2004 Indian Ocean Tsunami. (Nalini Kasynathan – courtesy OxfamCAA) Figure 5: Two small boats stranded on the first floor of a building after the

open Indian Ocean, away from the tsunami energy was directed into the by 1833 Sumatra earthquake. Most besues imenust of the butildme Higure 6: Calculated maximum

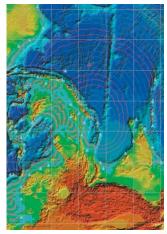






coast of Australia. were recorded on the west abnormal sea-level variations passed Cocos Island while minor. A half metre wave earthquake was relatively 26 December 2004 Sumatra For Australia, the impact of the

Academy of Science) Pacific. Isunami Laboratory - Russian the integrated isunami Database for the Renerated using software provided with and alternate colour every hour. (Figure Contours are at 15-minute intervals, triangle southwest of Indonesia). із індісяєва ру тре тавейта іпчетей Cocos Islands tide gauges. (The latter эцилэц рин эт үүн үүүүү эчүү эш is roughly constrained by the tsunami Indian Ocean Tsunami. The source zone Figure 4: Travel-time contours for the



above the earthquake's origin or 'focus \* boint on the Earth's surface directly

lost their lives. Ocean rim. Close to 300 000 countries along the Indian and affecting many other Sri Lanka and Ihailand communities in Indonesia, Indian Ocean, devastating its epicentre\* across the



tsunami which spread from ocean floor generated a The displacement of the average slip of 5-10 m. 100-150 km, and had an The width of the fault was

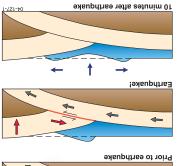
length of the Andaman Ihrust. ruptured the entire 1200 km The 'Indian Ocean Tsunami' under the Eurasian Plate. Australian plate is sliding of Sumatra where the Indooccurred off the west coast A magnitude 9.3 earthquake

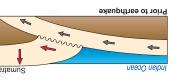
main shock. red dot indicates the epicentre of the Andaman Islands earthquake. The large Figure 3: The 26 December Sumatra-



**7004** Secomper 2004

the lower plate. the upper plate is deformed due to drag and release of tsunami. The red arrows indicate the direction in which the displaced sea surface propagates outward as a displacing the sea surtace; 10 minutes atter earthquake nopper plate to rebound to its initial, unflexed position, Earthquake! - Stress on the plate boundary causes the olate drags against the upper plate, causing flexure; tsunami. They are generated when the lower subducting earthquakes are the most common source of destructive Figure 2: Prior to the earthquake - Subduction zone





appear as a series of breaking waves. seafloor may also cause the tsunami to of metres. Local details of the shape of the this recession can exceed many hundreds wave's arrival. It the seatloor slope is shallow, sea will recede from the coast before the edge of the tsunami wave is its trough, the falling tide. In instances where the leading a frough, it may appear as a rapidly rising or of a tsunami to reach the shore is a crest or coast. Depending on whether the first part several metres or more in height near the that is unnoticeable at sea may grow to be grows. This is called shoaling. A tsunami As the tsunami's speed diminishes, its height water near the coast, the tsunami slows. oben ocean and travels into the shallower As a tsunami leaves the deep water of the

esobit diw ob of gnidton incorrect as they have si siyi tha 'səvew lebit' Tsunami are sometimes called

air, reaching speeds up to 1000 km/h. therefore be unnoticed by ships or from the may be less than a metre. Tsunami waves may may be as much as 150 km but the height a deep ocean, the length from crest to crest away from their source. As a tsunami crosses period. Tsunami waves move outwards, The waves are of extremely long length and of which may or may not be the highest. A tsunami is a series of sea waves, the first eruptions or even ocean meteorite impacts. like earthquakes, landslides, volcanic Tsunami can be caused by under-sea events

all the way to the seafloor. of a tsunami involves the movement of water to depths of 150 m. In contrast, the passage swell waves may cause motion in the water on the ocean. Normal ocean and wind A tsunami is different from normal waves

#### TSUNAMI EXPLAINED



ANDAMAN–SUMATRA EARTHQUAKE: SUIII dillilis a Japanese word: **(su** meaning 'harbour' and **nami** meaning 'wave'.

WHERE CAN I GET MORE INFORMATION?

#### **Bureau of Meteorology**

www.bom.gov.au/info/tsunami/tsunami\_info.shtml

**Emergency Management Australia** 

www.ema.gov.au

#### **Geoscience Australia**

www.ga.gov.au

**International Tsunami Information Centre** 

www.tsunamiwave.info/

**National Oceanic and Atmospheric Administration** 

www.noaa.gov/tsunamis.html



**Australian Government** 





**Australian Government** 

Geoscience Australia

**Bureau of Meteorology** 

**Attorney-General's Department** 

Emergency Management Australia

This pamphlet is produced jointly by Emergency Management Australia, Geoscience Australia and the Bureau of Meteorology.

