Public Education on

TSUNAMI HAZARD

SOUTH CHINA SEA

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FOREWORD

Tsunami is unique and rare. It can be categorized as local tsunami and distance tsunami. Local tsunami strikes from its source and to the local whereby distance tsunami travels for a long distances and strikes far from the original source. Tsunami nowadays causes anxiety and panic, thus, having some basic knowledge on tsunami can make society be more precautious and know what to do next.

The booklet is the outcome of a unique collaborative effort. Centre for Global Sustainability Studies (CGSS) took the initiative for the production, design and graphic work, 1OT1C in UNESCO Office Jakarta for consultation and discussion with Indian Ocean Tsunami Information Centre in Jakarta, the International Tsunami Information Centre in Hawaii, Chair of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region and the Tsunami Unit in IOC UNESCO in Paris.

Above all, the booklet would not have been realized without the devotion of Mr. Ardito M Kodijat, Programme Officer, Disaster Risk Reduction and Tsunami Information Unit –Indian Ocean Tsunami Information Centre of UNESCO IOC Jakarta and Mr Bernardo ALIAGA ROSSEL, Programme Specialist, Tsunami Unit in IOC UNESCO in Paris for the scenarios and coordination work. Last but not least CGSS research team in developing this tsunami awareness material.

Dr Mohd Sayuti Hassan
Project Leader
Centre for Global Sustainability Studies (CGSS)
INTRODUCTION

Tsunamis are giant waves with massive destructive force which can cause severe damages and loss of human lives. The word tsunami comes from the Japanese word “tsu” and “nami” which respectively means “Harbor” and “Wave”. Countries affected by the tsunami are not only those who are close to the source, but also those who are far from the source (distant tsunami or far field tsunami). Historically, the most devastating tsunamis ever being recorded, is the Asian tsunami or the Indian Ocean tsunami which occurred in the Indian Ocean in 2004. The destructive waves hit coastlines from Tailand to Africa killing an estimated more than 230,000 and destroying cities. This makes tsunami as one of the deadliest natural hazard in the world.

Despite its rank as one of the deadliest natural hazards, tsunami hazards are often underestimated. Awareness and education on tsunami hazard is vital in minimizing the loss of human lives. There has been many public education and awareness materials being published and made freely available to the public. This booklet is designed to update the currently existing public education and awareness materials on tsunami hazard especially in the South China Sea area. It is hoped that this booklet will contribute significantly towards raising the awareness of people at all levels and reduce their vulnerabilities to tsunami hazards.
The South China Sea

The South China Sea region, which covers the region and its adjoining basins including Sulu Sea and Celebes Sea, is identified as one of the most vulnerable regions to major tsunamigenic earthquakes due to the high seismicity of the Manila Trench, Cotabato and Negros Trench and Sulawesi Trench. The South China Sea is located in the convergence zone between Pacific plate (Philippine plate), Indian plate and Euro-Asian plate, and the interactions of these plates made the crust of this region suffer tectonic stress in many directions and put the South China Sea under a complex environment of tectonic stress.

In fact, the South China Sea with the adjacent Philippine Sea plate bordered by the Manila Trench is an excellent region for tsunami waves to occur and furthermore, the coastal heights along the SCS are generally low, thus making it extremely vulnerable to incoming tsunami waves with a height of only a couple meters.

The tsunami's vulnerable countries in the South China Sea region include China, Taiwan, Philippine, Brunei, Malaysia, Vietnam, Indonesia and Singapore.

Quick Info

In other countries, South China Sea is known as East Sea (in Hanoi) and West Philippines Sea (in Philippines).

South China Sea has over 250 small islands, atolls, cays, shoals, reefs, and sandbars.
Tsunami Sources in the South China Sea

In the aftermath of the 2004 Indian Ocean tsunami, there has been a pronounced increase in the number of tsunami hazard studies in the South China Sea region and its adjoining basins.

