organizations from the Wider Caribbean Region. Through the coordinating efforts of the IOCARIBE Sub-commission starting in 1993, a Group of Experts formulated a proposal for the building of the Intra-Americas Tsunami Warning System that was endorsed by the IOC General Assembly in 2002.

Website: http://ioc3.unesco.org/cartws

ICG/IOTWS

Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System established by Resolution XXIII-12 of the 23rd Session of the IOC General Assembly in 2005. The IOC Regional Programme Office in Perth, Australia, serves as the IOTWS Secretariat. Presently, there are 27 Member States.

Website: http://ioc.unesco.org/indotsunami

ICG/ITSU

Intergovernmental Coordination Group for the International Tsunami Warning System in the Pacific established by Resolution IV-6 of the 4th Session of the IOC General Assembly in 1965. The ICG-ITSU was renamed ICG/PTWS in 2005.

Website: http://www.tsunamiwave.info

ICG/NEAMTWS

Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connecting Seas, established by Resolution XXIII-13 of the 23rd Session of the IOC General Assembly in 2005. The ICG is comprised principally of IOC Member States bordering the north-eastern Atlantic and those bordering or within the Mediterranean or connected seas.

Website: http://ioc3.unesco.org/neamtws

ICG/PTWS

Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System, renamed by Resolution ITSU-XX.1 of the 20th Session of the ICG/ITSU in 2005. Presently, there are 28 Member States. The ICG/PTWS was formerly the ICG/ITSU. The ITIC in Honolulu serves as the PTWS Secretariat.

Website: (http://ioc3.unesco.org/ptws)

ICG Tsunami Warning Focal Point (TWFP)

7x24 contact person, or other official point of contact or address, designated by an ICG Member State government for rapidly receiving and issuing tsunami event information (such as warnings). The Tsunami Warning Focal Point has the responsibility of notifying the emergency authority (civil defense or other designated agency responsible for public safety) of the event characteristics (earthquake and/or tsunami), in accordance with the procedures of the Tsunami Response Plan. The Tsunami Warning Focal Point receives international tsunami warnings from the PTWC, NWPTAC, or other regional warning centres.

ICG Tsunami National Contact (TNC)

The person designated by an ICG Member State government to represent his/her country in the coordination of international tsunami warning and mitigation activities. The person is part of the main stakeholders of the national tsunami warning and mitigation system programme. The person may be the Tsunami Warning Focal Point, from the national disaster management organization, from a technical or scientific institution, or from another agency with tsunami warning and mitigation responsibilities.

IOC

Intergovernmental Oceanographic Commission of UNESCO. The IOC provides Member States of the United Nations with an essential mechanism for global cooperation in the study of the ocean. The IOC assists governments to address their individual and collective ocean and coastal problems through the sharing of knowledge, information, and technology and through the coordination of national programmes.

Website: http://ioc.unesco.org/iocweb/index.php

ITIC

International Tsunami Information Centre. ITIC was established in November 1965 by the IOC of UNESCO. In 1968, the IOC first convened the ICG/ITSU to coordinate tsunami warning and mitigation activities in the Pacific. The ITIC serves as the PTWS Secretariat. Additionally, the ITIC provides technical and capacity building assistance to Member States for the global establishment of tsunami warning and mitigation systems in the Indian and Atlantic Oceans, the Caribbean and Mediterranean Seas, and other oceans and marginal seas. In the Pacific, the ITIC specifically monitors and recommends improvements

to the PTWS, coordinates tsunami technology transfer among Member States interested in establishing regional and national tsunami warning systems, acts as a clearinghouse for risk assessment and mitigation activities, and serves as a resource for the development, publication, and distribution of tsunami education and preparedness materials.

Website: (http://www.tsunamiwave.info)

IUGG

International Union of Geodesy and Geophysics. The IUGG is a non-governmental, scientific organization established in 1919, dedicated to promoting and coordinating studies of the Earth and its environment in space. The IUGG Tsunami Commission, established in 1960, is an international group of scientists concerned with various aspects of tsunamis, including an improved understanding of the dynamics of generation, propagation, and coastal runup of tsunamis, as well as their consequences to society.

Website: (http://iugg.org)

JMA

Japan Meteorological Agency. JMA established a tsunami warning service in 1952. JMA now serves as a National Tsunami Warning System that continuously monitors 24 hours-a-day all seismic activity in Japan, and issues timely information concerning earthquakes and tsunamis. In 2005, the JMA began operations of the Northwest Pacific Tsunami Advisory Center (NWPTAC). The NWPTAC provides supplementary tsunami information for events in and around Japan and the northwest Pacific in close coordination with the PTWC.

Website: (http://www.jma.go.jp/jma)

Master Plan

The principal long-term guide for improving the TWS. The Plan provides a summary of the basic elements which comprise the TWS, a description of its existing components, and an outline of the activities, data sets, methods, and procedures that need to be improved in order to reduce tsunami risk. The first edition of the ICG/PTWS Master Plan was released in 1989. The second edition was released in 1999.

Website: (http://ioc3.unesco.org/itic/categories.php?category_no=64)

Ocean-wide Tsunami Warning

A warning issued to all participants after there is confirmation of tsunami waves capable of causing destruction beyond the local area. Ocean-Wide Tsunami Warnings contain estimated tsunami arrival times (ETAs) at all Forecast Points. Ocean-Wide Tsunami Warning Bulletins also normally carry information on selected wave heights and other wave reports. The Warning will be cancelled when it is determined that the tsunami threat is over. As local conditions can cause wide variations in tsunami wave action, the all-clear determination should be made by the local action agencies and not the TWC. In general, after receipt of a Tsunami Warning, action agencies can assume all-clear status when their area is free from damaging waves for at least two hours, unless additional ETAs have been announced by the TWC (for example for a significant aftershock) or local conditions, that may include continued seiching or particularly strong currents in channels and harbours, warrant the continuation of the Tsunami Warning status.

Sample: Pacific-Wide Tsunami Warning (initial)

TSUNAMI BULLETIN NUMBER 004

PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS

ISSUED AT 2119Z 25 FEB 2005

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT ALASKA – BRITISH COLUMBIA – WASHINGTON – OREGON – CALIFORNIA.

…A PACIFIC-WIDE TSUNAMI WARNING IS IN EFFECT…

THIS WARNING IS FOR ALL COASTAL AREAS AND ISLANDS IN THE PACIFIC.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME – 1804Z 25 FEB 2005

COORDINATES – 52.3 NORTH 160.7 EAST

LOCATION – OFF EAST COAST OF KAMCHATKA

MAGNITUDE – 8.8

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION	LAT	LON	TIME	AMPL	PER
NIKISKI	60.7N	151.4W	0057Z	0.52M	**MIN
SEVERO KURILSK	50.7N	156.1E	2042Z	0.12M	64MIN

TIME - TIME OF THE MEASUREMENT

AMPL - AMPLITUDE IN METERS FROM MIDDLE TO CREST OR MIDDLE TO TROUGH OR HALF OF THE CREST TO TROUGH

PER - PERIOD OF TIME FROM ONE WAVE CREST TO THE NEXT

EVALUATION

SEA LEVEL READINGS CONFIRM THAT A TSUNAMI HAS BEEN GENERATED WHICH COULD CAUSE WIDESPREAD DAMAGE TO COASTS AND ISLANDS IN THE PACIFIC. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS THREAT. THIS CENTER WILL CONTINUE TO MONITOR SEA LEVEL DATA TO DETERMINE THE EXTENT AND SEVERITY OF THE THREAT.

A TSUNAMI IS A SERIES OF WAVES AND THE FIRST WAVE MAY NOT BE THE LARGEST. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND CAN VARY SIGNIFICANTLY ALONG A COAST DUE TO LOCAL EFFECTS. THE TIME FROM ONE TSUNAMI WAVE TO THE NEXT CAN BE FIVE MINUTES TO AN HOUR, AND THE THREAT CAN CONTINUE FOR MANY HOURS AS MULTIPLE WAVES ARRIVE.

FOR ALL AREAS – WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.

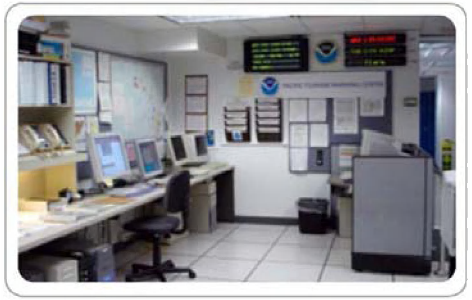
PTWC

Established in 1949, the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, acts as the operational headquarters for the PTWS and works closely with other sub-regional and national centres in monitoring and evaluating potentially tsunamigenic earthquakes. It provides international warnings for teletsunamis to countries in the Pacific Basin as well as to Hawaii and all other US interests in the Pacific outside of Alaska. The West Coast and Alaska Tsunami Warning Center (WC/ATWC) provides services to the Gulf of Mexico and Atlantic coasts of the USA, and to the west and east coasts of Canada. PTWC is also the warning centre for Hawaii's local and regional tsunamis. In 2005, the PTWC and JMA began providing interim advisory services to the Indian Ocean. The PTWC also assists Puerto Rico and the US Virgin Islands with advisory information, and the WC/ATWC provides services to the west and east coasts of Canada.

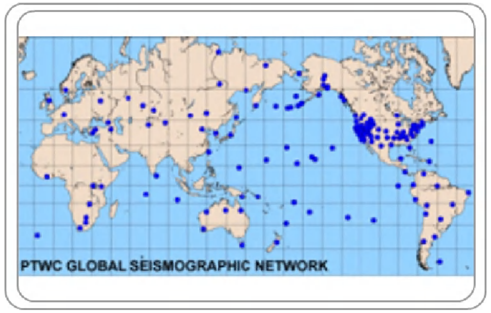
The operational objective of the PTWC is to detect and locate major earthquakes in the region, to determine if tsunamis were generated, and to provide timely tsunami warnings to national authorities. To achieve this objective, the PTWC continuously monitors seismic activity and sea levels, and disseminates information messages through a variety of communications methods. The PTWC and the WC/ATWC are operated by the US NOAA National Weather Service.

Website: (http://www.prh.noaa.gov/ptwc)
(http://wcatwc.arh.noaa.gov/)

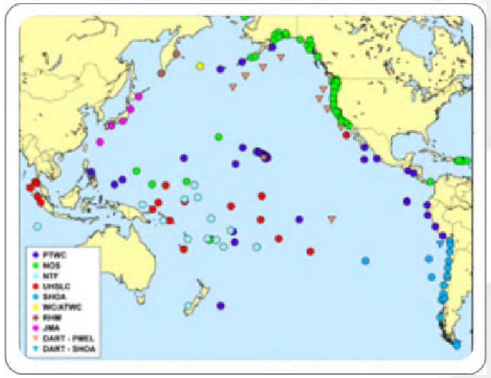
PTWC facilities located at Ewa Beach, Hawaii, USA.



PTWC operations area.



Global seismic network used by PTWC to monitor seismicity.



Sea level network used by PTWC to monitor Pacific sea levels. Circles show coastal sea level stations and triangles show NOAA DART systems. Colors indicate responsible agency: PTWC (dark blue), NOAA National Ocean Service (green), Univ of Hawaii Sea Level Center (red), SHOA (blue green), JMA (pink), Russian Hydromet (brown), Australia National Tidal Center (light blue), WC/ATWC (yellow), NOAA National Data Buoy Center (orange).

PTWS

Pacific Tsunami Warning and Mitigation System. The PTWS is an international programme for coordination of tsunami warning and mitigation activities in the Pacific. Administratively, participating nations are organized under the IOC as the ICG/PTWS with the ITIC acting as the PTWS Secretariat and the PTWC acting as the operational headquarters for tsunami warning. Among the most important activities of the PTWS is the detection and location of major earthquakes in the Pacific region, the determination of whether they have generated tsunamis, and the provision of timely and effective tsunami information and warnings to coastal communities in the Pacific to minimize the hazards of tsunamis, especially to human life and welfare. To achieve this objective requires the national participation and contribution of many seismic, sea level, communication, and dissemination facilities throughout the Pacific Region

Regional Expanding Tsunami Watch-Warning Bulletin (RWW)

A message issued initially using only seismic information to alert countries of the possibility of a tsunami and advise that a tsunami investigation is underway. In the Pacific, Tsunami Warning status will encompass regions having less than three hours until the estimated time of tsunami arrival. Those areas having three to six hours will be placed in a Watch status. Additional bulletins will be issued hourly or sooner until either a Pacific-wide tsunami is confirmed or no further tsunami threat exists.

SAMPLE: Expanding Regional Tsunami Warning and Watch (initial)

TSUNAMI BULLETIN NUMBER 001

PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS

ISSUED AT 1819Z 25 FEB 2005

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON - CALIFORNIA.

