Protecting people and property from tsunamis
http://www.ioc-tsunami.org/

What is a tsunami?
Tsunami is a Japanese word meaning ‘harbour (tsu) wave (nami)’ and refers to the large and potentially destructive ocean wave created by the shock from an underwater earthquake (up to 100 km below the surface), a volcanic eruption or, sometimes, a landslide. After a trigger event, the wave radiates out in every direction from the centre of the shock (its epicentre), travelling in the deep ocean at as much as 1000 kilometres per hour (as fast as a jumbo jet). Tsunami waves are very long (often 100 km between crests) but are only a few tens of centimetres high where the ocean is deep. When a tsunami wave reaches the shallow waters of a coast, sometimes after many hours of travel, it slows down quickly and piles up, creating a wall of water. This wave strikes inland with tremendous force, creating loss of life and physical damage. Other waves then follow, about an hour apart or less. Tsunamis may sometimes be tens of metres high, but waves under two metres high can still cause massive destruction in low-lying areas.

Did you know?
➢ Tsunami waves are generated primarily by earthquakes occurring below the sea floor, but can also be caused by volcanic eruptions and submarine or aerial landslides
➢ Although there are no records of large meteorites or asteroids reaching the earth, if they fall in the sea they can generate huge, disastrous tsunami waves.
➢ Tsunamis are a series of long-wavelength, long-period ocean waves. They are not surface waves. They come ashore for hours. The first wave may not be the largest.
➢ Tsunamis travel at jet airliner speeds in the deep ocean, but the waves are only centimetres high and cannot be felt aboard ships.
➢ They slow down and grow in height tremendously upon entering shallow water. Tsunamis can crest to 10-m high, strike with devastating force, and quickly flood all low-lying coastal areas.
➢ About 60% of tsunamis have their source in the Pacific, mostly along the fault lines around the Pacific coast (“rim of fire”).
➢ During each of the past five centuries, there were three to four Pacific-wide tsunamis
➢ Japan experiences frequent earthquakes and tsunamis and has invested heavily in warning and protecting its citizens.
➢ The Indian Ocean tsunami of 26 December 2004 was the first known basin-wide destructive tsunami in the Indian Ocean.
➢ After an earthquake, move quickly inland and to higher ground. Rush to the hills before the first wave comes and do not return until the tsunami alert is over.
➢ At the coast, a tsunami may be tens of meters high. On July 9, 1958 a 520 metre wave was observed in Lituya Bay, Alaska (USA), triggered by a huge rock fall.
Tsunami facts and figures

Tsunamis are relatively common in the Pacific, which is surrounded by seismic areas. But they have been observed everywhere, from the North Atlantic to the shores of Antarctica.