1. West Taiwan
- Located at the boundary of the Philippine Sea plate and the Eurasian plate.
- Located at the intersection of the Manila trench and the Ryukyu trench.
- Predicted earthquake magnitude: 6.8-7.2.

2 a,b,c. Manila Trench (North, Central, South)
- Located west of the islands of Luzon and Mindoro in the Philippines.
- At least six tsunamigenic earthquakes had occurred in this zone.
- Predicted earthquake magnitude: 8.3-8.7 (North), 8.1-8.5 (Central), 6.3-6.7 (South).

3. South China Sea (North)
- Lengths ranging from some hundreds to a thousand km.
- Can generate medium earthquakes and tsunamis.
- The most active faults in South China Sea oceanic crust.
- Predicted earthquake magnitude: 6.6 to 7.7.

4. South China Sea (West)
- A deep-seated fault zone.
- Acts as boundary between the Indo-sinian geoblock and the South China Sea oceanic crust.
- Predicted earthquake magnitude: 6.2-6.6.

5. Borneo-Palawan (Northwest)
- Consists of a giant submarine landslide known as the Brunei Slide.
- Ranks as one of the largest slope failures on Earth.
- Predicted earthquake magnitude: 6.4-6.5.

6. Sulu-Negros Trench
- Located west of the islands of Luzon and Mindoro in the Philippines.
- At least six tsunamigenic earthquakes had occurred in this zone.
- Predicted earthquake magnitude: 8.3-8.7 (North), 8.1-8.5 (Central), 6.3-6.7 (South).

7. Cotabato Trench
- A short trench system located along the southwestern coast of Mindanao.
- Predicted earthquake magnitude: 8.1-8.5.

8. Gorontalo
- The SEA triple junction (Transform-Transform-Trench type, central part coinciding with Sulawesi) where the Pacific-Philippine, Indo-Australian Plates and the Sunda Block meet is an example of how collision can be accommodated by crustal block rotation.
- Predicted earthquake magnitude: 6.5-7.0.
Potential Tsunami Hazard Analysis

The worldwide scientists have successfully assessed the probability of tsunami hazards for the coasts bordering South China Sea with greater accuracy, and most of them found that these coasts face a greater risk of tsunami hazards which the risk of large tsunamis in the SCS region primarily comes from the Manila trench that lies to the west of Luzon in the Philippines.

The Manila Trench is where the Eurasian plate is actively sub-ducting eastward underneath the Luzon volcanic arc on the Philippine Sea plate. The report by Earth Observatory Singapore highlights the Manila trench system is interesting because it shares many of the characteristics of the source areas that brought on the 2004 Sumatra-Andaman earthquake, as well as the Japan Trench of the 2011 Tohoku-Oki earthquake.

Based on research available data and model results, there is a possibility of a destructive basin-wide tsunami in the SCS from Manila trench source especially the impact towards coastal areas in China, Vietnam, Taiwan, Philippine, and Malaysia.
History of Tsunami in the South China Sea

Historical events in the South China Sea area show that most earthquakes and tsunamis occur near the Manila Trench, the Negro Trench, the Cotabaco Trench and the Gorontalo Trench, and most destructive tsunamis occurred in Sulawesi Sea. Current available data by Earth Observatory of Singapore shows that both the Philippines and China were more frequently affected by tsunamis historically. The main tsunami threat in the South China Sea comes from the Manila Trench megathrust, along which no earthquake larger than Mw 7.8 has been observed since 1560s.

