Tsunami inquiry unit

Investigate the science of tsunamis, explore case studies from around the world and identify opportunities to reduce the risk of a disaster.

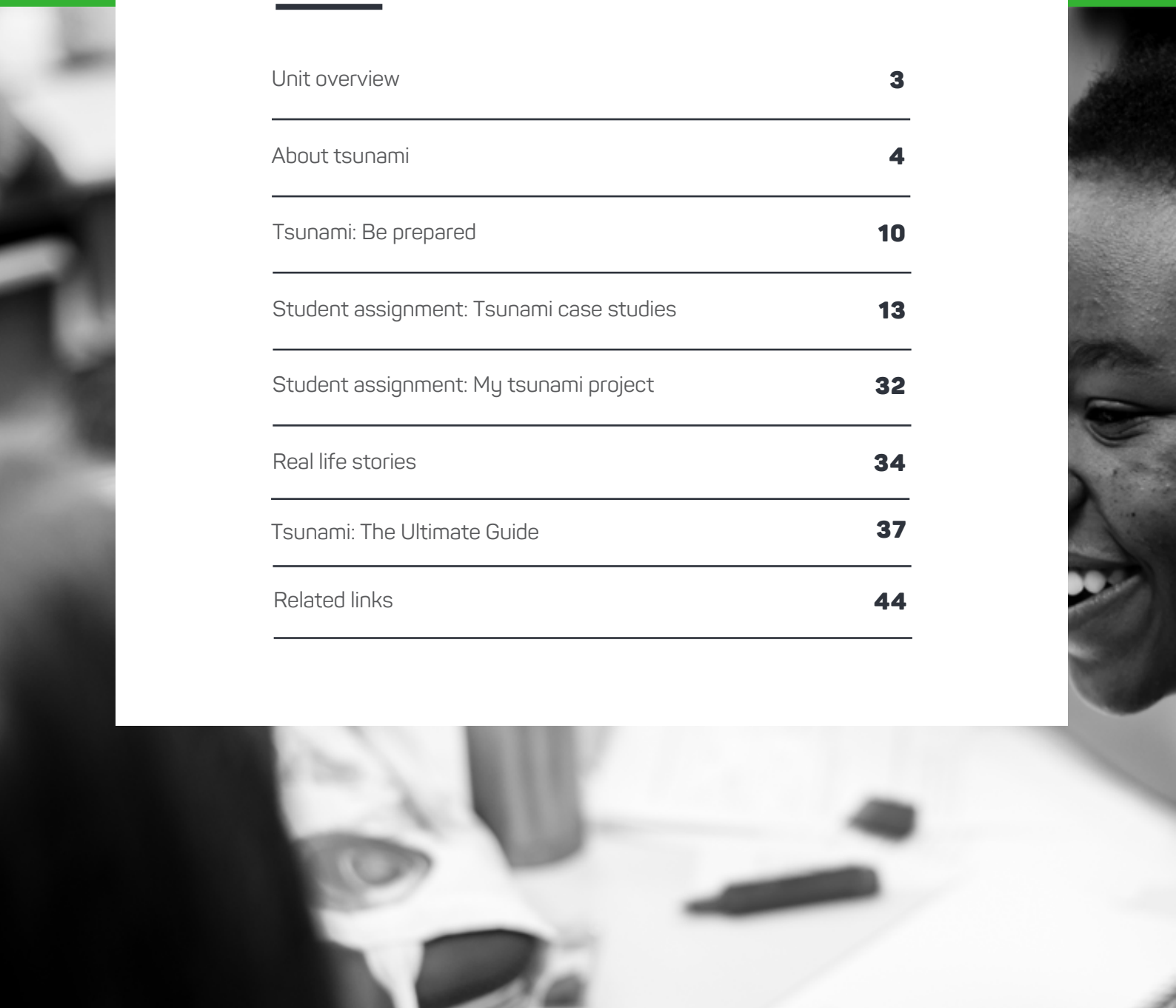
Australian Curriculum: Geography
UPPER PRIMARY / LOWER SECONDARY

ITEMS

- Lesson plan
- Student assignments
- About tsunami
- Real life stories
- Tsunami: Be prepared
- Related links

Australian Institute for Disaster Resilience

Contents



Tsunami unit of work

Inquiry sequence

ACHGK053	What is a tsunami?
ACHGK053	How are places connected to the tsunami event?
ACHGK053	What impacts can a tsunami have on people and places?
ACHGK053	How do people in Australia connect and respond to the significant event?
ACHGK053	How does global research help manage these significant events?
ACHGK053	Would you know what to do if a tsunami occurred near you?