Regional and local tsunamis causing 2,000 or more deaths

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Source Location</th>
<th>Estimated Dead or Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>365</td>
<td>21 July</td>
<td>Crete, Greece</td>
<td>5,700</td>
</tr>
<tr>
<td>887</td>
<td>2 August</td>
<td>Niigata, Japan</td>
<td>2,600</td>
</tr>
<tr>
<td>1341</td>
<td>31 October</td>
<td>Aomori Prefecture, Japan</td>
<td>2,600</td>
</tr>
<tr>
<td>1498</td>
<td>20 September</td>
<td>Enshunada Sea, Japan</td>
<td>31,000</td>
</tr>
<tr>
<td>1570</td>
<td>8 February</td>
<td>Central Chile</td>
<td>2,000</td>
</tr>
<tr>
<td>1586</td>
<td>18 January</td>
<td>Ise Bay, Japan</td>
<td>8,000</td>
</tr>
<tr>
<td>1605</td>
<td>3 February</td>
<td>Nankaido, Japan</td>
<td>5,000</td>
</tr>
<tr>
<td>1611</td>
<td>2 December</td>
<td>Sanriku, Japan</td>
<td>5,000</td>
</tr>
<tr>
<td>1674</td>
<td>17 February</td>
<td>Banda Sea, Indonesia</td>
<td>2,243</td>
</tr>
<tr>
<td>1687</td>
<td>20 October</td>
<td>Southern Peru</td>
<td>*5,000</td>
</tr>
<tr>
<td>1692</td>
<td>7 June</td>
<td>Puerto Real, Jamaica</td>
<td>2,000</td>
</tr>
<tr>
<td>1703</td>
<td>30 December</td>
<td>Boso Peninsula, Japan</td>
<td>*5,233</td>
</tr>
<tr>
<td>1707</td>
<td>28 October</td>
<td>Enshunada Sea, Japan</td>
<td>2,000</td>
</tr>
<tr>
<td>1707</td>
<td>28 October</td>
<td>Nankaido, Japan</td>
<td>30,000</td>
</tr>
<tr>
<td>1746</td>
<td>29 October</td>
<td>Central Peru</td>
<td>4,800</td>
</tr>
<tr>
<td>1751</td>
<td>20 May</td>
<td>Northeast of Honshu, Japan</td>
<td>2,100</td>
</tr>
<tr>
<td>1755</td>
<td>1 November</td>
<td>Lisbon, Portugal</td>
<td>*60,000</td>
</tr>
<tr>
<td>1771</td>
<td>24 April</td>
<td>Ryukyu Islands, Japan</td>
<td>13,486</td>
</tr>
<tr>
<td>1783</td>
<td>5 February</td>
<td>Straits of Messina, Italy</td>
<td>*30,000</td>
</tr>
<tr>
<td>1792</td>
<td>21 May</td>
<td>Kyushu Island, Japan**</td>
<td>4,300</td>
</tr>
<tr>
<td>1854</td>
<td>24 December</td>
<td>Nankaido, Japan</td>
<td>*3,000</td>
</tr>
<tr>
<td>1883</td>
<td>27 August</td>
<td>Krakatau, Indonesia**</td>
<td>36,000</td>
</tr>
<tr>
<td>1896</td>
<td>15 June</td>
<td>Sanriko, Japan</td>
<td>*27,122</td>
</tr>
<tr>
<td>1899</td>
<td>29 September</td>
<td>Banda Sea, Indonesia</td>
<td>*2,460</td>
</tr>
<tr>
<td>1923</td>
<td>1 September</td>
<td>Sagami Bay, Japan</td>
<td>2,144</td>
</tr>
<tr>
<td>1933</td>
<td>2 March</td>
<td>Sanriko, Japan</td>
<td>3,022</td>
</tr>
<tr>
<td>1941</td>
<td>26 June</td>
<td>Andaman Sea, India</td>
<td>5,000</td>
</tr>
<tr>
<td>1976</td>
<td>16 August</td>
<td>Moro Gulf, Philippines</td>
<td>4,456</td>
</tr>
<tr>
<td>1992</td>
<td>12 December</td>
<td>Flores Sea, Indonesia</td>
<td>*2,500</td>
</tr>
<tr>
<td>1998</td>
<td>17 July</td>
<td>Papua New Guinea</td>
<td>2,183</td>
</tr>
<tr>
<td>2004</td>
<td>26 December</td>
<td>Banda Aceh, Indonesia</td>
<td>*227,898</td>
</tr>
</tbody>
</table>

* May include earthquake casualties **Tsunami generated by volcanic eruption

Detection and early warning of a tsunami

Most tsunamis are caused by earthquakes. Because it is impossible to predict when an earthquake will occur, it is also impossible to determine exactly when a tsunami will be generated. However, by looking at past tsunamis, we know where they are most likely to be generated. Tsunamis created by earthquakes have their source in seismically active areas.

In 1965, following devastating tsunamis generated from earthquakes in Chile (1960) and Alaska (1964), the newly-created IOC was requested to establish an International Tsunami Warning System in the Pacific, with the Pacific Tsunami Warning Centre (PTWC) and the International Tsunami Information Centre (ITIC) in Honolulu, Hawaii Islands (USA).

Since 1965 the IOC has continuously tried to extend cover for the Indian Ocean and the Caribbean region, similar to the Pacific Tsunami Warning System PTWS for the Pacific Ocean. But the dangers of a tsunami were ignored because they have been so rare in these areas.

On 24 December, 2004 a massive (magnitude 9.1) earthquake off the coast of Banda Aceh, in Western Sumatra (Indonesia), generated a tsunami that caused over 230,000 deaths and billions of dollars of damage in 11 countries. Although Banda Aceh, itself, bore the brunt of
the catastrophe, coasts and their populations in Sri Lanka, India and nine other Indian Ocean
countries as far as 5000 km away, were also severely hit by the tsunami. It was the first basin-
wide tsunami on record in the Indian Ocean. As there was no early warning system in the
region, local people and tourists were neither warned, nor prepared to face the disaster.
Following this catastrophe the IOC was mandated to establish a global warning system. It
became imperative that a tsunami should never again create such avoidable loss of life.