Locations of Historical Tsunamigenic Earthquakes or Tsunami

Historical Earthquake Seismicity and Tsunami Maps
Tsunami History Timeline

1677
West Luzon (Philippines)
Wave Height: 1m

09/11/1828
Pasig River (Philippines)
Wave Height: 1m

18/12/1867
Keelung (Taiwan)
Wave Height: 7.5m

22/05/1782
Kaohsiung (Taiwan)
Wave Height: 10m

03/06/1863
Pasig River (Philippines)
Wave Height: 2m

1872
Agno (Philippines)
Wave Height: 1m

24/05/1960
Hong Kong, Keelung (Taiwan), Hualien (Taiwan)
Wave Height: 0.3m-0.66m

17/02/1996
Changkang, Keelung (Taiwan)
Wave Height: 0.25m-0.55m

16/09/1994
Dongshan (Fujian), Penghu (Taiwan)
Wave Height: 0.18m-0.47m

15/11/1994
Mindoro
Wave Height: 3m-4m

1999
Iba Palauig (Philippines)
Wave Height: 1.5m

Notes
Tsunami Report in 2007-2016 from International Tsunami Information Center
2007 to 2012 - No report in South China Sea region
2013 - Taiwan (Only earthquake on 2 June and 31 October)
2014 to 2015 - No report in South China Sea region
2016 - Taiwan (Only earthquake on 5 February)
What is a Tsunami?

A tsunami is a series of travelling waves of extremely long length and period, generated when a large volume of ocean water is rapidly displaced by a sudden displacement of the seabed.

How Tsunami Travels?

In the deep ocean, a series of travelling waves of extremely long in length and period travels at a speed of 500-1000 km/h.

As the waves travel inland, they build up to higher heights as the depth of the ocean decrease.

Near the shore, tsunami waves slow down to just a few tens of km/h.

A sudden displacement of the seabed displaces a large volume of ocean water.

Out in the depth of the ocean, tsunami waves do not dramatically increase in height.

Quick Info

Tsunami is a Japanese term meaning wave ("nami") in a harbour ("tsu") which is also equivalent to "seismic sea waves".

Tsunamis have no connection with tides; the popular name, tidal wave, is entirely misleading.
What Causes Tsunami?

Tsunami can be triggered by various sources like submarine earthquakes, submarine landslides, volcano eruptions, and even nuclear explosions or asteroid impacts.

The waves caused by the disturbance may travel across entire ocean basins with little loss of energy.

The most tsunamis are generated by shallow large earthquakes in subduction zones.

Tsunamis are also known as seismic sea waves because they are most often generated by earthquakes.
Characteristics of Tsunami

The speed of tsunami waves depends on ocean depth rather than the distance from the source of the wave. Scientists can predict when a tsunami will arrive at various places by knowing the source characteristics of the earthquake that generated the tsunami and the characteristics of the seafloor along the paths to those places.

How Fast Tsunami Travels?

Tsunami in deep ocean

\[
\begin{array}{c}
450 \\
650 \\
650 \\
mph
\end{array}
\]

The constant energy released from a tsunami can generate waves that can travel over deep water as fast as a commercial jet plane.

Tsunami approaching shores

\[
\begin{array}{c}
30 \\
200 \\
200 \\
mph
\end{array}
\]

As the waves travel towards the shore (shallower water) the speed decreases. The speed of the wave is equivalent to almost three times the speed of a cheetah.

How Big is Tsunami Wave?

Tsunami in deep ocean

\[
\begin{array}{c}
20 \text{ inches/} \\
1.6 \text{ feet}
\end{array}
\]

316,800 feet

Tsunami waves form only a small hump on the open sea, barely noticeable and harmless.

Tsunami approaching shores

\[
\begin{array}{c}
100 \text{ feet or more}
\end{array}
\]

5,000 to 10,000 feet

As the wave travels towards the shore (shallower water) the speed decreases and in order the wave height increases to conserve the energy released.

Quick Info

When the ocean is over 6,000 m deep, unnoticed tsunami waves can travel over 500 mph.

One coastal community may see no damaging tsunami wave activity while in another nearby community destructive waves can be large and violent.

Reefs, bays, entrances to rivers, undersea features and the slope of the beach all help to modify the tsunami as it attacks the coastline.
Local Versus Distant Tsunami

Depending on tsunami travelling characteristics and the energy release, tsunami can be divided into distant-tsunamis or ocean wide tsunamis (or far-field tsunamis) local-tsunamis (or near-field tsunamis).