... A TSUNAMI WARNING AND WATCH ARE IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

RUSSIA / JAPAN / MARCUS IS. / MIDWAY IS. / WAKE IS. / N. MARIANAS / MARSHALL IS. / GUAM / HAWAII / JOHNSTON IS. / CHUUK / POHNPEI / TAIWAN / KOSRAE / YAP / PHILIPPINES / BELAU / NAURU / KIRIBATI / SAMOA / AMERICAN SAMOA / FIJI / MEXICO / HONG KONG / NEW CALEDONIA / COOK ISLANDS / FR. POLYNESIA

A TSUNAMI WATCH IS IN EFFECT FOR

NEW ZEALAND / EL SALVADOR / NICARAGUA

FOR ALL OTHER PACIFIC AREAS, THIS MESSAGE IS AN ADVISORY ONLY.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 1804Z 25 FEB 2005

COORDINATES - 52.3 NORTH 160.7 EAST

LOCATION - OFF EAST COAST OF KAMCHATKA

MAGNITUDE - 8.1

EVALUATION

IT IS NOT KNOWN THAT A TSUNAMI WAS GENERATED. THIS WARNING IS BASED ONLY ON THE EARTHQUAKE EVALUATION. AN EARTHQUAKE OF THIS SIZE HAS THE POTENTIAL TO GENERATE A DESTRUCTIVE TSUNAMI THAT CAN STRIKE COASTLINES NEAR THE EPICENTRE WITHIN MINUTES AND MORE DISTANT COASTLINES WITHIN HOURS. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL MONITOR SEA LEVEL DATA FROM GAUGES NEAR THE EARTHQUAKE TO DETERMINE IF A TSUNAMI WAS GENERATED AND ESTIMATE THE SEVERITY OF THE THREAT.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. THE TIME BETWEEN SUCCESSIVE TSUNAMI WAVES CAN BE FIVE MINUTES TO ONE HOUR.

SAMPLE: Expanding Regional Tsunami Warning and Watch (cancellation)

TSUNAMI BULLETIN NUMBER 003

PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS

ISSUED AT 2019Z 25 FEB 2005

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT

ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON - CALIFORNIA.

... TSUNAMI WARNING AND WATCH CANCELLATION ...

THE TSUNAMI WARNING AND WATCH ARE CANCELLED FOR ALL COASTAL AREAS AND ISLANDS IN THE PACIFIC.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 1804Z 25 FEB 2005

COORDINATES - 52.3 NORTH 160.7 EAST

LOCATION - OFF EAST COAST OF KAMCHATKA

MAGNITUDE - 8.1

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION	LAT	LON	TIME	AMPL	PER
NIKISKI	60.7N	151.4W	0057Z	0.52M	**MIN
SEVERO KURILSK	50.7N	156.1E	2042Z	0.12M	64MIN

TIME - TIME OF THE MEASUREMENT

AMPL - AMPLITUDE IN METERS FROM MIDDLE TO CREST OR MIDDLE TO TROUGH OR HALF OF THE CREST TO TROUGH

PER - PERIOD OF TIME FROM ONE WAVE CREST TO THE NEXT

EVALUATION

SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTRE. FOR THOSE AREAS WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

NO TSUNAMI THREAT EXISTS FOR OTHER COASTAL AREAS IN THE PACIFIC ALTHOUGH SOME OTHER AREAS MAY EXPERIENCE SMALL SEA LEVEL CHANGES FOR ALL AREAS THE TSUNAMI WARNING AND TSUNAMI WATCH ARE CANCELLED.

THIS WILL BE THE FINAL BULLETIN ISSUED FOR THIS EVENT UNLESS ADDITIONAL INFORMATION BECOMES AVAILABLE.

Regional Fixed Tsunami Warning Bulletin

A message issued initially using only seismic information to alert all participants of the possibility of a tsunami and advise that a tsunami investigation is underway. The area placed in a Tsunami Warning status encompasses coastal regions with 1,000 kilometres (625 miles) of the earthquake epicentre.
A Regional Fixed Tsunami Warning will be followed by additional bulletins without expanding the warning area until it is either upgraded or cancelled.

SAMPLE: Fixed Regional Tsunami Warning (initial)

TSUNAMI BULLETIN NUMBER 001

PACIFIC TSUNAMI WARNING

CENTER/NOAA/NWS

ISSUED AT 1819Z 25 FEB 2005

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT ALASKA - BRITISH COLUMBIA - WASHINGTON – OREGON - CALIFORNIA.

... A TSUNAMI WARNING IS IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR RUSSIA

FOR ALL OTHER PACIFIC AREAS, THIS MESSAGE IS AN ADVISORY ONLY.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 1804Z 25 FEB 2005

COORDINATES - 52.3 NORTH 160.7 EAST

LOCATION - OFF EAST COAST OF KAMCHATKA

MAGNITUDE - 7.7

EVALUATION

IT IS NOT KNOWN THAT A TSUNAMI WAS GENERATED. THIS WARNING IS BASED ONLY ON THE EARTHQUAKE EVALUATION. AN EARTHQUAKE OF THIS SIZE HAS THE POTENTIAL TO GENERATE A DESTRUCTIVE TSUNAMI THAT CAN STRIKE COASTLINES IN THE REGION NEAR THE EPICENTRE WITHIN MINUTES TO HOURS. AUTHORITIES IN THE REGION SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL MONITOR SEA LEVEL GAUGES NEAREST THE REGION AND REPORT IF ANY TSUNAMI WAVE ACTIVITY IS OBSERVED. THE WARNING WILL NOT EXPAND TO OTHER AREAS OF THE PACIFIC UNLESS ADDITIONAL DATA ARE RECEIVED TO WARRANT SUCH AN EXPANSION.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. THE TIME BETWEEN SUCCESSIVE TSUNAMI WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	COORDINATES	ARRIVAL TIME
RUSSIA		
PETROPAVLOVSK-K	52.9N 158.3E	1926Z 25 FEB
UST KAMCHATSK	56.2N 162.5E	1943Z 25 FEB
MEDNNY IS	54.6N 167.6E	1946Z 25 FEB
SEVERO KURILSK	50.6N 156.3E	2000Z 25 FEB
URUP IS	45.9N 150.2E	2031Z 25 FEB

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.

THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

SAMPLE: Fixed Regional Tsunami Warning (cancellation)

TSUNAMI BULLETIN NUMBER 003

PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS

ISSUED AT 2019Z 25 FEB 2005

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT ALASKA - BRITISH COLUMBIA - WASHINGTON - OREGON - CALIFORNIA.

... TSUNAMI WARNING CANCELLATION ...

THE TSUNAMI WARNING IS CANCELLED FOR ALL COASTAL AREAS AND ISLANDS IN THE PACIFIC.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 1804Z 25 FEB 2005

COORDINATES - 52.3 NORTH 160.7 EAST

LOCATION - OFF EAST COAST OF KAMCHATKA

MAGNITUDE - 7.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION	LAT	LON	TIME	AMPL	PER
NIKISKI	60.7N	151.4W	0057Z	0.52M	**MIN
SEVERO KURILSK	50.7N	156.1E	2042Z	0.12M	64MIN

Tsunami Bulletin Board (TBB)

TBB is an ITIC-sponsored e-mail service that provides an open, objective scientific forum for the posting and discussion of news and information relating to tsunamis and tsunami research. The ITIC provides the service to tsunami researchers and other technical professionals for the purpose of facilitating the widespread dissemination of information on tsunami events, current research investigations, and announcements for upcoming meetings, publications, and other tsunami-related materials. All members of the TBB are welcome to contribute. Messages are immediately broadcast without modification. The TBB has been very useful for helping to rapidly organize post-tsunami surveys, for distributing their results, and for planning tsunami workshops and symposia. Members of the TBB automatically receive the tsunami bulletins issued by the PTWC, WC/ATWC, and JMA.

Tsunami Information Bulletin (TIB)

TWC message product advising the occurrence of a major earthquake with an evaluation that there is either:
a) no widespread tsunami threat but the small possibility of a local tsunami or
b) there is no tsunami threat at all that indicates there is no tsunami threat.

SAMPLE: Tsunami Information Bulletin (shallow undersea event)

TSUNAMI BULLETIN NUMBER 001

PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS

ISSUED AT 1819Z 25 FEB 2005

THIS BULLETIN IS FOR ALL AREAS OF THE PACIFIC BASIN EXCEPT ALASKA – BRITISH COLUMBIA – WASHINGTON – OREGON – CALIFORNIA

…TSUNAMI INFORMATION BULLETIN…

THIS MESSAGE IS FOR INFORMATION ONLY. THERE IS NO TSUNAMI WARNING OR WATCH IN EFFECT.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME – 1804Z 25 FEB 2005

COORDINATES – 52.3 NORTH 160.7 EAST

LOCATION – OFF EAST COAST OF KAMCHATKA

MAGNITUDE – 6.7

EVALUATION

NO DESTRUCTIVE PACIFIC-WIDE TSUNAMI THREAT EXISTS BASED ON HISTORICAL EARTHQUAKE AND TSUNAMI DATA.

HOWEVER - EARTHQUAKES OF THIS SIZE SOMETIMES GENERATE LOCAL TSUNAMIS THAT CAN BE DESTRUCTIVE ALONG COASTS LOCATED WITHIN A HUNDRED KILOMETERS OF THE EARTHQUAKE EPICENTRE. AUTHORITIES IN THE REGION OF THE EPICENTRE SHOULD BE AWARE OF THIS POSSIBILITY AND TAKE APPROPRIATE ACTION.

THIS WILL BE THE ONLY BULLETIN ISSUED FOR THIS EVENT UNLESS ADDITIONAL INFORMATION BECOMES AVAILABLE.

Tsunami Response Plan (TRP)

The Tsunami Response Plan describes the actions taken to ensure public safety by responsible agencies after notification by the Tsunami Warning Focal Point (TWFP), typically the national Tsunami Warning Centre. 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, 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 Response Plan should also include post-tsunami actions and responsibilities for search and rescue, relief, rehabilitation, and recovery.

Tsunami Warning

The highest level of tsunami alert. Warnings are issued by the TWCs due to confirmation of a destructive tsunami wave or the threat of an imminent tsunami. Initially the warnings are based only on seismic information without tsunami confirmation as a means of providing the earliest possible alert to at-risk populations.
Warnings initially place a restricted area in a condition that requires all coastal areas in the region to be prepared for imminent flooding. Subsequent text products are issued at least hourly or as conditions warrant to continue, expand, restrict, or end the warning. In the event a tsunami has been confirmed which could cause damage at distances greater than 1,000 kilometres (625 miles) from the epicentre, the warning may be extended to a larger area.

Tsunami Warning Centre (TWC)

Centre that issues timely tsunami information messages. The messages can be information, watch, or warning messages, and are based on the available seismological and sea level data as evaluated by the TWC, or on evaluations received by the TWC from other monitoring agencies. The messages are advisory to the official designated emergency response agencies.

Regional TWCs monitor and provide tsunami information to Member States on potential ocean-wide tsunamis using global data networks, and can often issue messages within 10-20 minutes of the earthquake. Local TWCs monitor and provide information on potential local tsunamis that will strike within minutes. Local TWCs must have access to continuous, real-time, densely-spaced data networks in order to characterize the earthquakes within second and issue a warning within minutes.

An example of a Regional Tsunami Warning Centre is the Pacific Tsunami Warning Center, which provides international tsunami warnings to the Pacific. After the 26 December 2004 tsunami, the PTWC and JMA have acted as an Interim Regional TWC for the Indian Ocean.

Examples of sub-regional TWCs are the NWPTAC operated by the JMA, WC/ATWC operated by the US NOAA NWS, CPPT operated by France. These centres, along with Russia and Chile, also act as national TWCs providing local tsunami warnings for their countries.

Tsunami Warning Centre Products

Tsunami Warning Centres issue four basic types of messages:

1. Information bulletins when a large earthquake has occurred but there is little or no tsunami threat.
2. Regional watch and warning bulletins when there is a potential threat of a destructive tsunami.
3. Ocean-wide warning bulletins when there is confirmation of tsunami waves capable of widespread tsunami destruction beyond the local area.
4. Tsunami communication test messages to regularly exercise the system.

Initial evaluations and messages are based only on the faster arriving seismic information, specifically earthquake location, magnitude, and depth. If a tsunami threat is possible, estimated tsunami wave arrival times are calculated and sea level records are examined to confirm whether a tsunami has been generated.

Watch and Warning bulletins are updated hourly until the threat is gone. In the Pacific, the types of messages issued by the PTWC include a Pacific-Wide Tsunami Warning Bulletin, Regional Expanding Tsunami Warning and Watch Bulletin, Regional Fixed Tsunami Warning Bulletin, Tsunami Information Bulletin, and Tsunami Communication Test Dummy Message.