REQUIRED RESOURCES

- Computers with internet access
- Atlas
- Outline map of the world, Pacific Ocean-focused
- 'My severe storm project' activity sheet
- Tsunami: The Ultimate Guide

Learning areas

YEAR 8 GEOGRAPHY

ACHGK053	Causes, impacts and responses to a geomorphological hazard
ACHGS055	Develop geographically significant questions and plan an inquiry, using appropriate geographical methodologies and concepts
ACHGS056	Evaluate sources for their reliability and usefulness and select, collect and record relevant geographical data and information, using ethical protocols, from appropriate primary and secondary sources
ACHGS057	Represent data in a range of appropriate forms, for example, climate graphs, compound column graphics, population pyramids, tables, field sketches and annotated diagrams, with and without the use of digital and spatial technologies
ACHGS058	Represent spatial distribution of different types of geographical phenomena by constructing appropriate maps at different scales that conform to cartographic conventions, using spatial technologies as appropriate
ACHGS059	Interpret geographical data and other information using qualitative and quantitative methods, and digital and spatial technologies as appropriate, to identify and propose explanations for spatial distributions, patterns and trends, and infer relationships
ACHGS060	Apply geographical concepts to draw conclusions based on the analysis of data and information collected
ACHGS061	Present findings, arguments and ideas in a range of communication forms selected to suit a particular audience and purpose; using geographical terminology and digital technologies as appropriate
ACHGS062	Reflect on their learning to propose individual and collective action in response to a contemporary geographical challenge, taking account of environmental, economic and social considerations, and predict the expected outcomes of their proposal.

Unit overview

Objectives

The objectives of the unit activities are for students to:

- develop an understanding of the causes of a tsunami
- understand how tsunami occur
- develop an understanding of the impact of tsunami on people and the environment
- develop an understanding of how best to prepare for a tsunami event.

Get the facts

This inquiry unit has been developed paying particular attention to:

- What is a tsunami?
- Where do tsunami occur?
- Tsunami warnings.
- Be prepared.
- Report a tsunami.
- Build your own resource guide.

Students are also encouraged to complete 'My tsunami project'.

About tsunami

A tsunami is often triggered by undersea earthquakes that cause massive changes to the ocean floor. A tsunami can also be caused by seismic events, landslides, or even asteroid impacts.

A tsunami is a series of ocean waves that are usually caused by seismic events. The word tsunami is a Japanese word and is pronounced 'soo-nah-mee'. It means 'harbour wave' with 'tsu' meaning harbour and 'nami' meaning wave.

Japan has experienced many tsunamis throughout its history. Along Japan's coastline, there are many bays which act like funnels and concentrate the force of tsunami waves, meaning tsunamis have a greater impact on these areas that on other settlements or boats at sea.

Sometimes tsunamis are called 'tidal waves', but this is not correct as tsunamis are not caused by the tides. Although tsunami impact on a coastline can be affected by tide level, tides are affected by the gravitational pull of the sun and moon, while tsunamis are usually caused by earthquakes.

Tsunamis are usually formed by undersea events that create sudden and large disturbances to the water in the ocean. These underwater events can be caused by:

- earthquakes
- landslides
- erupting volcanoes
- other movements in the earth's crust
- large explosions.

What causes a tsunami?

When an undersea earthquake or other major disturbance causes a section of the ocean floor to suddenly rise or sink, the mass of water above the affected area also rises or sinks. This unexpected movement of the water creates a series of powerful waves. Undersea earthquakes that cause massive changes to the ocean floor and the displacement of a large volume of water are the most common causes of a tsunami. Tsunamis can also be caused by other undersea events such as volcanoes or landslides.

A tsunami can also be caused from events above the ocean floor. These events could include a meteorite crashing into the ocean, major landslides near a coastline or material from an erupting volcano forming a landslide. The impacts of tsunamis triggered this way tend to be localised. More than 75 per cent of tsunamis are caused by undersea earthquakes.

