

# TSUNAMI

## Background reading

### What are the myths about tsunami?

There are many myths surrounding tsunami behaviour. Here we address some of the most common ones.

#### ***A tsunami is a single giant wave***

No, a tsunami is a series of low, fast and long ocean waves that is caused by a sudden displacement of a large body of water. The sudden displacement occurs often over a large area and the waves move out in all directions.

#### ***A tsunami is a huge cresting wave***

While tsunami can be large, they are usually seen as a series of low but long powerful waves with massive momentum. They rarely crest like normal ocean and wind swell waves you may see at the beach.

#### ***A tsunami is a huge slow wave when in the middle of the deep ocean***

Even though tsunami can be travelling close to 950 kilometres per hour in the deep ocean, they are generally unnoticeable because they are often very low.

#### ***A tsunami is a tidal wave***

Tsunami are sometimes called 'tidal waves' but this is misleading. Although the impact of tsunami on a coastline can be affected by tide level, tsunami are unrelated to tides. Tidal waves are caused by tidal affects like the moon, wind or seasonal change while tsunami are most commonly caused by undersea earthquakes.

### How do tsunamis work?

A tsunami is a series of waves travelling across the ocean due to a sudden displacement of a large body of water. This displacement can be caused by events such as undersea earthquakes, undersea landslides, land sliding into the ocean, volcanic eruptions or even asteroid impacts.

### Three stages of tsunami

Tsunami are different from wind swell waves and have three overlapping but quite distinct stages.

Generation of tsunami is caused by any force that disturbs a water column.

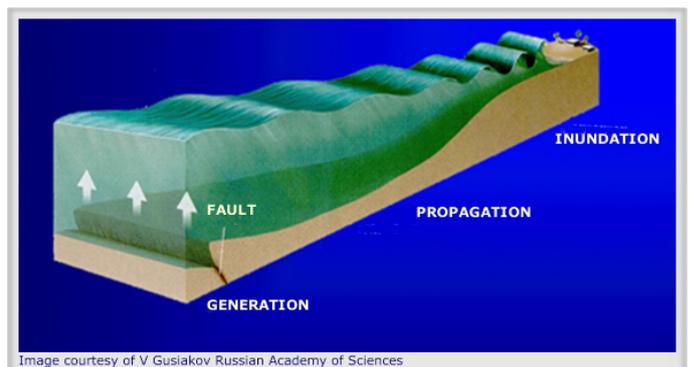
Propagation of this displaced water occurs as it moves across the deep ocean. When a tsunami is generated, the waves will spread out in all directions.

Tsunami:

- ▶ can travel as fast as 950 kilometres per hour through deep water and;
- ▶ have extremely long wavelengths in the deep ocean.

Inundation is the stage which can result in some localised overflow onto the immediate foreshore. Less frequently, tsunami can result in more serious inundation of coastal land, serious threat to lives and damage to property, especially in low lying coastal areas.

Tsunamis will look and behave differently depending on the shape of the sea floor and coastline. As tsunami move into shallow water their amplitude may increase. When this occurs it is called shoaling. Shoaling does not occur in every coastal environment. It is more likely to occur in a bay, harbour or lagoon where the wave is funnelled as it moves inland.



### How tsunami differ from wind swell waves

The wavelength of wind swell waves is much shorter than that of tsunami. You can see the next wind swell wave coming to the beach.

Normal ocean and wind swell waves can cause motion in the water to depths of 150 metres. These waves may cause motion without inundating normally dry land areas. If you click on the animations below you can see how the motion of a wind swell wave differs from that of a tsunami.

Tsunamis have extremely long wavelengths, up to hundreds of kilometres, even as they reach shallow coastal water. The second and third waves can arrive ten minutes to two hours apart. The passage of tsunami involves the movement of water all the way to the seafloor. The energy moving through tsunami may result in them being able to travel long distances inland.

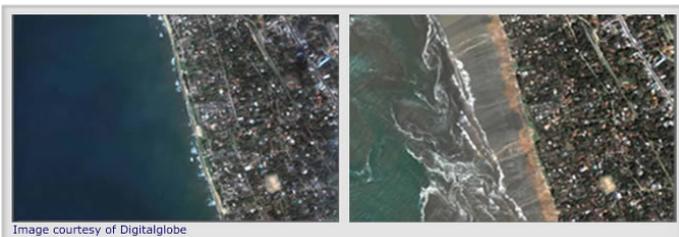
## What happens when a tsunami reaches the shore?