Local Tsunami

- Waves that travel and affect regions close to the source.
- Travel to nearby regions within minutes.
- Travel over 100 km from the source.
- Waves travel and cause destruction near the source.

Distant Tsunami

- Waves that travel at a long distance and strike far from the local or original source.
- Travel to faraway regions within 3 hours.
- Travel more than 1,000 km from its source.
- Waves continue to travel across an entire ocean basin to cause additional destruction.

Example: In 2004 Indian Ocean Tsunami, Indonesia was hit by local tsunami while other affected countries were hit by distant tsunami.

Destructive Tsunami

Happens when tsunami waves become extremely large in height, they savagely attack coastlines, causing devastating property damage and loss of life. A small wave only 30 centimetres high in the deep ocean may grow into a monster wave 30m high as it sweeps over the shore.

Non-Destructive Tsunami

Happen almost every day as a result of minor earthquakes and other events. They are very often too far away from land or they are too small to have any effect when they hit the shore. When a small tsunami comes to the shoreline it is often seen as a strong and fast-moving tide.
The Effect of Tsunamis

Situations that can increase our vulnerability to tsunami, for instance, building homes in high-risk places makes us more vulnerable. For instance, if you live too close to the ocean you will be more vulnerable to tsunami.

**People**

Families with low incomes often live in high-risk areas around coastal area because they can’t afford to live in safer places. People who lives in wooden houses are also more vulnerable to tsunami.

Elderly and small children are vulnerable to common diseases associated with tsunamis such as typhoid fever, cholera and malaria.

These diseases are most likely to occur during tsunami disaster because clean water and food in the affected area are contaminated with dirty water and mosquito.

People living in coastal areas are the most vulnerable than people living far from the coastal areas. This is because as the tsunami travels far from its source, the high water level will start to decrease.

**Economy**

Tourism industry would be the most affected industry. People who work in tourism industry will lose their jobs as their workplace (resorts, guest house, etc) is washed off by tsunami waves.

Agricultural industry would also be affected. Tsunami waves will wash off plants and animals which will affect the country that depends on the industry.

**Environment**

The sea water brought by the tsunami to the land will change the pH level of the soil as the sea water has a high salinity level.

The high level of salt content will halt the growth of plants as the water in the plant will be drawn out by soil that contains high salt concentration. This will affect the agricultural yields to the country.
Tsunami Warning System

Tsunami warning system is used to detect, locate and determine location of earthquake that can cause tsunamis.

How Tsunami Warning System Works?

SATELLITE
The satellite is used to allow the communication between the surface buoy with the tsunami warning centre. All data will be transmitted to the centre via the satellite.

SURFACE BOUY
The surface buoy which is equipped with sensor will receive the data from the underwater sensor. Then, the data from the buoy will be transmitted to a satellite.

MONITOR
A monitor which is placed on the sea floor (underwater) will measure the height and pressure of sea water. The data will be transmitted to a surface buoy.

WARNING CENTRE
Once the tsunami warning centre collects and analyzes the data, warning will be issued to the nearest areas that tsunami could reach. The centre will continuously monitor the sea level data to determine if a tsunami has occurred.

THE PUBLIC
People in the affected area will be warned via several mediums (siren, emails, etc) about the tsunami threat so that they are well prepared if tsunami occurs.

Quick Info
Deep-ocean Assessment and Reporting of Tsunamis (DART) system is one of the component in tsunami warning system. It consists of a bottom pressure recording system which can detect tsunamis as small as one centimetre, and a surface buoy for real-time communications.
Who Governs Tsunami Early Warning System?

The Regional Set Up

Pacific Tsunami Warning System
- Pacific Tsunami Warning Center (PTWC) is the main operational headquarters for the system.
- Serves 46 Member States within Pacific rim and island.
- Provide warnings for tsunamis that can cause damage far away from their source to almost every country around the Pacific region.
- The warnings will be disseminate to the public by PTWC.
- PTWC is the interim warning centre to countries within the South China Sea region.
- The Intergovernmental Coordination Group for PTWS meets regularly to establish and implement working plans in the Pacific region.

