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A tsunami hits the north-east coast of Japan after a magnitude 9.0 earthquake on March 11, 2011. (AAP Photo/Kyodo News)

Tsunamis: how they form

BY ALEXANDRA BACK | MARCH 18, 2011

Tsunamis have occurred through history, but there is still much to learn about them. Here are the basics.

TSUNAMIS WERE VIRTUALLY UNHEARD of in the mass media until the catastrophic monster waves that struck on Boxing Day in 2004 (http://www.australiangeographic.com.au/blogs/on-this-day/2014/12/on-this-day-in-history-boxing-day-tsunami). But large events like the earthquake (/search-results.htm?q=earthquake) and tsunami (/search-results.htm?q=tsunami) in Chile in 2010 and the recent Japanese disaster have put tsunamis back into the public consciousness.

Though they have occurred through history, their unpredictability and infrequency makes them difficult to study. Scientists know what causes them and, following the advent of tsunami warning centres, can measure how fast they travel and when they may reach distant shores.

But because each tsunami is unique and not all earthquakes produce them, there is still little known about where the worst waves will strike and how big they will be. "There's no hard or fast rule - it basically depends on how big and how shallow the quake is," says Professor Dale Dominey-Howes, co-director of the Australian Tsunami Research Centre and Natural Hazards Research Centre at UNSW.

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Tsunamis: How they form

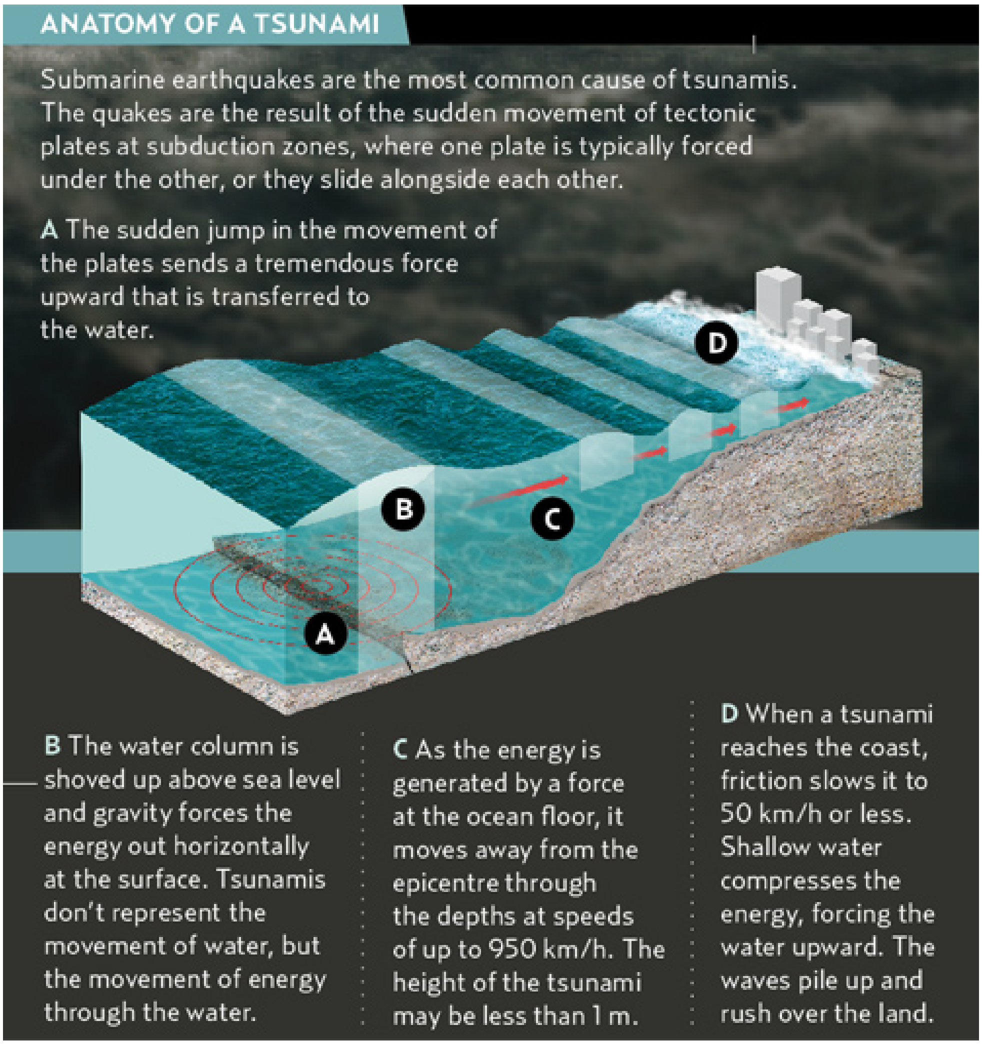
Underwater volcanoes (/journal/submarine-volcano-grows-at-record-rate.htm) erupting, icebergs calving and in rare instances meteorites (/journal/australias-meteorite-craters.htm) hitting the ocean have all produced the giant waves in the past. But very large underwater earthquakes are responsible for about three-quarters of all tsunamis.