Tsunami Watch

The second highest level of tsunami alert. Watches are issued by the Tsunami Warning Centres (TWCs) based on seismic information without destructive tsunami confirmation. The watch is issued as a means of alerting the affected populations located, for example, one to three hours tsunami travel time beyond the warned area. Subsequent text products are issued at least hourly to expand the watch and warning area, upgrade all areas to a warning, or end the watch and warning. A Tsunami Watch may be included in the text of the message that disseminates a Tsunami Warning.

UNESCO

United Nations Educational, Scientific and Cultural Organization. Established in 1945, UNESCO promotes international cooperation among its Member States in the fields of education, science, culture and communication.

Today, UNESCO works as a laboratory of ideas and standard setter to forge universal agreements on emerging ethical issues. The Organization also serves as a clearinghouse that disseminates and shares information and knowledge, while helping Member States to build their human and institutional capacities in diverse fields. The UNESCO Constitution states: "Since wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed".

Website: http://www.unesco.org/bpi

WDC

World Data Center. The WDC system was created to archive and distribute data collected from the observational programmes of the 1957-1958 International Geophysical Year. Originally established in the United States, Europe, Russia, and Japan, the WDC system has since expanded to other countries and to new scientific disciplines. The WDC system now includes 52 Centres in 12 countries. Its holdings include a wide range of solar, geophysical, environmental, and human dimensions data. These date cover time scales ranging from seconds to millennia and they provide baseline information for research in many disciplines. Tsunamis are collected by the WDC for Solid Earth Geophysics. The WDC-SEG is co-located with the US NOAA National Geophysical Data Center.

Website: http://www.ngdc.noaa.gov/wdc/wdcmain.html

The Resource Collection is *TsunamiTeacher's* "library", where all the background materials are listed. The information produced by *TsunamiTeacher* itself can easily be located by going to the beginning of the training modules and using the "rollovers" to find topics of interest.

TsunamiTeacher's website-based background resources are not listed here. There are however, comprehensive sets of Internet links to tsunami-related organizations and websites contained in the "Links and Contacts" section of the kit.

Materials in the Resource Collection are listed alphabetically by title, along with very basic information about the resource and the publisher. It is divided into three categories:

1. Information bank

2. Photographs and graphics bank

3. Audio-visual bank

Information bank

- Classroom materials
- Policies and Legal Frameworks
- Public awareness and education
- School curricula
- Tsunami warning systems
- Tsunami mitigation – Planning and preparedness
- Tsunami science and history

Classroom materials

Teachers can also draw on some of the general brochures already described in preceding sections of the Resource Collection.

A Living God

In 1896, three months after Japan's devastating Sanriku tsunami, Lafcadio Hearn Koizumi Yagumo wrote the true story of a Japanese chief who saved 400 villagers. Hearn's story was included in *Gleanings in Buddha-Fields*, published in 1897 by Houghton Mifflin Company of Boston and New York, and has been made available for educational purposes.

How the Smart Family Survived a Tsunami

Full-colour cartoon booklet that helps to prepare children for disasters, produced in 2002 by the Washington Military Department Emergency Management Division, United States.

The man who saved his village

Another story about a man who saved his village, this time from the 2004 Indian Ocean tsunami, is told by William Hermann of *The Arizona Republic*. It was featured in Sri Lanka's *Sunday Observer* in January 2005, and can be used for educational purposes.

The Natural Disasters Puzzle Book

An activity book for primary school children, produced by the Washington Military Department Emergency Management Division in 2005.

Tommy Tsunami Colouring Book

A 15-page colouring book, based on the cartoon characters Tommy Tsunami and Ernie Earthquake, produced by the West Coast & Alaska Tsunami Warning Center.

Tsunami – Lesson Learnt from Japanese Story "Inamura No Hi"

After the 2004 Indian Ocean tsunami, two booklets were produced telling the story of Japanese chief Hamaguchi Gohei, who saved his villagers from a tsunami. They are published by the Malaysian Medical Relief Society, Asian Disaster Reduction and Response Network and Asian Disaster Reduction Centre, supported by the Japanese government.

Tsunami Safety Guide – Teacher's Notes

Each letter in the word "tsunami" is used to describe tsunamis or offer a safety tip, in this pamphlet produced by the Tsunami Memorial Institute in Hawaii. It also has descriptions of tsunamis and how to prepare for them.

Tsunami Trivia Worksheet

The Oregon Department of Geology and Minerals Industries (DOGAMI) developed, among other things, a one-page quiz worksheet that asks a few pictorial questions about tsunamis and has a word search puzzle.

Tsunami Warning!

UNESCO produced a cartoon booklet, *Tsunami Warning!*, aimed at informing young people about tsunamis, the dangers that they present and what can be done to save lives and property. It comes in two forms – a laid-out word document whose text can be rewritten or translated; and a set of cartoons that can be used to construct a new booklet.

Policies and Legal Frameworks

Characteristics of Effective Emergency Management Organizational Structures

A self-assessment manual designed to help top local government administrators – elected or appointed – strengthen emergency management structures. Produced by the Public Entity Risk Institute, United States.

New Zealand's National Civil Defence Emergency Management Plan

In New Zealand, the Civil Defence Emergency Management Act of 2002 led to a National Civil Emergency Management Plan, which took effect in July 2006. To view other documents pertaining to New Zealand's emergency management laws and plans,

visit: www.civildefence.govt.nz

Disaster Countermeasures Basic Act of June 1997 – Japan

A comprehensive model of disaster legislation, produced by the National Land Agency in Japan with the general purpose of protecting national territory and the lives and welfare of citizens and their property.

Hawaii – Civil Defense and Emergency Act

The State of Hawaii's Revised Statutes, Chapter 128 of the Civil Defense and Emergency Act, which deals, among other things, with emergency activities relating to natural disasters such as tsunamis.

Natural Disasters and Sustainable Development: Understanding the Links Between Development, Environment and Natural Disasters

A 12-page document providing guidance to policymakers on how to link disaster strategies to development, and to other areas of government. Produced by the United Nations International Strategy for Disaster Reduction (ISDR) ahead of the 2002 World Summit on Sustainable Development in Johannesburg.

Standardized Emergency Management System Regulations – California

In California, regulations were developed in 1996 by the Office of Emergency Services to standardize responses to emergencies involving multiple jurisdictions or multiple agencies.

Public awareness and education

Disaster Preparation Handbook

The Washington Military Department Emergency Management Division produced a practical illustrated *Disaster Preparation Handbook* as an emergency planning and response guide. It is a multi-hazard handbook, applicable to tsunamis.

Protecting your Health in an Emergency

A booklet produced in New Zealand, containing a comprehensive set of tips for the public on being prepared for a disaster, knowing what to do during a disaster, and restoring safe conditions as soon as possible after a disaster.

Risk Communication Guide for State and Local Agencies

The California Offices of Emergency Services produced this 18-page guide In 2001. It provides basic information to emergency managers about developing a risk communication strategy to effectively communicate risk issues with the community.

Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan

True stories from the great Pacific-wide tsunami of 1960 are told in an 18-page illustrated booklet produced in 1999 by the US Geological Survey and National Tsunami Hazard Mitigation Programme in cooperation with Universidad Austral de Chile, University of Tokyo, University of Washington, Geological Survey of Japan and Pacific Tsunami Museum.

Tsunami safety advice

The International Tsunami Information Centre has compiled clear and pithy safety and "What to do" advice for people before and during a tsunami. Here are four advice lists:

What to do before a tsunami
"Sensing a Tsunami"
International Tsunami Information Centre safety rules
Guidance to mariners

Refer [Resource Collection] to view Media Kit resources developed by Washington States Emergency Management Division, USA [PDF] in the CD-ROM

School curricula

Tsunami Curriculum – Move to High Ground

Grades K to six

A tsunami curriculum was developed by the Washington Military Department Emergency Management Division for primary school pupils. It includes a teacher guide. The content teaches children about earthquakes and tsunamis, and how to prepare for them.

Tsunami Curriculum – Move to High Ground

Grades seven to 12

This curriculum was also developed by the Washington Military Department Emergency Management Division, for secondary school pupils. There is a teacher guide. The content comprises an interdisciplinary set of four lesson plans that do not differentiate between grades.

Earthquakes and Tsunamis

Pre-primary school

This collaborative Chile-UNESCO curriculum contains a separate activity textbook and teacher guide. Children are introduced to two characters, Johnny Shaking and Tommy Tsunami, who appear regularly through five chapters.

I Invite You to Know the Earth I

Grades two to four

A joint Chile-UNESCO curriculum comprising a textbook and a teacher guide. It is aimed at pupils of seven to nine years old, who have progressed beyond initial stages of reading and writing and have fine motor skills, and contains six topic units.

I Invite You to Know the Earth II

Grades five to eight

This Chile-UNESCO curriculum contains a textbook and a teacher guide aimed at pupils of 10 to 13 years old, who show many adult characteristics in their learning and are able to assimilate a large amount of information. There are five topic units.

Earthquakes and Tsunamis

Secondary school

This collaborative Chile-UNESCO curriculum contains a textbook and a teacher guide targeting secondary school pupils. It investigates earthquakes and tsunamis in-depth and has six chapters and a wealth of suggested activities.

Tsunami

Primary school – grades four to six

This new curriculum set comprises a 32-page, full-colour, illustrated textbook and a teacher guide. It is a collaborative project of the UNESCO Intergovernmental Oceanographic Commission, the Asian Disaster Reduction Center in Japan, and the Thai government's Bureau of Academic Affairs and Education Standards, Ministry of Education, and Department of Disaster Prevention and Mitigation, Ministry of the Interior.

Tsunami warning systems

Assessment of Capacity Building Requirements for an Effective and Durable Tsunami Warning and Mitigation System in the Indian Ocean

During 2005 assessments of 16 countries in the Indian Ocean were conducted by teams of experts to identify capacity building needs and support requirements for developing a tsunami warning system in the Indian Ocean. Their findings are described in this UNESCO-IOC report.

Communications Plan for the Interim Tsunami Advisory Information Service for the Indian Ocean Region

A Plan produced in January 2006 by NOAA's Richard H Hagemeyer Pacific Tsunami Warning Center and the Japan Meteorological Agency, providing a summary of the interim services provided by the PTWC and JMA to Indian Ocean countries, and a general overview of the operational procedures involved.

Tsunami Warning System in Japan

This four-page summary describes what is considered to be the most responsive tsunami warning system in the world, operated by the Japan Meteorological Agency (JMA), to protect citizens from local, regional and teletsunamis. Established in 1952, the Japan Tsunami Warning System is responsible for issuing tsunami warnings to the public.

Communications Plan for the Pacific Tsunami Warning and Mitigation System

The communications operating manual for participants in the Pacific Tsunami Warning and Mitigation System and for the Richard H Hagemeyer Pacific Tsunami Warning Center (PTWC), produced in January 2006.

From Commitments to Action: Advancements in Developing an Indian Ocean Tsunami Warning and Mitigation System

A booklet produced by UNESCO-IOC in 2006, looking at the development of an Indian Ocean Tsunami Warning and Mitigation System, commitments that have been made, actions taken and long term plans.

Operations, Systems and Procedures Manual: Pacific Tsunami Warning Center

The draft of a Manual being produced by PTWC Tsunami Warning Science Officer Dr Stuart A Weinstein, providing information on the PTWC's mission, operations, procedures, software and message products.

Pacific Tsunami Warning and Mitigation System: Master Plan, 2nd Edition

In 1999 the UNESCO-IOC Intergovernmental Coordinating Group for the Pacific Tsunami Warning and Mitigation System (ICG-PTWS) produced a Second Edition of its *Master Plan*, which provides a brief overview of the tsunami hazard in the Pacific, describes the warning system and charts future directions.

PowerPoint of the Pacific Tsunami Warning Center

This presentation describes the mission, operations, and activities of the Richard H Hagemeyer Pacific Tsunami Warning Center in Hawaii.

PowerPoint of the Centre Polynésien de Prévention des Tsunamis

This presentation describes the tsunami warning center, located in Papeete, Tahiti. The CPPT was first established in the 1960s. Over the years, it has continuously improved its methods of real-time earthquake analysis for tsunami warning. In 2003, a new integrated tsunami warning plan was developed and starting in 2006, sirens will be installed through the territory.

PowerPoint of the JMA Tsunami Warning Center

This presentation, created by Masahiro Yamamoto, formerly the Director of Japan Tsunami Warning Center of the Japan Meteorological Agency, describes the plate tectonics and seismic activity in Japan, as well as Japan's emergency response to tsunamis.

PowerPoint on Tsunami Warning Centre Management and Staffing

This presentation describes the key functions and management considerations for successful and sustainable operation of a tsunami early warning center. Created by Masahiro Yamamoto, formerly the Director of Japan Tsunami Warning Center of the Japan Meteorological Agency.