### **Drawdown**

If the wave trough arrives before the wave crest there may, but not always, be a drawdown of the coastline which exposes the ocean floor.

The distance of drawdown varies depending on the wavelength as it approaches the coast and also the slope of the beach. For example, the drawdown could be hundreds of metres if the beach slope isn't very steep. There can be anywhere between five and twenty minutes before the tsunami arrives.

Satellite images of the Sri Lankan coast show the extent of drawdown before the 2004 Indian Ocean Tsunami.



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### **Inundation**

As tsunami approach the shoreline, speed reduces and wave height can grow significantly – up to several metres.

It is not so much this movement of water but the energy moving through it that makes tsunami so dangerous. This is when the potential for inundation of normally dry land occurs.

### **Dangerous rips and currents**

A relatively small tsunami may still result in strong rips and currents that can be dangerous to swimmers and other marine users. This is the most likely impact we would experience in Australia.



This image of the 2004 Indian Ocean Tsunami shows the formation of a dangerous rip which is headed back out to sea (indicated by the yellow arrows).

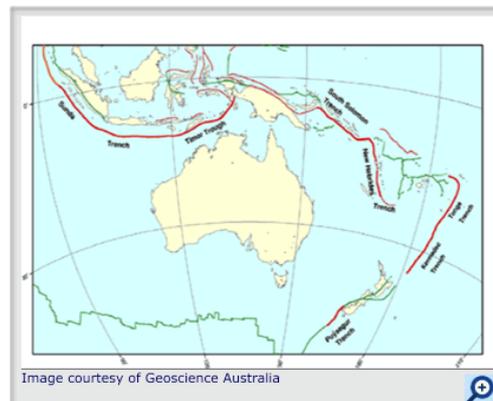
## What causes a tsunami?

A tsunami is a series of waves travelling across the ocean due to a sudden displacement of a large body of water.

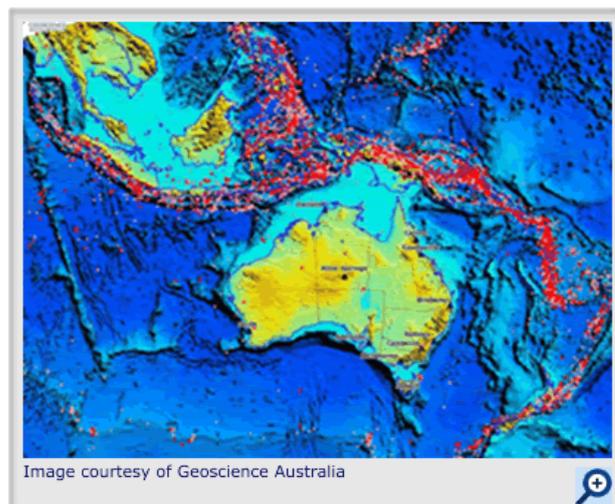
This displacement can be caused by events such as undersea earthquakes, undersea landslides, land sliding into the ocean, volcanic eruptions or even asteroid impact.

### **Undersea earthquakes**

Over 80% of tsunami in the Pacific Ocean are thought to have been caused by undersea earthquakes. Australia is surrounded by 8,000 kilometres of active tectonic plate boundaries and most earthquakes and volcanic eruptions occur where these plates meet. These boundaries are called subduction zones.



The red lines on this map indicate the closest tectonic plate boundaries to Australia.



The red and pink dots in this image represent past earthquakes. They are located along the tectonic plate boundaries.

### **Undersea landslides and land sliding into the sea**

Undersea landslides and land sliding into the sea may cause localised tsunami.

Undersea landslides occur when a large amount of sediment is dislodged from the seafloor, displacing a water column and potentially generating tsunami.

Land sliding into the sea, usually caused by an earthquake, may also cause destructive local tsunami.



Image courtesy of DJ Miller USGS  
 A landslide into Lituya Bay, Alaska, in 1958 caused a localised tsunami. The bare areas around the lake side in this image indicate where the trees were stripped away by the tsunami.

### Volcanic eruptions

Though less common, volcanic eruptions in or near the ocean have potential to cause tsunami. These occur in several ways:

- ▶ destructive collapses of coastal, inland and underwater volcanoes which result in massive landslides
- ▶ pyroclastic flows, which are dense mixtures of hot blocks, pumice, ash and gas, plunging down volcanic slopes into the ocean pushing water outwards or;
- ▶ a volcano collapsing after an eruption, causing overlying water to drop suddenly.