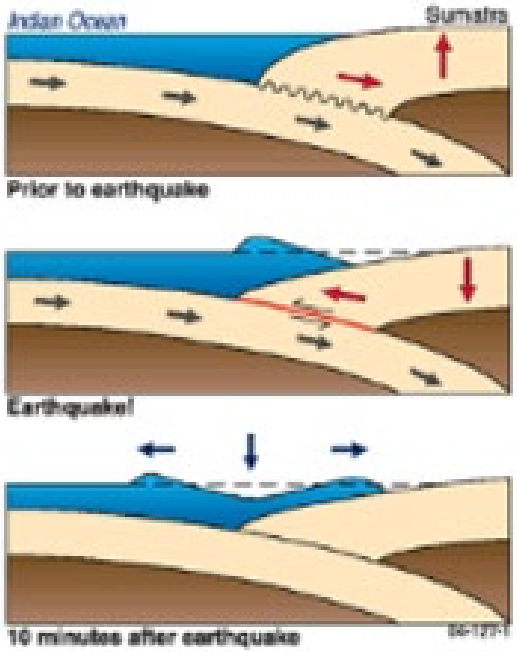
Where do tsunamis occur?

Most tsunamis occur in the Pacific and Indian Oceans. The boundary of the Pacific Ocean experiences frequent earthquakes and is commonly known as the Ring of Fire. There are two major subduction zones in the Indian Ocean that can also generate tsunamis.

Active volcanoes, plate tectonics and the 'Ring of Fire'

Subduction zone earthquakes are the most common source of destructive tsunamis. These earthquakes are generated when two tectonic plates meet, and one goes under the other, usually by only a few centimetres. The sinking (subducting) plate drags against the upper plate, causing flexing. Continued stress on the plate boundary results in the upper plate rebounding to its original position, displacing the sea water above.

Sumatra earthquake and tsunami, 26 December 2004



In the case of the December 2004 earthquake off the coast of Indonesia, the tsunami was generated ten minutes after the displaced sea surface spread outward from the epicentre as a tsunami.

In this illustration, the red arrows indicate the direction in which the upper plate is deformed due to drag and release of the lower plate.

A tsunami can really move!

In the deep water of the ocean, the waves that are created have a large wavelength but are not usually bigger than one metre tall. A tsunami wave may be hundreds of kilometres in length and it moves at a high speed across great distances without losing much of its energy.

Tsunami waves move out from where a large body of water has been disturbed, similar to the way ripples move away from the place where a rock has been dropped into a pond.

In the open ocean, a tsunami can travel as fast as 950 kilometres per hour, a similar speed to a passenger jet. It loses speed as it approaches land, but it does not lose much of its energy. As it slows down, the height of the waves build.

How big is a tsunami?

In the open ocean it can be difficult to notice a tsunami wave. However, as a tsunami wave approaches land and moves into more shallow water, the leading edge of the wave slows down but the back of the wave is still travelling at its original speed. This causes the water to bunch up and increase the wave height. This is known as 'shoaling'. When it reaches land, it may behave like a series of breaking waves or one large, powerful wave.

The tremendous energy of the wave can cause great quantities of water to surge inland, far beyond where even the highest of tides would usually reach.

Some of the largest tsunami waves were generated by the volcanic eruption of Krakatoa in 1883, reaching a height of 37 metres. In 1737, a tsunami was estimated to be 64 metres high as it struck Cape Lopatka in north-east Russia.

Tsunami waves are different from normal waves

Tsunamis are different from normal waves. Normal waves are generated by the wind and it is only the water near the surface that is moving. In a tsunami all the water from surface to sea bed is moving and the movement has been generated by something (usually an earthquake) that has displaced water. In the open ocean, tsunami create little movement and are not a significant threat to shipping.

When a tsunami wave reaches the shore, its wavelength might be more than 100 kilometres. Tsunamis can last for several hours or even days depending on location. This is very different to the waves that we are used to seeing at the beach, which typically last for less than a minute and have a wavelength of 100 metres.

The energy behind a tsunami can strip sand off beaches, uproot trees, and crush buildings. People and boats are powerless against the force of a tsunami and the amount of water carried inland is capable of inundating vast areas of normally dry land.

Pacific Ocean

The map below shows that tsunamis occur frequently in the Pacific Ocean. This region is sometimes called the Ring of Fire because this is where most of the seismic activity in the world takes place.