Tsunami mitigation – Planning and preparedness

Developing TsunamiReady Communities: Translating Scientific Research into Useable Emergency Management Products

This paper, written by George Crawford, Washington State's Earthquake Program Manager, and presented at the 8th US National Conference on Earthquake Engineering in April 2006, describes Washington State's efforts to develop and promote tsunami awareness and preparedness in coastal communities.

On Shore Tsunami Communications – Getting the Tsunami Warning to the People on the Beach

This paper describes how Washington State has used the NOAA Weather Radio Emergency Information Network and the All Hazard Alert Broadcasting (AHAB) Radio to notify people on the beach of impending tsunamis.George Crawford, Washington State's Earthquake Program Manager, authored and presented this paper at the Eighth U.S. National Conference on Earthquake Engineering in April 2006.

All Hazard Alert Broadcasting (AHAB) Radio

Washington Emergency Management Division (EMD) in partnership with Federal Signal has designed and developed a system that provides both tone and voice alert and notification to state and local emergency management and federal authorities with the ability to activate alert and notification devices for any hazardous situation. These devices can be installed at high risk facilities or in areas that are high trafficked by both the public and public/private sector that are prone to natural and man-made hazards.

Radio and Internet for the Communication of Hydro-meteorological and Climate-Related Information for Rural Development

RANET (Radio and Internet) is an international collaboration with the goal of making hydro-meteorological and climate-related information available to rural populations, to aid their day-to-day resource decisions and preparations against natural hazards.

NOAA NWS Emergency Managers Weather Information Network (EMWIN)

EMWIN is a nonproprietary operational dissemination system developed by the NOAA NWS Office of Operational Systems for the emergency management community. It consists of a suite of data access methods that make available a live stream of weather and other critical emergency information through a continuous, dedicated low speed data broadcast using an audio signal from the GOES satellite or terrestrial re-transmitter.

Tsunami Emergency Response After Receiving a Warning – Hawaii State and County Civil Defense

Former Earthquake and Tsunami Programme Manager for Hawaii State Civil Defense, B Yanagi, describes Hawaii's emergency response procedures after receiving a tsunami warning as an example of an "end to end" warning and mitigation system.

British Columbia Tsunami Warning and Alert Plan

The British Columbia Provincial Emergency Program produced a 53-page tsunami warning and alert plan in 2001, identifying actions to be taken by the government to disseminate warnings to coastal communities of a potentially destructive tsunami.

Tsunami Emergency Response Plan for Hawaii, United States

As the agency responsible for public safety in the State, Hawaii State Civil Defense has developed a comprehensive Tsunami Emergency Response Plan that is closely integrated with the Pacific Tsunami Warning Centre warning and information bulletins. The plan featured here discusses tsunami response at the state and county level.

Case Study: Hawaii, USA – Emergency Response and Tsunami Preparedness

A power-point presentation produced by the Hawaii State Civil Defense Agency, describing how the State's tsunami warning and response is organized and operates, and briefly outlining mitigation efforts.

City and County of Honolulu Emergency Operations Plan: Tsunami Evacuation and Sheltering

Published in 1991, to supplement the Honolulu City Emergency Operations Plan, this document is an example for planners and emergency manager of evacuation operations, responsibilities, and maps. The full title of the document is Annex S, Appendix 2, *City and County of Honolulu Emergency Operations Plan: Tsunami Evacuation and Sheltering.*

International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework Summary Report

A summary report of an Intergovernmental Oceanographic Commission (IOC) workshop held in Paris, France, 3–8 March 2005, and attended by technical delegates from over 45 countries. The workshop examined the key mitigation elements requiring hazard and risk modeling, and the need to improve tsunami analysis and simulation.

NOAA TIME Seattle Tsunami Mapping Project: Procedures, Data Sources, and Products

This report published in 2003 describes the NOAA Center for Tsunami Mapping Efforts (TIME) project to model and map potential tsunami inundation along the Puget Sound shores of Seattle, Washington.

Designing for Tsunamis: Seven Principles for Planning and Designing for Tsunami Hazards

In 2001 NOAA's National Tsunami Hazard Mitigation Program led a multi-state project that published this manual, which presents tsunami mitigation guidelines as they relate to land use, site planning and building design and construction.

Emergency Planning Manuals for Businesses

Three guides to emergency planning for businesses, produced by Auckland City Civil Defence in New Zealand, to assist businesses to improve the emergency preparedness of their businesses. They were produced for the Ministry of Civil Defence's Public Education Advisory Committee, and sponsored by New Zealand Safety Limited.

Implementation Plan for Tsunami Mitigation Projects

A comprehensive tsunami mitigation strategy and planning document produced in 1998 for the NOAA National Tsunami Hazard Mitigation Program by Dr Lori Dengler of Humboldt University, United States.

A summarized version of the Implementation Plan for Tsunami Mitigation Projects can be found at:

http://www.pmel.noaa.gov/tsunami-hazard/loriplan.html

Living with Risk: A global review of disaster reduction initiatives

The United Nations International Strategy for Disaster Reduction (ISDR) investigated links between environmental management and disaster reduction, and its findings are outlined in this document. "Chapter Five: A section of disaster reduction applications" discusses a range of ways to reduce disaster risk, and a selection of disaster reduction applications.

The homepage of Living at Risk is at:

http://www.unisdr.org/eng/about_isdr/bd-lwr-2004-eng-p.htm

Model Community Emergency Response Plan

An emergency response plan produced by Elise G DeCola and Tim L Robertson in 2002 for the Yukon River Inter-Tribal Watershed Council, United States. Contains Tsunami response flow charts, checklists and procedures.

Oahu Civil Defense Agency Evacuation Maps

The Oahu Civil Defense Agency in Honolulu, Hawaii, developed a set of tsunami evacuation maps that are published in the Hawaiian telephone directories. The maps are produced by Dr George Curtis.

Post-Tsunami Survey Field Guide

In 1998 the Intergovernmental Oceanographic Commission published a *Post-Tsunami Survey Field Guide* to assist IOC Member States, scientists, authorities and community leaders to organize and conduct post-tsunami field survey reconnaissance investigations.

Risk Identification and Analysis: A Guide for Small Public Entities

The Public Entity Risk Institute in Fairfax, United States, produced a 12-page free-use booklet to provide small public entities with a "user-friendly process to identify and analyze their risks on an enterprise-wide basis." It is just as useful for businesses.

Special Paper 31 – Mitigating Geologic Hazards in Oregon: A Technical Reference Manual

In 1999 the Oregon Department of Geology and Mineral Industries produced this Special Paper, written by John D Beaulieu and Dennis L Olmstead. It describes the basic elements that should be present in any effective hazards regulatory or decision making process.

Special Paper 31 – Mitigating Geologic hazards in Oregon can be found at:

http://www.oregongeology.com/sub/earthquakes/SpecialPaper31.pdf

Special Paper 32 – Geologic Hazards: Reducing Oregon's Losses, a technical reference manual that summarizes Special Paper 31, can be found at:

http://www.oregongeology.com/sub/earthquakes/specialpaper32.pdf

Structural Response to Tsunami Loading – The Rationale for Vertical Evacuation

A pilot study on construction design, pulling in lessons from the Indian Ocean tsunami, was conducted for the Federal Emergency Management Agency (FEMA) by Ian Robertson and Kason Pacheco of University of Hawaii at Manoa, and Harry Yeh of Oregon State University.

Supplement to the Emergency Planning Guidance for Local Governments

A 206-page guidance manual to assist "in the initial development of a tsunami response plan and the procedures necessary to deal with a tsunami's impact on their communities," produced for the California Governor's Office of Emergency Services, United States. It is supplementary to *Local Planning Guidance on Tsunami Response – 2nd Edition.*

Tsunami mitigation for the City of Suva, Fiji

A Suva Earthquake Risk Management Scenario Pilot Project (SERMP) was produced for the government of Fiji, considering mitigation measures for earthquakes and tsunamis striking Suva. This article was published in the *Science of Tsunami Hazards* journal, Volume 18, Number 1 (2000).

Tsunami! Safety Tips for the Washington Coast

Brochure produced by the Washington Military Department, providing an example of a tsunami evacuation map as well as basic information on tsunamis, how people can protect themselves against earthquakes and tsunamis, emergency supply kits, emergency radio channels and contact details for emergency services.

Tsunami Sign Placement Guidelines

In 2003 the State of Oregon Department of Geology and Mineral Industries published *Tsunami Sign Placement Guidelines*, by Mark Darienzo, an 11-page manual that describes the types of tsunami signs available and placement guidelines for the Oregon.

Government of Sri Lanka Guidelines for Tsunami Evacuation Signboards

After the December 26, 2004 tsunami ravaged coastal areas, Sri Lanka installed signboards to assist people in tsunami danger areas to find evacuation routes and safe areas upon receiving a tsunami warning. Specifications for text, fabrication, placement, and erecting of signboards are provided in this guide.

Tsunami Warning Systems and Procedures – Guidance for Local Officials

A booklet on local tsunami warning public notification systems and procedures prepared by Oregon Emergency Management for the National Tsunami Hazard Mitigation Program of NOAA in the United States.

Tsunami Warnings: Understanding in Hawai'i

In a 2004 Hawaii-based study, Dr Chris Gregg and his colleagues examined the relationship between repeated and long-term exposure to monthly siren soundings - used to alert the population to an emergency – as well as the availability of published material describing the tsunami warning system and evacuation routes, and the degree to which these factors evoked an immediate and appropriate response for tsunamis.

Natural Warning Signs of Tsunamis: Human Sensory Experience and Response to the December 26, 2004 Earthquake and Tsunami, Thailand

A study team interviewed some 663 adult residents of Thailand affected by the December 26, 2004 earthquake and tsunami events in an effort to understand the continuum of thinking and behavioral response of survivors upon observing the natural warning signs of the impending tsunami.

PowerPoint on Numerical Modeling

This PowerPoint presentation introducing numerical modeling has been compiled by the ITIC from materials presented by Dr Fumihiko Imamura of Tohoku University, Dr Costas Synolakis of the University of Southern California, and Gaye Downes of the Institute of Geological and Nuclear Science, New Zealand.

Tsunami Modelling Manual

This manual, written by Dr.Fumihiko Imamura, Dr. Ahmet Cevdet Yalciner, and Res. Assist. Gulizar Ozyurt and revised in April 2006, describes the Tsunami Inundation Modeling for Exchange (TIME) programme. TIME is a joint effort of the International Union of Geophysics and Geodesy and UNESCO-IOC, developed as part of the UN's International Decade for Natural Disaster Reduction. This effort has helped develop national capacities to conduct inundation modeling through long-term, hands-on training programmes conducted through the Disaster Control Research Center at Tohoku University in Japan.

PowerPoint by the ADRC: Japan Tsunami Warning and Mitigation System - Preparedness

This ADRC PowerPoint by Akiko Nakamura briefly describes the Japan Tsunami Warning System and discusses in detail how, through a series of community workshops, evacuation routes and maps were established to better prepare for and reduce the impact of tsunamis.

Hawaii Tsunami Observer Plan

Developed in 2002 by a team of tsunami scientists for the Civil Defense Division, State of Hawaii Department of Defense, this plan serves as a field guide for conducting safe and accurate measurements of tsunami run-ups and inundations. It also establishes and maintains a system to pre-position survey equipment and supplies, train volunteer tsunami observers, and input and preserve data tsunami records.

Marquesas 2004 Tsunami Drill

This excerpt from the ITIC Newsletter describes a two-day tsunami warning exercise conducted in the Marquesas Islands by the local Civil Defense and the CPPT (Centre Polynesien de Prevention des Tsunamis), which issues tsunami warnings for French Polynesia. The purpose of the exercise was to re-evaluate, revise, and validate its tsunami emergency plan.

Pacific-wide Tsunami Drill – Exercise Pacific Wave 06

This tsunami exercise workbook outlines the May 2006 Pacific-wide tsunami drill. The purpose of the exercise is to evaluate the ability of Pacific countries to respond to an ocean wide tsunami. The exercise provides an opportunity for Pacific Countries to exercise their operational lines of communications, review their tsunami response procedures, and to promote emergency preparedness.

TsunamiReady Program

This 10-page description outlines a National Weather Service (NWS) initiative that promotes tsunami hazard preparedness as an active collaboration among Federal, state and local emergency management agencies, the public, and the NWS tsunami warning system. This collaboration strives to increase tsunami awareness and enhance mitigation efforts among communities at risk.

Summary – Consideration of the Requirements for Vertical Evacuation: Engineering Design and Construction Guidance

This document summarizes a multi-phased project, and other related engineering studies involving the United States' NTHMP, FEMA, NOAA, and the western US States focused on the consideration of requirements necessary to permit safe vertical evacuation in areas where the shortness of evacuation time prevents safe evacuation inland.