### What do we know about tsunami throughout history?

Throughout history, destructive tsunami have occurred in all of the world's oceans and seas.

Although tsunami occur most frequently in the Pacific Ocean, they are also known to occur anywhere and many ancient descriptions of sudden catastrophic waves exist.

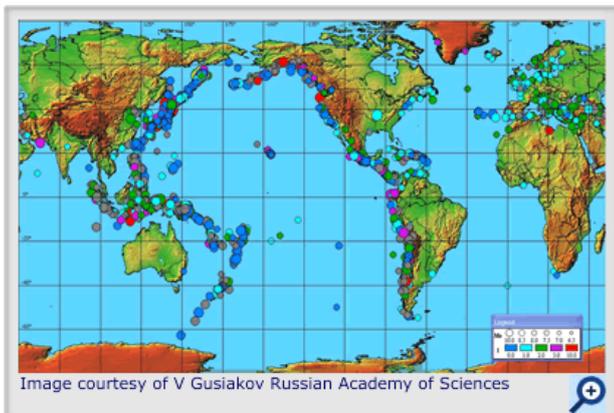


Image courtesy of V Gusiakov Russian Academy of Sciences  
 This map shows the location, size and intensity of over 2,000 tsunami events that have occurred since 1628BC. The colour of the circle reflects the tsunami intensity and the bigger the circle, the greater the event. Most tsunami have been generated along the active tectonic plate boundaries.

## Some major historical events

### 1755 Lisbon

The Lisbon undersea earthquake and tsunami occurred on 1 November 1755 at 9:40am. The tsunami, and subsequent fire, engulfed the city killing between 60,000 to 100,000 people. This was one of the most destructive events in recorded history. Geologists today estimate that the Lisbon earthquake was a magnitude 9 event.

### 1883 Krakatoa

The Krakatoa eruption of 27 August 1833, was amongst the most severe volcanic explosions in modern times. This catastrophic volcanic eruption caused two-thirds of the island to collapse beneath the sea. This generated a series of devastating tsunami, some as high as 35 metres. Tsunami ravaged nearby coastlines of Java and Sumatra, killing close to 40,000 people. Vessels as far away as the South African coastline were affected by this event.



Image courtesy of USGS  
 This map of Krakatoa shows the area of land mass that collapsed into the ocean as a result of this event.

### 1896 Japan

On 15 June 1896 at approximately 7:30pm, a magnitude 8.5 earthquake off the Sanriku Coast, Japan, triggered a tsunami which arrived on shore 30 minutes later.

Although the earthquake itself is not thought to have resulted in any fatalities, the tsunami which reached a height of 38.2 metres in places killed almost 20,000 people.

### 1946 Hilo

Another destructive Pacific-wide tsunami was generated by a magnitude 7.8 earthquake near Unimak Island, Alaska.

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Five hours after the initial earthquake, and without warning, a tsunami reached Hawaii causing considerable damage and loss of life. The tsunami completely obliterated Hilo's waterfront, killing 159 people.



*This image shows the 1946 tsunami breaking over palm trees at Hilo.*

### **1958 Lituya Bay**

Lituya Bay, Alaska, was the site of the largest localised tsunami ever recorded. On the evening of 7 July 1958 a magnitude 8.0 earthquake caused a massive rockslide at the head of Lituya Bay.

The land mass fell into the bay causing the water to surge and generate a tsunami. It inundated approximately 13 square kilometres of land along the shores of Lituya Bay, sending water as far as 1,000 metres inland and clearing millions of trees.

The tsunami reached a height of 524 metres.



*This image shows bare rock where trees were cleared by the 1958 tsunami.*

### **1964 Alaska**

On 29 March 1964 Prince William Sound, Alaska, was hit by a magnitude 9.2 earthquake.

The earthquake generated a major tsunami that struck the southeast coast of Alaska, the Pacific coast of British Columbia and the west coast of the United States.

The violent shaking during the earthquake caused many large landslides and undersea landslides, which

also produced destructive localised tsunami at many locations along the Alaskan coast.



*Image courtesy of National Geophysical Data Centre*

*This image shows the extent of inundation along the coastline of Valdez, Alaska, in 1964.*

### **1998 Papua New Guinea**

A tsunami struck the north coast of Papua New Guinea on Friday 17 July 1998. The tsunami was thought to have been caused by an undersea landslide which resulted from a magnitude 7 earthquake and which produced movement of the sea bed. The tsunami caused widespread injury, resulting in the deaths of over 2,000 people and leaving approximately 9,500 people homeless. Tsunami wave heights reached 15 metres in some areas.