In 2005, UNESCO-IOC was mandated to coordinate intergovernmental efforts to set up an
Indian Ocean Tsunami Warning System (IOTWS), building on over 40 years of
experience gained with the Pacific Warning System. Five years later, after a tremendous
effort involving 28 Member States, the system is planned to be operational by 2011. The
Pacific Tsunami Warning Centre (PTWC) in Hawaii, USA and the Japanese Meteorological
Agency (JMA) in Tokyo, Japan have, since April 2005, been providing an interim tsunami
advisory service to the Indian Ocean. Similar tsunami warning systems are reaching
completion for the Mediterranean and the North East Atlantic (NEAMTWS)
and the Caribbean (CARIBE-EWS), thus
covering all the earthquake (and therefore
 tsunami) prone ocean basins in the world.
PTWC provides an interim tsunami
warning service to the Caribbean Sea. “We
are now able to ensure global cover for
tsunami and other sea-level related
hazards” says Peter Koltermann, head of
IOC’s Tsunami Unit.

How does a tsunami early warning system work?

The first step is to detect and
localise an event that is likely
to cause a tsunami. In most
cases this is an underwater
earthquake of sufficient
magnitude (usually greater
than magnitude 7). Because at
present it is impossible to
predict when an earthquake
will occur, it is also
impossible to determine
exactly when a tsunami will
be generated. However, by
looking at past tsunamis, we
know where they are most
likely to be generated.
Tsunami travel paths and
arrival times can be calculated
quite precisely. Given the
appropriate communications
hardware, and institutional
infrastructure, even the smallest village can, in theory, be notified that a tsunami is on the way
so that they can take measures (e.g. evacuation to higher ground) to limit loss of life. These
warnings are produced and send out by Tsunami Early Warning Centres to national disaster
and emergency agencies. Making communities aware of the tsunami risk hazard and
preparing to minimize the risk is the greatest challenge to save lives and livelihoods. Intense work by national and local authorities is required to establish and maintain this awareness.

Tide gauges – confirm or cancel a warning
Not every underwater earthquake generates a tsunami, so monitoring changes in the sea level is used to confirm the generation of tsunamis and predict their travel. Sea level data are needed at high time-resolution with fast transmission to the warning centres. The sea level data are also required to cancel tsunami warnings.

Deep sea moored Buoys – added certainty
To provide even greater certainty that a tsunami has been generated, very sensitive ‘DART’ buoys (Deep ocean Assessment and Reporting of Tsunami) are deployed to measure sea level changes by observing deep sea pressure changes. Similar buoys are now being deployed in the Indian Ocean. Unlike tide gauges, they are expensive and need regular maintenance in remote areas of the ocean.

Communications
Once a tsunami warning has been issued, it has to get to those who are likely to be affected in time for them to take preventive action. Warnings are sent using several different means of communication on officially dedicated systems. In Japan – one of the most frequently struck countries – earthquake warnings are broadcast on television within 30 seconds of a tremor. Tsunami warnings follow very rapidly.

Awareness and preparedness
“The most difficult part of a successful tsunami warning system,” says Bernardo Aliaga, Programme specialist at IOC, “is preparing and informing the public on what to do once a warning has been issued.” This he says is the “first mile” of a successful warning system. While the technical aspects of early warning systems have developed rapidly in recent years, there is still much work to do with communities at risk. In much of Indonesia, the epicentre of an underwater earthquake can be so near to the coast that people have to be able to recognise and act on the signs immediately. Says Laura Kong, Director of the UNESCO IOC International Tsunami Information Centre, “They have to know that, if they’re near a coast and the earth is shaking so violently that they can’t stand up, there’s a very good possibility that a wave might have been generated. It’s time to head uphill as soon as you can.”

In the light of the 2004 Indian Ocean tsunami, where tourists also lost their lives, hotels in many countries (e.g. Indonesia and Thailand) now give a tsunami information kit to guests, showing the evacuation route and meeting points. These hotels also have access to the tsunami warnings.

To help raise awareness and inform the public, UNESCO-IOC has published a Tsunami Teacher DVD for use by teachers, students, private enterprise, etc. It is so far available in Indonesian, French, and English language versions. Thai, Spanish and Urdu versions are being finalised.