Development of Design Guidelines for Structures that Serve as Tsunami Vertical Evacuation Sites

This Washington Division of Geology and Earth Resources open file report completed in November 2005 summarizes Phase I of a study by Harry Yeh, Oregon State University, Ian Robertson, University of Hawaii, and Jane Preuss, of Planwest Partners. The purpose of the first phase of the study was to extract data from unpublished tsunami surveys to estimate forces from tsunami waves on buildings, to analyze buildings that survived tsunami wave attack, and to test those forces against building code designs.

Overview of the Development of Design and Construction Guidance for Special Facilities for Vertical Evacuation from Tsunami

This overview describes the activities planned for Phase II of the above described project. Phase II will build on Phase I results to develop design and siting specifications, a manual for field data collections, and an outreach program consisting of the creation of databases and a series of workshops to disseminate and train design professionals in the application of the guidelines. The Phase II contract has been let to the Applied Technology Council of Redwood City, California, under contract to the Federal Emergency Management Agency, and is anticipated to be completed in 2006 or 2007.

Overview of the Performance Based Tsunami Engineering Project

The Performance Based Tsunami Engineering (PBTE) Project is a 4-year Small Group Research Project to be carried out by the University of Hawaii, Oregon State University, and Princeton University with funding from the US National Science Foundation under the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) Programme. The Project brings together experts in structural, ocean, and coastal engineering, hydrodynamics and computational mechanics, tsunami, fluid-transport and scour, and experimental modeling, tsunami and seismic hazard analysis, disaster management and preparedness, and tsunami and seismic community response and social science to develop and disseminate methodology and tools for implementation of site specific Performance Based Tsunami Engineering (PBTE) for use in the analysis, evaluation, design and retrofit of coastal structures and facilities.

Tsunami science and history

This section contains documents, manuals and guides, booklets, brochures, power-point presentations, and school curricula and lesson materials.

The Great Waves

An illustrated, 12-page full-colour brochure on tsunamis. Produced by UNESCO-IOC, the International Tsunami Information Centre, Laboratoire de Geophysique in France, and the US National Oceanic and Atmospheric Administration. It may be reproduced for educational purposes.

Tsunami Glossary

An illustrated, 24-page full-colour booklet of tsunami terms and definitions, acronyms and organizations, produced by UNESCO-IOC and the International Tsunami Information Centre in 2006. It may be reproduced for educational purposes.

Tsunami – Understanding the Giant Wave

An illustrated scientific article on the science and histories of tsunamis, mitigation, research and warning systems. Written in 2000 by Professor Philip Liu of Cornell University in New York; updated in 2006 by Dr Laura Kong, Director of the International Tsunami Information Centre.

Audio-visual bank

Asian Tsunami: Disaster of the Century

Asian Tsunami: Disaster of the Century is a 30-minute compilation of film materials from the 2004 tsunami produced by the Asia-Pacific Broadcasting Union. The programme may only be used for educational purposes, and as a complete package.

The copyright contact details for the ABU:

Director, Programme Department

Address: Asia-Pacific Broadcasting Union, PO Box 1164, 59700 Kuala Lumpur, Malaysia

Tel: +60 3 2282 2480

Fax: +60 3 2282 5292

Website: http://www.abu.org.my

Hawai'i Tsunami Warnings 1986, 1994 – Neighbour Islands

Short films on tsunami waves and warnings in Hawaii were produced by the International Tsunami Information Centre in 2005, one is Hawai'i Tsunami Warnings 1986, 1994 which is about Oahu and the other Hawai'i Tsunami Warnings 1986, 1994 - Neighbour Islands which is about Hawai'i, Kauai and Maui. These describe the 1986 and 1994 tsunami warnings for Hawaii, and how authorities, the media and residents responded.

The copyright contact details for the ITIC:

Address: International Tsunami Information Centre, 737 Bishop Street, Suite 2200, Honolulu, HI 96813, Hawaii, United States

Tel: +1 808 532 6422

Fax: +1 808 532 5576

Website: http://www.tsunamiwave.info

E-mail: itic.tsunami@noaa.gov

Japan Broadcasting Corporation – NHK Japan

Disaster Broadcast: An In-house Training Guide

A Japan Broadcasting Corporation production that contains six video clips featuring footage of earthquakes and what happens next in Japan regarding tsunami warnings.

Notes on Disaster Prevention: Surviving a Tsunami

An NHK Japan production featuring three 30-second clips relating specifically to the 2004 Indian Ocean tsunami. The clips have already been distributed to member of the ABU.

The copyright contact details for NHK Japan are:

Address: 2-2-1 Jinnan, Shibuya-ku, Tokyo 150-8001, Japan

Tel: +81 3 3465 1111

Website: http://www.nhk.or.jp/english/

Tsunami Model Visualization for Suva, Fiji

In 2003 the Pacific Disaster Center in Hawaii produced a Tsunami Model Visualization for Suva, Fiji. It demonstrates the use of computer modeling, data and information resources, and visualization techniques to simulate the evolution of a tsunami wave on Suva.

The contact details for this visualization are:

Pacific Disaster Center

Address: 1305 N. Holopono St., Suite 2, Kihei, Maui, HI 96753, United States

Tel: +1 808 891 0525

Fax: +1 808 891 0526

Website: http://www.pdc.org

Run to High Ground!

The animated film for children, which runs for 14 minutes, and was produced by the Washington State Military Department Emergency Management Division, and the Provincial Emergency Programme of British Columbia in association with Global Net Productions. It can be used for educational purposes only.

Tsunami: Waves of Destruction

Tsunami: Waves of Destruction is a 17-minute production of Hawaii State Civil Defense and Hawaii Public Television, and is a Charlotte Simmons Production. A longer 28-minute version is also available.

Permission (v) has been obtained to duplicate the DVD for educational purposes, from Ray Lovell of Hawaii State Civil Defense. It is also available from VideoLab, Honolulu. Tel: +1 808 593 0400

Save Your Lives from Tsunami!

Save Your Lives from Tsunami! is a 17 minute film on CD planned and produced by the Japan Meteorological Agency in cooperation with NHK Enterprises 21, Inc.

Produced in 2004 in Japanese and English, the film defines tsunamis, the characteristics of tsunami waves, and their generation mechanisms. The film introduces Professor Tsunami who teaches the viewer about tsunamis, how to prepare for one, and what to do one a tsunami hits. Film recordings of tsunami waves and the damage that they caused in and around Japan is shown. Finally, the film describes the operation of the Japan National Tsunami Warning System by the Japan Meteorological Agency to immediately warn people against tsunamis.

The film uses animations to illustrate the earthquake and tsunami generation process, and shows actual footage of the waves striking coastal towns in Japan.

The CD is freely available from JMA and the ITIC.

Japan Meteorological Agency
Earthquake and Tsunami Observations Division
Seismological and Volcanological Department
Address: 1-3-4 Otemachi, Chiyoda-ku, Tokyo 100 8122, Japan

Tel: +81 3 3212 8341
Fax: +81 3 3215 2963

Website: http://www.jma.go.jp/en/tsunami/

International Tsunami Information Centre
Address: 737 Bishop Street, Suite 2200, Honolulu HI 96813, Hawaii, United States

Tel: +1 808 532 6422
Fax: +1 808 532 5576

Website: http://www.tsunamiwave.info/

Tsunami Background Informational Video (B-Roll)

Produced by NOAA Public Affairs and ITIC in 2005, the Tsunami B-Roll (Background Information Video) is a collection of interviews, tsunami science and numerical tsunami propagation animations, and other graphics for use by broadcast media as filler or background footage during a television news presentation or a documentary program. It may also be useful to emergency managers, educators, and for training. The subject matter covers the science of tsunamis, the U.S. tsunami warning centres in Hawaii and Alaska, the U.S. National Tsunami Hazard Mitigation Program, Tsunami Ready, and the ITIC.

In total, the interview video runs 57 minutes and is available in Beta-SP and DVD format. Additionally, small-size video clips of the interviews are part of the TsunamiTeacher DVD or downloadable from the ITIC

web site: http://ioc3.unesco.org/itic/categories.php?category_no=279

The DVD high-resolution compilation and the individual broadcast-quality video clips are freely available from the ITIC. Graphics, Photos, and Animations are available from the ITIC web site.

International Tsunami Information Centre

Address: Suite 2200, 737 Bishop Street, Honolulu HI 96813-3213, United States

Tel: +1 808 532 6422
Fax: +1 808 532 5576

Website: http://www.tsunamiwave.info/

This section of *TsunamiTeacher* lists contact details for a wide range of organizations that are involved in tsunami-related activities. It is aimed at people who are seeking additional information, resources or expertise on tsunamis.

The links and contacts fall into five categories – intergovernmental groups that coordinate tsunami warning systems; key tsunami-related organizations and centres; tsunami research groups; tsunami websites; and links to media websites that cover tsunamis. A brief description accompanies each of the links and contacts.

The list was up-to-date at the time of *TsunamiTeacher's* publication. It is likely that some of the contact numbers and addresses will change over time.

1. Intergovernmental coordination of warning systems – lead contacts

2. Tsunami-related key organizations

3. Tsunami research groups

4. Tsunami website links

5. Tsunami media links

1. Intergovernmental coordination of tsunami warning systems – lead contacts

UNESCO's Intergovernmental Oceanographic Commission (IOC) and International Tsunami Information Centre (ITIC) coordinate tsunami warning and mitigation activities at the international level, working with national governments and their representatives to ensure the smooth operation of multilateral tsunami systems.

UNESCO-IOC has a long-established (recently renamed) Intergovernmental Coordination Group (ICG) for the Pacific Ocean. Following the 2004 tsunami, the IOC set up ICGs for the Indian Ocean, North-eastern Atlantic Ocean Mediterranean and connected seas, and Caribbean and adjacent regions. Warning centres to support the new regional warning systems are being established.

1.1: UNESCO Intergovernmental Oceanographic Commission

1.2: UNESCO-IOC Intergovernmental Coordination Groups

1.3: UNESCO-IOC International Tsunami Information Centre

1.1: UNESCO Intergovernmental Oceanographic Commission

Dr Patricio Bernal
Executive Secretary
Intergovernmental Oceanographic Commission

IOC Tsunami Unit
Dr. Peter Koltermann
Head

Address: 1 Rue Miollis,(75732 Paris, CEDEX 15, France

Fax: +33 1 4568 5810/12

E-mail: ioc.tsunami@unesco.org

UNESCO-IOC: http://ioc.unesco.org/iocweb/index.php

UNESCO: http://www.unesco.org

1.2: UNESCO-IOC Intergovernmental Coordination Groups

ICG-CARIBE-EWS: IOCARIBE, secretariat

ICG for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions

Cesar Toro
Head, IOCARIBE

Address: IOCARIBE, Calle de la Factoria no 36-57, (Casa del Marquez de Valdehoyos), Cartagena, Colombia

Tel: +575 664 6399
Fax: +575 660 0407

ICG-CARIBE-EWS: http://ioc3.unesco.org/cartws

IOC-PERTH – ICG-IOTWS secretariat

ICG for the Indian Ocean Tsunami Warning and Mitigation System

Tony Elliot

Head, Secretariat

Address: IOC-PERTH, c/o Bureau of Meteorology, PO Box 1370, West Perth WA 6872, Australia

Tel: +61 8 9226 2899
Fax: +61 8 9226 0599

ICG/IOTWS: http://ioc.unesco.org./indotsunami

SC-IOC Tsunami Unit – ICG-NEAMTWS secretariat

ICG for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connecting Seas

Address: 1 Rue Miollis,(75732 Paris, CEDEX 15, France

Tel.: +33 1 456 83974

E-mail: ioc.tsunami@unesco.org

ICG-NEAMTWS: http://ioc3.unesco.org/neamtws

ICG-PTWS: IOC ITIC, secretariat

ICG for the Pacific Tsunami Warning and Mitigation System

Dr. Laura SL Kong
Director, ITIC

Address: 737 Bishop Street, Suite 2200, Honolulu HI 96813-3213, USA

Tel: +1 808 532 6422
Fax: + 1 808 532 5576

E-mail: itic.tsunami@unesco.org

Website: http://ioc3.unesco.org/ptws

1.3: UNESCO-IOC International Tsunami Information Centre

ICG for the Pacific Tsunami Warning and Warning System: secretariat

Dr Laura SL Kong
Director

E-mail: l.kong@unesco.org,

Address: 737 Bishop Street, Suite 2200, Honolulu HI 96813-3213, USA

E-mail: itic.tsunami@unesco.org, tsunamiteacher@unesco,org

Tel: +1 808 532 6422
Fax: + 1 808 532 5576

Website: http://www.tsunamiwave.info/, http://ioc.unesco.org/itic

2. Tsunami-related key organizations

2.1: Asian Disaster Reduction Center (ADRC)

2.2: Centre Polynésien de Prévention des Tsunamis (CPPT)

2.3: International Union of Geodesy and Geophysics – Tsunami Commission (IUGG-TC)

2.4: Japan Meteorological Agency (JMA)

2.5: National Oceanic and Atmospheric Administration (NOAA)

NOAA and tsunamis

National Tsunami Hazard Mitigation Program (NTHMP)

National Geophysical Data Center (NGDC)

Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC)

West Coast and Alaska Tsunami Warning Center (WC-ATWC)

2.6: Pacific Tsunami Museum

2.7: Russian Federation Tsunami Warning Centres

2.8: Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA)

2.9: US Geological Survey (USGS)

Earthquake Hazards Program - National Earthquake Information Center (NEIC)

Tsunami and Earthquakes Research Group

2.1 Asian Disaster Reduction Center (ADRC)

The crucial need to promote multinational cooperation in efforts to mitigate disasters in Asia was stressed at a ministerial-level Asian disaster reduction conference held at Kobe, in Japan's Hyogo Prefecture, in 1995 and attended by delegates from 28 countries in Asia and elsewhere. The Asian Disaster Reduction Center was established in Kobe to promote and conduct research into multinational disaster reduction cooperation in Asia. The ADRC also facilitates the exchange of disaster reduction experts between countries and disaster organizations in the region, and accumulates and provides disaster reduction information.