*Image courtesy of Pacific Tsunami Museum*

*This image shows an example of the damage caused by the 1998 Papua New Guinea tsunami.*

### **2004 Indian Ocean**

On the morning of 26 December 2004 a magnitude 9.3 undersea earthquake occurred off the west coast of Sumatra, where the Indo-Australian Plate is sliding under the Eurasian Plate.

The part of the fault that ruptured was 1200 kilometres long and caused part of Indonesia to move westwards by five to ten metres.

This displacement of the ocean floor caused a tsunami, devastating communities in Indonesia, Sri Lanka and Thailand and affecting many other countries along the Indian Ocean rim.

Close to 300,000 people lost their lives.



Image courtesy of Anders Grawin

This image shows the 2004 Indian Ocean Tsunami approaching Koh Jum Island in Thailand.

### Tsunami in Australia

The Australian coastline has experienced tsunami through recorded history but most have been marine based threats and have presented little threat of land inundation to our coastal communities. Despite this, unusual rips or currents caused by even relatively small tsunami can be dangerous to marine users and boats.

The offshore tsunami hazard to Australia varies from 'relatively low' for most of our coastline to 'moderate' on the north-west coast of Western Australia (WA). This is due to its proximity to Indonesia and other countries in that region prone to large undersea earthquakes and volcanic activity.

### 2004 Indian Ocean

The impact on Australia during the December 2004 Indian Ocean Tsunami was relatively minor. Although the more destructive waves did not travel towards Australia during this event, a half metre tsunami wave passed the Cocos Islands and dangerous rips and currents were experienced on the western and southern coasts of Australia.

At least 30 people were rescued after being swept out to sea, some relatively minor land inundation occurred and boats were damaged in marinas. Fortunately no lives were lost.



Image courtesy of the Geraldton Guardian

This images shows a fishing boat in Geraldton on the west Australia coast that was sunk at its mooring as a result of the 2004 tsunami in the Indian Ocean.

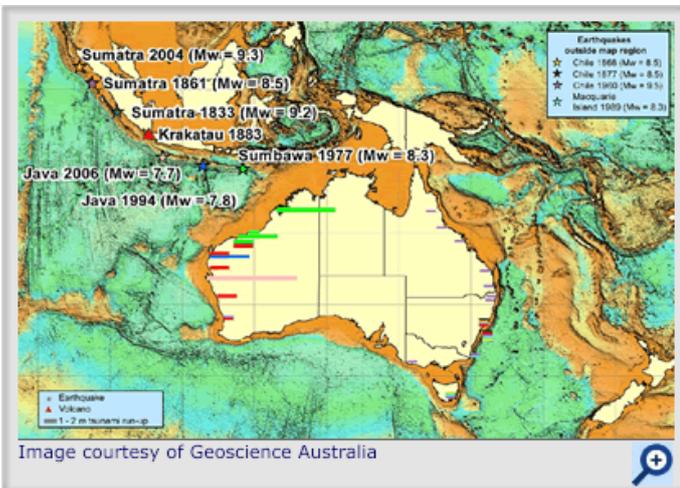


Image courtesy of Geoscience Australia

This map shows the location of tsunami which have impacted on the Australia coastline. Each event is colour coded and relates to actual undersea earthquakes and volcanic events.

The length of each line indicates a tsunami impact showing the known tsunami run-up height. The 2006 Steep Point event has the highest run-up height recorded and is indicated by the pink line on the image.

### 1960 Chile

In May 1960 a magnitude 9.5 earthquake along the tectonic plate boundaries off the coastline of Chile, resulted in the largest recorded tsunami along the east coast of Australia.

The event generated tsunami waves just under one metre in height in Sydney Harbour. Slight to moderate damage (mainly to boats) was recorded in harbours at Lord Howe Island, Evans Head, Newcastle, Sydney and Eden.

### 2006 Steep Point

On 17 July 2006 a magnitude 7.7 undersea earthquake south of Java generated a tsunami that affected parts of the WA coast, particularly Steep Point. Waves of up to two metres were recorded with evidence of inundation up to 200 metres inland. This tsunami caused widespread erosion, extensive vegetation damage and destroyed several campsites.