"Broadly speaking earthquakes have to be a magnitude six or above to trigger a tsunami," Dale says. "And the closer to the sea floor an earthquake its, the more likely it is to generate a tsunami."

This is largely because of the same principal as to why shallow earthquakes, like the Christchurch one, cause so much damage: a large amount of energy has a shorter distance to travel and less resistance to travel through.

A magnitude-9 earthquake for example, won't trigger a tsunami if it takes place hundred of kilometres below the earth's surface. But the earthquake that size off the coast of Japan last week was only 24 km below the ocean floor.

Most normal ocean waves have a wavelength (the distance between crests of consecutive waves) of at most 30 to 40 m, but tsunamis are completely different, says Dale. "They have wavelengths of 100 to 200 km and a wave period of tens of minutes to nearly an hour."



Indian Ocean tsunami tracking system - a new technology

Once a tsunami has been generated, scientists can accurately forecast the when (to within a couple of minutes) and the where it will hit coastline. Prior to the 2004 tsunami, though, there was no tsunami warning centre in the Indian Ocean, so warnings issued were slow or non-existent.

To track tsunami wave movements, scientists rely on a series of complex monitoring systems, starting with devices on ocean floors that are able to measure an increase in pressure at that point. This information is sent to buoys on the surface, which is passed to satellites and then to monitoring stations on land.

"Basically if you dump an extra metre of water on the water column you can measure that increase in pressure," says associate professor Stephen Roberts from the Mathematical Sciences Institute at the ANU where he works on modelling tsunamis.

From speeds of up to 800 km/h out at sea, tsunamis slow down significantly on approach to shore. Despite this, it is difficult to forecast how the wave will behave on arrival.

"I'm actually not so much worried with the deep ocean modelling, that's pretty under control...but what happens when the actual wave comes into shore," Stephen says. "You get all sorts of weird complex behaviour, waves that are bouncing off headlands and you can get amplification of the waves."

Tsunamis: What happens as they approach land

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Amazing video of the Japan tsunami (/journal/japanese-tsunami-best-video-footage.htm)

A boat out at sea would barely notice a tsunami passing beneath it, because the height of the wave in deep water is rarely over a metre. That's because below it, like the tip on an iceberg, is an enormous column of water - usually shifted from a large and sudden displacement of the sea floor. The 2004 Indian Ocean tsunami, for example, resulted from most of the 1600 km section of the sea floor moving 10-15 m sideways and being lifted 4-5 m.

This column, from the top of the wave to the sea floor, rises and falls as the massive amount of energy is pushed along from the source. As the wave moves toward land and the sea becomes more shallow, this column of water is squeezed upwards, increasing in height as ocean floor turns into beach.

"The front end of the wave slows down as it reaches the coast and the back end, which is still going very fast, is powering up behind the front end," Dale says. "That's why tsunamis flood land for many, many minutes and can go many kilometres inland."

Among the most vulnerable areas of a coast are funnel-shaped harbours and bays as the incoming flow of water bounces back in on itself from the enclosed shores. "Embayments are very problematic for focusing the tsunami energy and waves, so if you've got indented coastlines, like harbours, like embayments, tsunamis tend to get funnelled into those," Dale says.

"The safest places are high ground with strong cliff lines and where there is very deep water off the coast line, as tsunamis can't get big where there is very deep water,"

Natural vegetation like mangroves and large coral reefs can also act as barriers and can start to reduce the wave energy. But often the lowest-lying areas of the coast - and the most vulnerable to tsunamis - are often hubs of urban development.

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