Executive Director: Koji Suzuki

Address: Hitomiraikan 5F, 1-5-2, Wakinohama-kaigan-dori, Chuo-ku, Kobe City, Hyogo Prefecture, 651-0073 Japan

Tel: +81 78 262 5540
Fax: +81 78 262 5546

Website: http://www.adrc.or.jp/top.php

E-mail: rep@adrc.or.jp

2.2: Centre Polynésien de Prévention des Tsunamis (CPPT)

France (Commissariat à l 'Energie Atomique/ Département d 'Analyse et Surveillance de l 'Environnement, CEA/DASE) operates a tsunami warning centre for French Polynesia and promotes tsunami hazard mitigation in this region. This region encompasses the Society Islands, the Marquesas Islands, the Tuamoto Islands, and the Austral Islands. The CPPT was first established in 1965. Over the years, it has continuously improved its methods of real-time earthquake analysis for tsunami warning.In 2003, a new integrated tsunami warning plan was developed and starting in 2006, sirens will be installed through the territory. The CPPT has contributed to the PTWS the TREMORS (Tsunami Risk Evaluation through seismic MOment from a Real-time Systen) as a one-station seismic event detection and tsunami warning system for regional to distant earthquakes.

Dominique Reymond
Director

Address: Laboratoire de Géophysique, BP 640 Papeete Tahiti Polynésie Française

Tel: +689 82 80 25
Fax: +689 83 50 37

E-mail: reymond.d@labogeo.pf or cppt@labogeo.pf

2.3: International Union of Geodesy and Geophysics – Tsunami Commission (IUGG-TC)

The International Union of Geodesy and Geophysics (IUGG) is an international organization dedicated to advancing, promoting and communicating knowledge of the Earth system, the space environment and dynamic processes causing change. It convenes international gatherings, conducts research, assembles observations, gains insights, coordinates activities, liaises with scientific bodies, plays an advocacy role, and contributes to education.

The Union's IAPSO, IASPEI and IAVCEI Associations co-sponsor the IUGG Tsunami Commission, Commission (IUGG-TC), which focuses on tsunami research.

Dr JA Joselyn
Secretary General

Address: CIRES, Campus Box 216, University of Colorado, Boulder, CO 80309 0216, United States

Tel: +1 303 497 5147
Fax: +1 303 497 3645

Website: http://www.iugg.org/

E-mail: jjoselyn@cires.colorado.edu

Tsunami Commission
Dr. Kenji Satake
Chairman

Address: Geological Survey of Japan, AIST (National Institute of Advanced Industrial Science and Technology), Site C7 1-1-1 Higashi, Tsukuba 305-8567 Japan

Tel: + 81 29 861 3640
Fax: +81 29 852 3461

Website: http://www.aist.go.jp/GSJ/dER/activef/english/hptop1.html

E-mail: kenji.satake@aist.go.jp

2.4: Japan Meteorological Agency (JMA)

The Japan Meteorological Agency is a highly advanced meteorological service, and it discharges both national and international responsibilities. Among other things the Agency is responsible for issuing tsunami warnings and advisories, forecasting wave heights and arrival times, and for tsunami observations. The Japan Tsunami Warning Service was established in 1952. It provides tsunami alerts to other Asian and Pacific countries, and along with NOAA in the United States, is providing interim advisory services to the new Indian Ocean Tsunami Warning and Mitigation System, and the South China Sea.

Dr. Osamu Kamigaichi
Deputy Director, Earthquake and Tsunami Observations Division
Seismological and Volcanological Department
Japan Meteorological Agency

Address: 1-3-4 Otemachi, Chiyoda-ku, Tokyo 100 8122, Japan

Tel: +81 3 3212 8341
Fax: +81 3 3215 2963

Website: http://www.jma.go.jp/en/tsunami/

E-mail: okamigai@met.kishou.go.jp

United Nations Educational, Scientific and Cultural Organization
TsunamiTeacher
Links and Contacts

2.5: National Oceanic and Atmospheric Administration (NOAA)

NOAA is a federal agency in the United States that focuses on the condition of the oceans and the atmosphere. The large agency's roles within the Department of Commerce are to supply environmental information products, provide environmental stewardship of national coastal and marine environments, and to conduct applied scientific research into ecosystems, climate, weather and water, and commerce and transportation. NOAA does a great deal of work on tsunamis, including operating the Pacific Tsunami Warning System.

Address: 14th Street and Constitution Avenue NW, Room 6217, Washington DC 20230, United States

Tel: +1 202 482 6090
Fax: +1 202 482 3154

Website: http://www.noaa.gov/

NOAA and tsunamis

Delores Clark
NOAA Public Affairs Officer
c/o National Weather Service

Address: Suite 2200, 737 Bishop Street, Honolulu HI 96813

Tel: +1 808 532 6411
Fax: +1 808 532 5569

Website: http://www.tsunami.noaa.gov/

E-mail: Delores.Clark@noaa.gov

National Tsunami Hazard Mitigation Program (NTHMP)

This is the website portal page for NOAA's National Tsunami Hazard Mitigation Program:

http://www.pmel.noaa.gov/tsunami-hazard

National Geophysical Data Center (NGDC)

NGDC provides scientific stewardship, products, and services for geophysical data from the Sun to the Earth and Earth's sea floor and solid earth environment, including Earth observations from space. In tsunamis, it acts as the World Data Center for Solid Earth Geophysics – Tsunamis (WDC/SEG-Tsunamis) to archive data from significant tsunamis, and maintains a database of historical tsunamis that includes runup and inundations. The ITIC and NGDC Tsunami Program work closely together to collect and archive information on tsunamis throughout the world.

Susan McLean
Director

WDC/SEG-Tsunamis

E-mail: Susan.Mclean@noaa.gov

Paula Dunbar

Tsunami Programme Manager, NGDC

E-mail: Paula.Dunbar@noaa.gov,

Address: NOAA/NGDC/WPC, 325, Broadway, Boulder, Colorado 80305 USA

Tel: +1 303 497 6084
Fax: +1 303 469 6513

Website: http://www.ngdc.noaa.gov/seg/hazard/

Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC)

In the United States, NOAA and the National Weather Service's Pacific Tsunami Warning Center provides tsunami warnings to countries in the Pacific Basin as well as to Hawaii and all other United States interests in the Pacific outside of Alaska and the US West Coast – the latter two are served by the West Coast and Alaska Tsunami Warning Center. The PTWC is also the warning centre for Hawaii's local and regional tsunamis. Along with the Japan Meteorological Agency, the PTWC is providing interim tsunami advisory information to countries in the Indian Ocean region, Puerto Rico, the US Virgin Islands, nations in the Caribbean region outside the Gulf of Mexico, and the eastern seaboard of the United States.

Dr. Charles McCreery

Geophysicist-in-Charge

Address: 91-270 Fort Weaver Road, Ewa Beach HI 96706 2928, Hawaii, United States

Tel: +1 808 689 8207 ext 301
Fax: +1 808 689 4543

Website: http://www.prh.noaa.gov/pr/ptwc/

E-mail: charles.mccreery@noaa.gov or ptwc@ptwc.noaa.gov

West Coast and Alaska Tsunami Warning Center (WC-ATWC)

Paul Whitmore
Geophysicist-in-Charge

NOAA and the National Weather Service's West Coast and Alaska Tsunami Warning Center provides tsunami warnings to Alaska, United States western and eastern states and those in the Gulf of Mexico, and also to the western and eastern coasts of Canada. The ATWC website also has information on tsunamis and links to other useful websites.

Address: 910 S Felton Street, Palmer AK 99645, United States

Tel: +1 907 745 4212
Fax: +1 907 745 6071

Website: http://wcatwc.arh.noaa.gov/

E-mail: paul.whitmore@noaa.gov or wcatwc@noaa.gov

2.6: Pacific Tsunami Museum

The Pacific Tsunami Museum in Hilo, Hawaii, promotes public tsunami education among the people of Hawaii and the Pacific Region. It also serves as a living memorial to people who lost their lives during past tsunami events.

Donna Saiki
Director

Address: PO Box 806, Hilo HI 96721, Hawaii, United States

Tel: +1 808 935 0926
Fax: +1 808 935 0842

Website: http://www.tsunami.org/

E-mail: tsunami@tsunami.org

2.7: Russian Federation Tsunami Warning Centres

Three sub-regional centres in Petropavlovsk-Kamchatskiy, Kurilskiye, and Sakhalinsk were established after the 1952 Kamchatka earthquake that generated a Pacific-wide tsunami. Operated by the Russian Hydrometeorological Service, with assistance from the Russian Academy of Sciences and several other institutions, each center has full authority to issue a warning in case of a tsunami threat. Appropriate local authorities are advised when it is necessary to evacuate potentially affected population centers.

Sakhalin Tsunami Warning Center
Tatiana Ivelskaya
Chief

Address: 78 Zapadnaya Str, Yuzhno-Sakhalinsk 693000

Tel: +7 4242 423691
Fax: +7 4242 721307

Website: http://www.science.sakhalin.ru/Tsunami/

E-mail: T_Ivelskaya@SakhUGMS.ru, Tanya.Ivelskaya@gmail.com, or TWC@Sakhalin.ru

2.8: Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA)

In operation since 1964 as a consequence of the May 1960 Chilean tsunami, SNAM disseminates tsunami warnings to all coastal communities through the Navy Communications Facilities and through the National Emergency Office Radio Network. Chile works closely with other South American countries to mitigate tsunamis generated by large earthquakes occurring along the Peru-Chile trench.

Dr. Rodrigo Nunez
Deputy Director, SHOA

Address: Errázuriz 232, Playa Ancha, Valparaíso

SNAM Tel: +56 32 266 666
SNAM Fax: +56 32 266 542

Website: http://www.shoa.cl/servicios/tsunami/tsunami.php

E-mail: rnunez@shoa.cl, tsunamis@shoa.cl

2.9: US Geological Survey (USGS)

Earthquake Hazards Program - National Earthquake Information Center (NEIC) Tsunami and Earthquakes Research Group

As the US's largest water, earth, and biological science and civilian mapping agency, the USGS collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. The diversity of its scientific expertise enables it to carry out large-scale, multi-disciplinary investigations and provide impartial scientific information to resource managers, planners, and other customers.

Earthquake Hazards Program - National Earthquake Information Center (NEIC)

The mission of the NEIC is to determine rapidly the location and size of all destructive earthquakes worldwide and to immediately disseminate this information to concerned national and international agencies, scientists, and the general public. The NEIC/World Data Center for Seismology compiles and maintains an extensive, global seismic database on earthquake parameters and their effects that serves as a solid foundation for basic and applied earth science research.

Address: Box 25046, DFC, MS 966, Denver, Colorado 80225-0046

Tel: +1 303-273-8500
Fax: +1 303-273-8450

Website: NEIC: http://earthquake.usgs.gov/regional/neic/

Earthquake Information: http://earthquake.usgs.gov/eqcenter/

E-mail: sedas@usgs.gov

Tsunami and Earthquakes Research Group

USGS researchers study tsunamis in the Pacific northwest and other recent tsunamis, and conduct research toward understanding how sediments are transported during tsunami runup and deciphering the geologic record of prehistoric tsunamis.