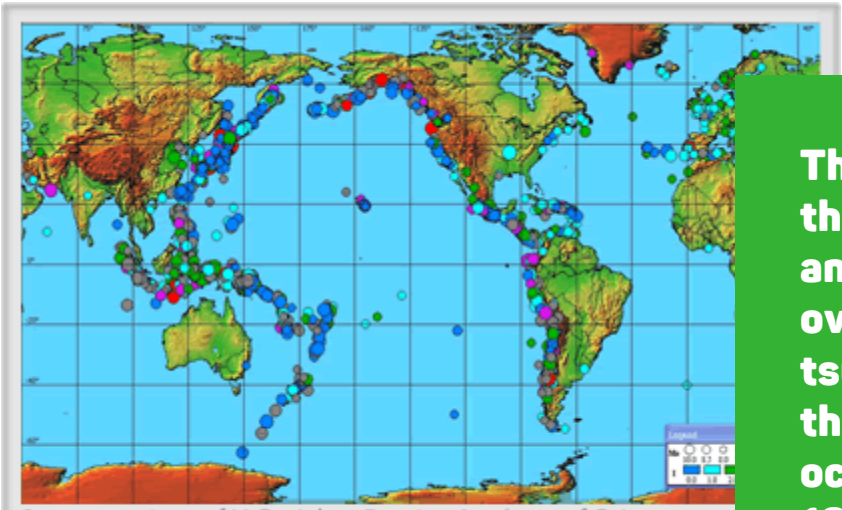


Image courtesy of V Gusiakov Russian Academy of Sciences

This map shows the location, size and intensity of over 2000 tsunami events that have occurred since 1628 BC.

The colour of the circle shows the tsunami intensity. The larger the circle, the greater the event. Most tsunamis have been generated along the active tectonic plate boundaries.

Indian Ocean

Tsunamis are not as common in the Indian Ocean because the seismic activity is less than in the Pacific Ocean. However, there have still been many major tsunamis recorded in this region such as the 2004 Sumatra, 1945 Pakistan and 1941 India tsunamis.

Tsunami in Australia

The Australian coastline has experienced tsunami throughout recorded history, but most have been small and have presented little threat to our coastal communities. Despite this, it is important to remember that unusual tides or currents caused by even relatively small tsunami can result in strong rips and currents. These can be dangerous to swimmers and marine users such as beachgoers, fishers, marine industries and boats.

The risk of a tsunami occurring on Australia's coastlines varies from 'relatively low' for most of our coastline to 'moderate' on the north-west coast of Western Australia. Most tsunamis in Australia are reported as marine foreshore threats. This is more severe than the 'no threat warning' but less severe than the 'land inundation threat warning'.

On 17 July 2006, an earthquake of magnitude of 7.7 on the Richter Scale, south of Java, generated a tsunami that reached the Australian coastline. The tsunami caused damage up to 200 metres inland. Roads and sand dunes were eroded, vegetation was uprooted, and several campsites were destroyed. Fish, corals and sea urchins were left stranded on roads and sand dunes, well above the high-tide mark.

The largest recorded tsunami in Australia was in August 1977. Cape Leveque in Western Australia experienced tsunami waves of up to 6 metres above sea level. The University of Western Australia has information about other tsunamis that have affected Western Australia.

Australia's North-West coastline

This map shows that the northern coastline of Western Australia is considered to be Australia's region of moderate tsunami risk.

This part of Australia is more likely to be affected by a tsunami because it is closest to other countries, such as Indonesia, that are more likely to have large earthquakes or volcanic eruptions.

Tsunami: Be prepared

Understanding the link between earthquakes and tsunamis has made it possible to establish tsunami warning systems.

A warning system involves recording two sets of data: seismic activity and changes in sea levels. Real-time data from seismic stations will indicate if an earthquake has occurred and automatic analysis will indicate the likelihood of a tsunami.

Not all earthquakes cause a tsunami, so another set of information is required. Sea-level readings are gathered from a number of ocean buoys and coastal gauges to work out if a tsunami has occurred and to monitor its path. If a tsunami is verified, communities can be warned.

The Pacific Tsunami Warning System was established in 1949 and a network of seismic monitoring stations and sea-level gauges. These detect earthquakes and abnormal changes in sea level and help scientists decide whether a tsunami has been triggered by an earthquake. If so, warnings go out to many countries and regions in the Pacific. Warning centres are located in both Hawaii and Alaska.

In Australia, the Joint Australian Tsunami Warning Centre (JATWC) is operated by the Bureau of Meteorology and Geoscience Australia. The Centre detects, monitors and verifies tsunami and warns the community. JATWC operates 24 hours a day, seven days a week.

There are three main warning levels:

- Watch - stay tuned for updates
- Marine warning - strong waves and currents and perhaps some localised run-up
- Land warning - foreshore and nearby land flooding is highly likely, with dangerous rips, waves and strong ocean currents.