Campers at Steep Point were lucky to escape when the July 2006 tsunami inundated their beach campsite, picked up their 4WD vehicle and moved it ten metres up the beach. Fish, starfish, corals and sea urchins were also deposited on roads and dunes well above the regular high-tide mark.



Image courtesy of Paul Dickenson

This image shows extensive damage to the Steep Point campsite.



Image courtesy of Paul Dickenson

This image shows the 4WD vehicle which was moved ten metres up the beach by the tsunami.

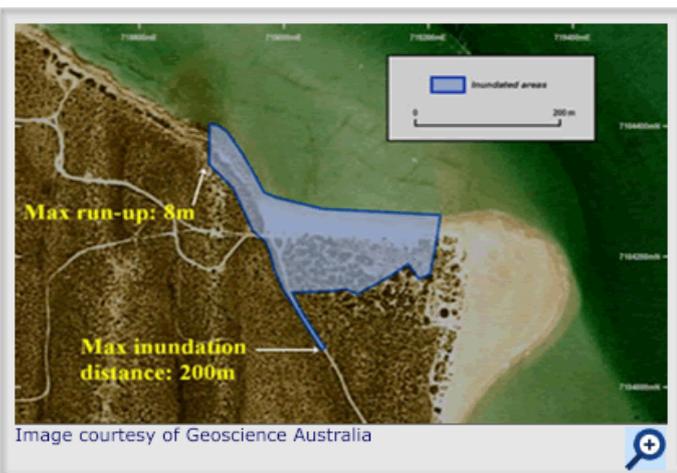


Image courtesy of Geoscience Australia

This aerial image shows the extent of the mapped inundation and run-up at Steep Point.

### 2007 Solomon Islands

On 2 April 2007 an 8.1 magnitude undersea earthquake off the coast of Gizo in the Solomon Islands caused tsunami waves between two metres and ten metres high. The tsunami caused widespread destruction in the

Solomon Islands with a death toll of 34.

As a result of this event, a senior Surf Lifesaver of 30 years experience at Coffs Harbour on the New South Wales north coast claimed there were dangerous rips and currents in the town's harbour, something he had never witnessed before.

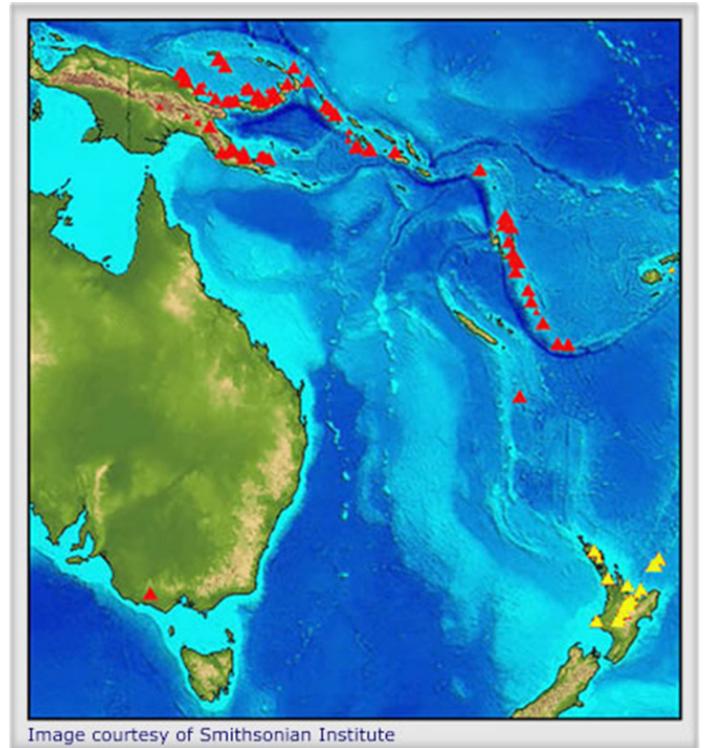


Image courtesy of Smithsonian Institute

Australasian active volcanoes in the last 10,000 years.

### Asteroid impact

An asteroid impact into the ocean could cause tsunami. Fortunately, this should be rare and there are no documented accounts of an asteroid having generated tsunami.

### Could we get a tsunami in Cairns?

Yes. It is not as likely as other natural disasters such as cyclone, flooding, landslips and earthquakes, but Cairns could be affected by a tsunami.

The Great Barrier Reef would probably lessen the impact but not stop a tsunami.