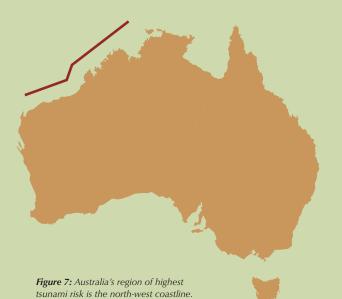
#### **AUSTRALIAN TSUNAMI**

In the last few thousand years the Australian coast may have experienced large tsunami, as evidenced by shell, coral and boulder deposits found well above sea level and several kilometres inland.

Minor tsunami are recorded about once every two years in Australia, but most are small and present little threat to our coastal communities. The tsunami threat to Australia varies from 'relatively low', for most of our coastline, to 'moderate' on the north-west coast of WA due to its proximity to Indonesia and other countries in that region prone to large earthquakes and volcanic activity.

Several large tsunami have hit Australia's north-west coast—the largest at Cape Leveque, WA, in 1977, with a 6 m wave height. Further south in the Onslow-Exmouth region, in June 1994, tsunami waves with over 4 m 'run-up' (i.e. it travelled inland to a point 4 m above sea level) appeared out of a calm sea and washed 300 m inland. Both of these WA tsunami were generated by earthquakes in Indonesia.

In May 1960, a great earthquake in Chile generated the largest recorded tsunami along the east coast of Australia. The event generated tsunami waves of just under a metre (trough to crest) at the Fort Denison tide gauge in Sydney Harbour. Slight to moderate damage (mainly to boats) resulted in harbours at Lord Howe Island, Evans Head, Newcastle, Sydney and Eden.



Tractic plants





**Figure 8:** Unusual tidal fluctuations were recorded in Augusta, South Australia, during the December 2004 tsunami. The strong currents caused by the tsunami dragged bathers out to sea, but they were either rescued or made it back to shore on their own. (Images courtesy Dave Piper)

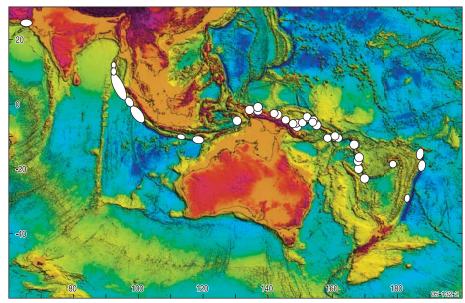


Figure 9. A map of the earth's surface, showing the major tectonic plate boundaries and locations of historic tsunamigenic earthquakes. The tsunami threat to the region originates from the system of subduction zone plate boundaries (also known as ocean trenches) extending through Indonesia, New Guinea, Vanuatu, Fiji and the trench systems to the north and south of New Zealand.

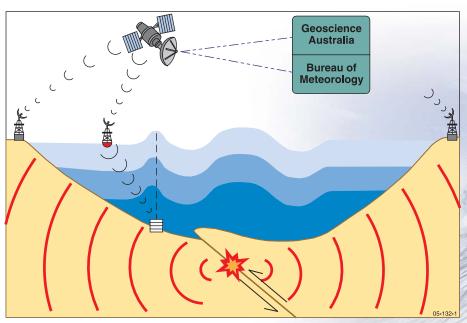


Figure 10. An undersea earthquake causes displacement of both the seafloor and the sea surface, and the spreading out of seismic waves (in red). The disturbance in the sea surface radiates outward as a tsunami, which travels much slower than the seismic waves. Once the seismic waves are detected by distant (usually land-based) seismometers, sealevel data from coastal tide gauges or DART buoys are analysed to determine whether a tsunami has actually been generated.

## If SHAKE DROP ROAR

### then RUN and WAIT

(Image courtesy Digital Globe

# WHAT ARE THE WARNING SIGNS OF AN IMPENDING TSUNAMI?

#### SHAKE

Evidence of a large undersea earthquake may be felt prior to a tsunami by an on-going shaking of the ground in coastal regions.

#### DROP

Sea level may drop dramatically before the arrival of a tsunami.

#### ROAR

A roaring sound may precede the arrival of the tsunami.

### WHAT DO I DO IF THERE IS A TSUNAMI?

If SHAKE DROP ROAR then RUN and WAIT.

#### RUN

Evacuate immediately to higher ground or well away from the waters edge. Do not go towards shore to watch a tsunami.

#### WAIT

Wait at the safe place for several hours. The tsunami may arrive within 30 minutes of the earthquake or other warning sign.

The backwash of a tsunami is also dangerous. As the large volume of water pushed onto land recedes back towards the ocean it may carry debris and people back to sea with it.



Figure 13: Kalutara Beach, Sri Lanka 1 January 2004 showing normal coastal wave conditions. (Image courtesy Digital Globe)

Figure 12: Kalutara Beach, Sri Lanka 26 December 2004 showing withd

Figure 11: "Tsunami Ready" sign in Washington, USA. (Image courtesy NOAA)