Website: http://walrus.wr.usgs.gov/tsunami/

3.Tsunami research groups

3.1: India, National Institute of Oceanography (NIO)

3.2: Italy, University of Bologna, Tsunami Research Team

3.3: Japan, Disaster Prevention Research Institute

3.4: Japan JAMSTEC, Submarine Cable Data Center

3.5: Japan - Research group on the 2004 Indian Ocean tsunami

3.6: Japan, Tohoku University, Tsunami Engineering Laboratory

3.7: Russian Federation, Russian Academy of Sciences, Tsunami Laboratory, Global Tsunami Historical Database

3.8: USA, Army Corps of Engineers, Coastal and Hydraulics Laboratory

3.9: USA, California Institute of Technology, Seismological Laboratory

3.10: USA, Humboldt State University

3.11: USA, NOAA Pacific Marine Environmental Laboratory (PMEL)

3.12: USA, Oregon Health and Science University, Center for Coastal and Land-Margin Research

3.13: USA, Oregon State University, Wave Research Laboratory

3.14: USA, Pacific Disaster Center

3.15: USA, University of Colorado, Natural Hazards Center

3.16: USA, University of Southern California, Tsunami Research Center

3.1: India, National Institute of Oceanography (NIO)

The National Institute of Oceanography in Goa, India, conducts a range of oceanographic research, including tsunami-related studies. It compiled a comprehensive report on the impact of the 2004 Indian Ocean tsunami on the Indian coast.

Address: Dona Paula – 403 004, Goa, India EPABX

Tel: +91 832 245 0450
Fax: +91 832 245 0602 or 2450603

Website: http://www.nio.org/jsp/indexNew.jsp

E-mail: ocean@nio.org

Tsunami web page: http://www.nio.org/jsp/tsunami.jsp

3.2: Italy, University of Bologna, Tsunami Research Team

The Tsunami Research Team (TRT-BO) is part of the Solid Earth Geophysics Group of the Department of Physics, University of Bologna in Italy. The Team's main areas of expertise are: tsunami generation; tsunami propagation and impacts on coasts; developing numerical models; field surveys of the effects of recent tsunamis; data collection on historical tsunamis; tsunami hazard and risk analysis; catalogues of Italian and European tsunamis; modeling of major Italian tsunamis; strategies to protect coastal zones; and developing tsunami warning systems globally and locally, and integrating them into multi-hazard systems.

Head: Professor Stefano Tinti

Address: Department of Physics – Sector of Geophysics, University of Bologna, viale Berti Pichat 8, 40127, Bologna, Italia

Tel: +39 51 209 5001
Fax: +39 51 209 5058

Website: http://labtinti4.df.unibo.it/BolognaTsunamiGroup/en_index.html

E-mail: Steve@ibogfs.df.unibo.it

3.3: Japan, Disaster Prevention Research Institute

The Disaster Prevention Research Institute at Kyoto University in Japan conducts research into a range of problems related to the prevention and reduction of natural disasters. It has five research divisions, five research centres and over 100 researchers who investigate all aspects of natural disasters, including tsunamis.

Inoue Kazuya
Director General

Tel: +81 774 383 348

Website: http://www.dpri.kyoto-u.ac.jp/

3.4: Japan JAMSTEC, Submarine Cable Data Center

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) established the first Long-Term Deep Sea Floor Observatory off Muroto Cape in fiscal year 1996, and the Long-Term Deep Sea Floor Observatory off Kushiro and Tokachi in the Kuril Trench in 1999 as part of a plan to build basic earth-quake observation networks in Japan. Both systems have tsunami sensors attached and provide real time data to the shore.

Website: http://www.jamstec.go.jp/scdc/top_e.html

3.5: Japan - Research group on the 2004 Indian Ocean tsunami

A group of Japanese scientists, engineers and disaster management specialists pooled their expertise into a Research Group on the 26 December 2004 Earthquake Tsunami Disaster in the Indian Ocean. There is a depth of technical and tsunami-related information, and web links, on their website.

Website: http://www.drs.dpri.kyoto-u.ac.jp/sumatra/index-e.html

3.6: Japan, Tohoku University, Tsunami Engineering Laboratory

The Tsunami Engineering Laboratory (TEL) is part of the Disaster Control Research Center, Graduate school of Engineering, at Tohoku University in Japan. TEL develops integrated technologies for reducing tsunami disasters, including: developing early warning systems to alert coastal residents; implementing and maintaining an educational programme on the indicators of tsunami dangers through databases, computer graphics and the results of field investigations; and producing tsunami hazard maps.

Professor Fumihiko Imamura
Head

Address: Graduate School of Engineering, Tohoku University, Aoba 06, Sendai 980-8579, Japan

Tel: +81 22 217 7513,
Fax: +81 22 217 7514

Website: http://www.tsunami.civil.tohoku.ac.jp/hokusai2/main/eng/index.html

E-mail: imamura@tsunami2.civil.tohoku.ac.jp

3.7: Russian Federation, Russian Academy of Sciences, Tsunami Laboratory, Global Tsunami Historical Database

The Tsunami Laboratory is a highly respected research programme of the Institute of Computational Mathematics and Mathematical Geophysics, in the Siberian Division of the Russian Academy of Sciences. Among other things, the Laboratory has built comprehensive historical tsunami databases covering all regions of the world and extending thousands of years back in time. The Global Tsunami Historical Database Project is a collaborative effort with the National Geophysical Data Center / World Data Center / SEG-Tsunamis.

Dr Viacheslav K Gusiakov
Head of the Laboratory

Email: gvk@sscc.ru

Address: Novosibirsk, RUSSIA, pr Lavrentieva 6

Tel: +3832 30 7070
Fax: + 3832 30 8783

Website: http://tsun.sscc.ru/tsulab/tsun_hp.htm or http://omzg.sscc.ru/tsulab/

3.8: USA, Army Corps of Engineers, Coastal and Hydraulics Laboratory

The Coastal and Hydraulics Laboratory, part of the Engineer Research and Development Center of the United States Army Corps of Engineers, conducts ocean, estuarine, riverine and watershed regional scale systems analyses research. Its multidisciplinary teams of scientists and engineers have advanced facilities and a strong reputation for experimental and computational expertise.

Director: Thomas Richardson

Address: Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg MS 39180, United States

Website: http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ResearchAreas;20

E-mail: chl-info@erdc.usace.army.mil

3.9: USA, California Institute of Technology, Seismological Laboratory

The Seismological Laboratory at the California Institute of Technology (Caltech) is recognized for its work in geophysical research, and serves as a focal point for earthquake information in Southern California and the world. The Laboratory's seismological research includes work on tsunamis.

Dr Jeroen Tromp
Director, Seismology Laboratory

Tel: +1 626 395 2417

Address: (1200 East California Boulevard, MS 252-21)Pasadena, California 91125 2100

Tel: +1 626 395 6919
Fax: +1 626 564 0715

Website: http://www.seismolab.caltech.edu/geodynamics.html

3.10: USA, Humboldt State University

Humboldt State University's Department of Geology conducts research into tsunami events and science, produces inundation maps and teaches curricula on tsunamis.

Dr Lori Dengler
Chair, Department of Geology

E-mail: Lori Dengler: lad1@axe.humboldt.edu

Address: Humboldt State University, Arcata, CA 95521, United States

Tel: +1 707 826 3931

Website: http://www.humboldt.edu/

3.11: USA, NOAA Pacific Marine Environmental Laboratory (PMEL)

NOAA's Pacific Marine Environmental Laboratory is an internationally respected research organization with a range of research programmes that produce a large volume of interdisciplinary scientific investigations in the fields of oceanography and atmospheric science, including tsunamis.

Dr Eddie Bernard
Director, PMEL

Address: Pacific Marine Environmental Laboratory, NOAA/R/PMEL, 7600 Sand Point Way NE, Seattle WA 98115, United States

Tel: +1 206 526 6239
Fax: +1 206 526-6815

Website: http://www.pmel.noaa.gov/

PMEL's Center for Tsunami Research

Website: http://nctr.pmel.noaa.gov/

Three areas of research – Deep-ocean Assessment and Reporting of Tsunamis (DART), modeling and forecasting, and inundation mapping – are easily accessed at the following website addresses:

Deep-ocean Assessment and Reporting of Tsunamis (DART)

http://nctr.pmel.noaa.gov/Dart/index.html

Modeling and forecasting

http://nctr.pmel.noaa.gov/research.html

Inundation mapping

http://nctr.pmel.noaa.gov/inundation_mapping.html

PMEL Tsunami Research Program

PMEL Tsunami Research Program

http://www.pmel.noaa.gov/tsunami/

Tsunami events and data

http://pmel.noaa.gov/tsunami/database_devel.html

The National Tsunami Hazard Mitigation Program

http://www.pmel.noaa.gov/tsunami-hazard/

The 2004 Indian Ocean tsunami

http://pmel.noaa.gov/tsunami/indo_1204.html

3.12: USA, Oregon Health and Science University, Center for Coastal and Land-Margin Research

The Center for Coastal and Land-Margin Research at Oregon Health and Science University tackles "society's need to manage increased development and manipulation of coasts and land-margins while preserving and enhancing their environmental integrity, and protecting human populations from natural and man-made hazards", including tsunamis.

Address: Department of Environmental and Biomolecular Systems, OGI School of Science and Engineering, Oregon Health and Science University, 20000 NW Walker Road, Beaverton, Oregon 97006, United States

Tel: +1 503 748 1147/1247
Fax: +1 503 748 1273

Website: http://www.ccalmr.ogi.edu/

The Center has a research programme on tsunamis at:

http://www.ccalmr.ogi.edu/tsunami/

3.13: USA, Oregon State University, Wave Research Laboratory

The OH Hinsdale Wave Research Laboratory, together with Oregon State University's Coastal and Ocean Engineering Program, is a leading centre for research in coastal engineering and near-shore science. Its research strengths include physical and numerical modeling of coastal dynamics, advanced laboratories for coastal research, and expertise in tsunami and coastal hazard mitigation.

Dr Daniel Cox
Associate Professor

Address: 202 Apperson Hall, Oregon State University, Corvallis OR 97331-2302, United States

Tel: +1 541 737 3631
Fax: +1 541 737 6974

Website: http://wave.oregonstate.edu/

E-mail: dan.cox@oregonstate.edu

3.14: USA, Pacific Disaster Center

The Pacific Disaster Center in Hawaii provides applied information, research and analysis that supports the development of more effective tsunami policies, institutions, programmes and information products for disaster management and humanitarian assistance efforts in the Asia Pacific region and beyond.

Dr Allen L Clark
Executive Director

Pacific Disaster Center

Address: 1305 North Holopono Street, Suite 2, Kihei, Maui, Hawaii 96753

Tel: +1 808 891 0525 or +1 888 808 6688

Website: http://www.pdc.org/iweb/index.jsp

3.15: USA, University of Colorado, Natural Hazards Center

The Natural Hazards Center at the University of Colorado advances and communicates knowledge on hazard mitigation and disaster preparedness, response and recovery. Working within an all-hazards interdisciplinary framework, the Center fosters information sharing and integration of activities among researchers, practitioners and policy-makers from around the world, conducts research and provides educational opportunities. It does a significant amount of work on tsunamis.

Director: Kathleen Tierney

Address: 482 UCB, Boulder, CO 80309-0482, United States

Tel: +1 303 492 6818
Fax: +1 303 492 2151

Website: http://www.colorado.edu/hazards/

E-mail: hazctr@colorado.edu

3.16: USA, University of Southern California, Tsunami Research Center

The Tsunami Research Center is involved in all aspects of tsunami research – inundation field surveys, numerical and analytical modeling, and hazard assessment, mitigation and planning. It developed the tsunami inundation maps for California and the tsunami code MOST, which is used by NOAA and is the only validated code used in the United States for tsunami hazard mapping with detailed inundation predictions.

Head: Professor Costas Synolakis

Address: Biegler Hall, University of Southern California, Los Angeles, California 90089 2531, United States

Tel: +1 213 740 5129
Fax: +1 213 744 1426

Website: http://www.usc.edu/dept/tsunamis/2005/index.php

E-mail: costas@usc.edu

NOAA Coastal Ocean Program (COP)

This programme uses a regional multidisciplinary approach to understanding and predicting the impacts of natural and anthropogenic influences on coastal ecosystems, communities and economies.