The National Set Up

National Tsunami Warning Center
- Serves as the middleman between IOTWMS and the public community.
- Issues tsunami warning instructions to the public.
- Educate the public about the danger of tsunamis.

Disaster Management Office
- Works together with NTWC to educate the public about tsunamis.

GOVERNANCE

Quick Info
- Tsunami warning system are established in four regions: the Pacific, the Indian Ocean, the Caribbean, and the North-East Atlantic/Mediterranean.

The systems are administered by intergovernmental coordination group (ICG) secretariats.
Natural Warning Signs

Although tsunami warning centre could predict distant tsunamis, it is fairly important to recognize any natural warning signs that signal any incoming distant tsunami so that we can be prepared ahead of time. The following natural signs might help you to recognize that tsunami is approaching your place:

- The sea water moves far away from the shore, exposing the ocean floor which is filled with muds.
- Loud and roaring sound like an oncoming train comes from the sea.
- Animals behave strangely. For example, animals such as birds, cats and dogs start fleeing or running far to the land.
- Fishes swarm near or jump to the shore.
- The sea water moves far away from the shore, exposing the ocean floor which is filled with muds.
Tsunami Preparedness & Mitigation

Evacuation Map
Make sure that you and the people in your community prepare an evacuation map to make sure that you know where you should be going when tsunami warning is issued.

Education
Read books, articles or brochures about tsunami so that you are well educated about tsunami information and to ensure that you know the danger of tsunami and what you should do if tsunami warning is issued.

Emergency Kits
Prepare an emergency kit which consist of basic necessity such as torchlight, first aid kit. Make sure that the emergency kits are stored in a reachable place.

Communication Plan
You and your family might not be together when tsunami occurs. Make sure that you develop a communication plan with your family so that you and your family know who you should be contacting if tsunami strikes.
How to Survive a Tsunami?

If you feel the place you are standing is shaking or if you hear there is a tsunami warning or news about tsunami, these are what you should and should not do:

**If you are in schools**

- Do not play jokes with your classmates.
- Do not go anywhere without your teacher’s permission.
- Follow the instruction given by teachers and other school personnel.

Make sure you entire family is aware of the warning or news.

Prepare a family emergency plan beforehand so that everyone knows what to do.

Move in an orderly, calm, and safe manner to the evacuation site or to any safe place outside your evacuation zone.

Follow the instruction given by local emergency and law enforcement authorities.

**If you are at home**

- Do not play jokes with your classmates.
- Follow the instruction given by local emergency and law enforcement authorities.
If you are at the beach or near the ocean

Move immediately to higher ground.

Do not wait for tsunami warning to be announced.

Stay away from rivers and streams that lead to the ocean.

Stay in your boat or ship and do not return to the land.

Move your boat or ship to deeper location.

If you are from large harbors or ports, keep in contact with the harbor authority and/or a vessel traffic system.

Follow the instruction given by the harbor authority and/or a vessel traffic system.

Don’t Be Scared. Be Prepared!

Get ready. Get together with your family to spot safe places, convince your parents that your family should have an Emergency Plan and put together an Emergency Kit with you.

If you are at the open ocean

Stay in your boat or ship and do not return to the land.

Move your boat or ship to deeper location.

If you are from large harbors or ports, keep in contact with the harbor authority and/or a vessel traffic system.

Follow the instruction given by the harbor authority and/or a vessel traffic system.
Get ready. Get together with your family to spot safe places, convince your parents that your family should have an Emergency Plan and put together an Emergency Kit with you.
REFERENCES


Mutter, J. (2006). When Disaster Strikes, What Makes the Poor Vulnerable?
WhenDisasterstrikeswhatmakesthepoorvulnerable.doc


Retrieved from link.springer.com/article/10.1007/s11156-012-0286-z

Retrieved from https://www.gdrc.org/uem/disasters/disenvi/tsunami.html


Retrieved from http://www.tsunami.gov/?page=history#2