Address: Center for Sponsored Coastal Ocean Research, 1305 East-West Highway, N/SCI2 SSMC4, Silver Spring MD 20910, United States

Tel: +1 301 713 3338
Fax: + 301 713 4044

Website: http://www.cop.noaa.gov/

E-mail: coastalocean@noaa.gov

4.Tsunami website links

4.1: After the tsunami – A special report

4.2: Cascadia Region Earthquake Workshop

4.3: Federal Emergency Management Agency (FEMA) – USA

4.4: Food and Agriculture Organization, UN – Tsunami Reconstruction

4.5: Indian Ocean Tsunami Geospatial Information Service – Hawaii

4.6: International Charter – Space and Major Disasters

4.7: International Institute of Seismology and Earthquake Engineering – Japan

4.8: International Tsunami Symposium – Seattle 2001

4.9: Links and Sources to tsunami publications

4.10: National Geophysical Data Center, World Data Center – SEG Tsunamis, Global Tsunami Historical Database

4.11: NOAA Web-link Compilation – 2004 Indian Ocean tsunami

4.12: Office for the Coordination of Humanitarian Affairs, UN

4.13: The Tsunami Initiative – Tsunami event and risk atlases, UK

4.14: *Tsunami!, USA, University of Washington*

4.15: TsunamiReady – USA National Weather Service

4.16: Tsunami Warning Systems and Procedures Guide - USA

4.17: UNOSAT, United Nations maps

4.18: Worldmap: Locations of past tsunamis around the world

4.1: After the tsunami – A special report

The National Science Foundation in the United States produced an excellent multi-media special report, *After the tsunami*, which looks at the 2004 Indian Ocean tsunami from a scientist's perspective and provides a range of tsunami resources:

Website: http://www.nsf.gov/news/special_reports/tsunami/index_high.jsp

4.2: Cascadia Region Earthquake Workshop

The Cascadia Region Earthquake Workgroup (CREW), in the United States, is a coalition of private and public representatives working together to improve the ability of north-west Cascadia region communities to reduce the effects of earthquakes. It also contains useful information about tsunami mitigation:

Website: http://www.crew.org/

4.3: Federal Emergency Management Agency (FEMA) – USA

The Federal Emergency Management Agency in the United States offers a wealth of useful and practical information and advise on tsunami preparedness and mitigation:

Website: http://www.fema.gov/hazards/tsunamis/

4.4: Food and Agriculture Organization, UN – Tsunami Reconstruction

The Food and Agriculture Organization is the United Nations' lead agency for reconstruction after the 2004 Indian Ocean tsunami. It has a Tsunami Reconstruction internet resource:

Website: http://www.fao.org/tsunami/

4.5: Indian Ocean Tsunami Geospatial Information Service – Hawaii

The Pacific Disaster Center in Hawaii created an Indian Ocean Tsunami Geospatial Information Service, as part of its Asia Pacific Natural Hazards Information Network, to help emergency managers respond to the 2004 disaster by, for instance, providing satellite imagery, population density data, coastline details and other information:

Website: http://www.pdc.org/mde/explorer.jsp

To access the South East Asia and Indian Ocean Tsunami Response Map Viewer go to:

http://www.pdc.org/apnhintsu/html/apnhintsu-init.jsp

4.6: International Charter – Space and Major Disasters

The European and French space agencies (ESA and CNES) initiated the International Charter – Space and Major Disasters following the UNISPACE III conference held in Vienna, Austria, in 1999. Space-related agencies in Canada, India, Argentine, Japan and the United States have since joined. The International Charter aims to provide a unified system of space data acquisition and delivery to countries and regions affected by disasters. Member agencies of the system commit resources and support the provisions of the Charter in a collaborative effort to mitigate the effects of disasters on human life and property:

Website: http://www.disasterscharter.org/main_e.html

4.7: International Institute of Seismology and Earthquake Engineering – Japan

The International Institute of Seismology and Earthquake Engineering conducts research in those fields. It has a web page on the 2004 Northern Sumatra earthquake that generated the Indian Ocean tsunami:

Website: http://iisee.kenken.go.jp/special/20050328sumatra.htm

4.8: International Tsunami Symposium – Seattle 2001

In the United States, the National Tsunami Hazard Mitigation Program Review and the International Tsunami Symposium held two meetings at the University of Washington Seattle campus in August 2001, attracting over 100 tsunami scientists from 16 countries. Scores of papers were delivered and the proceedings and abstracts can be accessed at:

Website: http://www.pmel.noaa.gov/its2001/

4.9: Links and Sources to tsunami publications

The National Tsunami Hazard Mitigation Program in the United States produced a list of the many research articles and reports it has published since 1995. The list was last updated in June 2005:

Website: http://www.pmel.noaa.gov/tsunami-hazard/NTHMP_Publications.pdf

4.10: National Geophysical Data Center, World Data Center – SEG Tsunamis, Global Tsunami Historical Database

The World Data Center for Solid Earth Geophysics and NOAA's National Geophysical Data Center have compiled a set of tsunami-related products as part of a programme to support engineers, oceanographers, seismologists and the public. The products include: a database providing information on tsunami source events and locations across the world; interactive maps; tsunami slide sets; tsunami publications; and over 3,000 tide gage records for tsunami events. The Global Tsunami Historical Database Project is a collaborative effort with the Tsunami Laboratory in Russia to merge several tsunami lists into a one high-qualify, referenced database.

Website: http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml

4.11: NOAA Web-link Compilation – 2004 Indian Ocean tsunami

NOAA's Web-link Compilation on the 2004 Indian Ocean tsunami contains links to a wealth of websites that cover aspects of the disaster ranging from field survey data, sea level data, satellite data, seismic data, model simulations, bathymetry and topography, Geographic Information System data, photographs and videos, and links to other sites:

Website: http://www.pmel.noaa.gov/tsunami/sumatra20041226.html

4.12: Office for the Coordination of Humanitarian Affairs, UN

The Office for the Coordination of Humanitarian Affairs was the United Nations' lead agency coordinating relief efforts in the aftermath of the 2004 Indian Ocean tsunami:

Website: http://ochaonline.un.org/

4.13: The Tsunami Initiative – Tsunami event and risk atlases, UK

This British initiative links scientists and the insurance industry in assessing tsunami risk, among other things. It has two atlases, one providing background on past tsunamis, and the other providing risk assessments of areas around the world:

Website: http://www.nerc-bas.ac.uk/tsunami-risks/html/Tinit.htm

4.14: *Tsunami!, USA, University of Washington*

Tsunami! is hosted and maintained by the University of Washington's Department of Earth and Space Sciences. It provides general information about tsunamis:

Website: http://www.ess.washington.edu/tsunami/index.html

4.15: TsunamiReady – USA National Weather Service

The National Weather Service in the United States, part of NOAA, has a TsunamiReady web page with a range of links to tsunami resources and information, including how communities can become TsunamiReady:

Website: http://www.tsunamiready.noaa.gov/

4.16: Tsunami Warning Systems and Procedures Guide - USA

This comprehensive tsunami warning and mitigation guide for local officials is in *TsunamiTeacher's* Resource Collection, and is included as a website link here for easy dissemination. The manual was produced by Oregon Management and the Oregon Department of Geology and Mineral Industries in 2001 for the National Tsunami Hazard Mitigation Program in the United States:

Website: http://www.pmel.noaa.gov/tsunami-hazard/SP35FORWEB.PDF

4.17: UNOSAT, United Nations maps

UNOSAT is a United Nations initiative to provide the humanitarian community with access to satellite imagery and Geographic Information System services. UNOSAT is implemented by the UN Institute for Training and Research (UNITAR) and managed by the UN Office for Project Services (UNOPS). Partners from public and private organizations are also part of the UNOSAT consortium:

Website: http://unosat.web.cern.ch/unosat/asp/charter.asp?id=61

4.18: Worldmap: Locations of past tsunamis around the world

The University of Southern California's Tsunami Research Group publishes a web-based Worldmap with click-throughs to background information on tsunamis around the world:

Website: http://cwis.usc.edu/dept/tsunamis/worldmappage.htm

5.Tsunami media links

5.1: Media tsunami websites
5.2: Internet blogs
5.3: Photographic sources
5.4: Satellite imagery

5.1: Media tsunami websites

This section links to media websites that have special coverage of the Indian Ocean tsunami of 26 December 2004 and its aftermath. Many of the media websites were suggested as background reading resources in the training modules.

Media websites that are directly accessible and effectively searched have been featured. Websites that require registration have not been included, because of the extra time this takes when researching the internet. English language media are the focus.

ReliefWeb, a site operated by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), provides reliable articles and information on disasters and relief efforts, including on the 2004 tsunami. It has an efficient site search engine:

http://www.reliefweb.int/rw/dbc.nsf/doc100?openForm

The IRIN – Integrated Regional Information Networks – agency is part of OCHA but is editorially independent. It provides news and analysis about sub-Saharan Africa, the Middle East and Central Asia for the humanitarian community, the media and others. It has a search engine with a wealth of articles on the 2004 tsunami:

http://www.irinnews.org/

This Asia Source web page links visitors directly to tsunami articles as well as a range of other tsunami-related websites, organized by topic. Some of the website links posted on Asia Source are also listed below:

http://www.asiasource.org/news/at_mp_02.cfm?newsid=122888

The BBC's in-depth tsunami disaster report website:

http://news.bbc.co.uk/1/hi/in_depth/world/2004/asia_quake_disaster/default.stm

The comprehensive CNN website special report, "After the Tsunami":

http://www.cnn.com/SPECIALS/2004/tsunami.disaster/

The Guardian in Britain has an Indian Ocean tsunami special report that contains dozens of articles:

http://www.guardian.co.uk/tsunami/0,15671,1380306,00.html

The *New York Times* special report, "Asia's deadly waves":

http://www.nytimes.com/aponline/international/AP-Tsunami.html

There are scores of tsunami articles in a collection called "The tsunami tragedy" on *The Hindu* website at:

http://www.hindu.com/thehindu/nic/0035/index.htm

Britain's *Financial Times* has a special report, "Tsunami Disaster: One year on", at:

http://news.ft.com/cms/e7abb2ca-5776-11d9-a8db-00000e2511c8.html

The *Sydney Morning Herald* has a must-register website, but there is a collection of direct-access stories at:

http://www.smh.com.au/specials/tsunami/

5.2: Internet blogs

Tsunami Warning Tracker is a quality web-blog site with a font of tsunami links and information:

http://tsunamiwarning.blogspot.com/

The comprehensive South-East Asia Earthquake and Tsunami Blog, also called TsunamiHelp, is at:

http://tsunamihelp.blogspot.com/

A related TsunamiHelp blog, specializing in enquiries, help-lines and emergency services, is at:

http://tsunamienquiry.blogspot.com/

Zoo Station's "Tsunami relief efforts" page provides a range of useful tsunami links:

http://wetware.blogspot.com/2004/12/tsunami-relief-efforts.html

The Indonesia Help – Earthquake and Tsunami Victims blog provides links to loads of tsunami articles and useful information on how to help:

http://indonesiahelp.blogspot.com/

The Tsunami Disaster in Malaysia and Thailand blog features articles, information and links related to the Indian Ocean tsunami:

http://tsunamipenang.blogspot.com

5.3: Photographic sources

Following the 2004 Indian Ocean tsunami, a number of websites were created to store tsunami photographs, and many media organizations feature tsunami photo-essays on their websites.

Photographs are featured on the National Geophysical Data Center site:

http://www.ngdc.noaa.gov/seg/hazard/slideset/tsunamis/

This site contains 18,000 photographs, thousands of reports and nearly 200 albums:

http://www.photoduck.com/photos.aspx?gid=932

Waves of Destruction features tsunami satellite imagery, photographs and videos:

http://www.waveofdestruction.org/

Tsunamis.com is a website built following the 2004 disaster, and it contains photographs as well as reports and other tsunami-related information:

http://www.tsunamis.com/tsunami-pictures.html

The BBC has several collections of photographs of the tsunami striking and its aftermath, from the most-affected countries. You can find them at:

http://news.bbc.co.uk/1/hi/in_pictures/4125643.stm

This photo-library of the tsunami, in French, contains hundreds of pictures:

http://www.futura-sciences.com/communiquer/g/showgallery.php/cat/543

Time Magazine's photo-essay on the tsunami is at:

http://www.time.com/time/photoessays/asia_earthquake/index.html

Time Asia has superb photo essays of the 2004 Indian Ocean tsunami, by country:

http://www.time.com/time/asia/photoessays/tsunami/

On CNN's tsunami website, in the left hand column is "Images of destruction":

http://edition.cnn.com/SPECIALS/2004/tsunami.disaster/

A year after the tsunami *The Guardian* published a collection of photographs taken by inhabitants of the Indonesian village of Nusa, charting its rebuilding efforts.

http://www.guardian.co.uk/gall/0,8542,1673036,00.html

A photo essay of ceremonies held on the first anniversary of the 2004 tsunami, to commemorate its 232,000 victims, is published on *The Guardian's* website:

http://www.guardian.co.uk/gall/0,8542,1673870,00.html

5.4: Satellite imagery

NASA's Earth Observatory has a set of stunning satellite images of how the 2004 struck coasts in the Indian Ocean:

http://earthobservatory.nasa.gov/NaturalHazards/shownh.php3?img_id=12646

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