Australian tsunami warning system

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

If you hear that a strong undersea earthquake has occurred, stand by for a possible tsunami warning. You should be prepared to move from low-lying coastal or lakeside areas to high ground at short notice. Remember that tsunamis are potentially dangerous and destructive. At no time should you move closer to the shore to watch a tsunami.

Warning signs

Look out for tsunami natural warning signs.

Feel the earth shake? A large undersea earthquake may be felt before the arrival of tsunami by an ongoing shaking of the ground in coastal regions. However, you may not feel an earthquake if the event is far away.

See ocean water disappear from the beach, bay or river? Before a tsunami, water may (though not always) recede from the shoreline before returning as a fast-moving wall of water. This is known as a drawdown. If you notice that the water is disappearing, tell your family and friends and prepare to move to higher ground.

Hear an unusual roaring sound? If you hear a loud roar approaching (a bit like a jet aeroplane or a train), tell your family and friends. It may be a tsunami approaching.

Action to take

Run to higher ground if you think there may be a tsunami approaching. If you see a wall of water coming or hear a tsunami warning, leave low-lying coastal areas immediately. Move away from the water and move quickly inland towards higher ground.

When an official warning has been issued

When the Joint Australian Tsunami Warning Centre (JATWC) issues an official warning, it means a tsunami has been detected. They will consult with state or territory emergency authorities to determine the appropriate response for the public.

The emergency authorities have a plan in place for a range of emergencies. If a tsunami was heading for Australia, the emergency authorities would distribute warnings on the radio and television stations telling people to move away from the danger zones. You should follow the instructions of your local emergency authorities if you are asked to evacuate. Head for higher ground and away from the beach or rivers that lead to the beach.

A phone number, 1300 TSUNAMI (1300 878 6264), is also available for the public to listen to tsunami warnings for Australia. The Bureau of Meteorology's website displays relevant tsunami warnings and information.

Remember that a tsunami is not a single wave; stay out of danger areas until an official 'all-clear' has been issued.

Never go to the shore to watch a tsunami. If you can see it, you are too close to escape.

Remember to wait until the emergency authorities inform you it is safe to return to the affected area. Be careful, as strong waves, currents and abnormal sea levels may still affect some beaches, harbours and waterways for hours or even days afterwards.

STUDENT ASSIGNMENT

Tsunami case study: Chile tsunami

This tsunami followed an earthquake measuring 8.8 on the Richter Scale. The epicentre of the earthquake was 115 kilometres north-north-east of Concepcion.

The epicentre of this quake was 230 kilometres north of the largest earthquake ever recorded (9.5 magnitude in 1960). This quake was the result of movement between the Nazca Plate on the eastern side of the Pacific Ocean and the South American Plate. The first waves hit approximately 34 minutes after the earthquake. Properties and businesses were damaged and over 200 lives were lost.

The quake measured 8.8 on the Richter scale and triggered a devastating tsunami. The epicentre of this earthquake was about 279 kilometres north of the largest earthquake ever recorded (9.5 on the Richter Scale in 1960).

Where did the tsunami occur?

1. Visit the NASA website to see the location of the earthquake: Natural Hazards. Complete the following:

a. How far was the epicentre of the earthquake from the coastline?

b. Which plates were involved?

c. The tectonic plates near Chile meet in a subduction zone. Use a diagram to explain why earthquakes and tsunami can occur in such an area.

d. Describe the shape of the sea bed near the coast line.

2. Visit the NOAA website Chile 2010 tsunami and click on the map showing maximum wave amplitude (you will need to wait for this to appear on the screen before clicking and opening the map). This map is showing wave height and the time it took for the first wave to arrive (blue lines).

Compare Concepcion and Hawai'i in terms of

a. how long it took the tsunami to arrive

b. the height of the waves

3. How long did it take for the tsunami to have an impact on the other side of the Pacific Ocean along the east coast of Australia? How does this compare to the time it takes to fly across the Pacific? (You may need to do some research here or talk to someone who has made this trip).

What was the impact?

4. Read about and watch accounts of the earthquake and tsunami.

global post account of Chile tsunami-earthquake

CNN account of Chilean earthquake

market watch story after Chile quake

List the ways in which Chile was impacted by the earthquake and tsunami and present the information in the form of a table.

Social impacts (e.g. people, health, food)	
Environmental impacts (e.g. flora, fauna, air, water, terrain)	
Economic impacts (e.g. income, jobs business, government expenses)	
Other	

5. In what ways might people a long way from the earthquake/tsunami area be affected?

6. Response to the earthquake /tsunami

a. Investigate a range of aid organisations and news reports to find examples of the emergency response to the earthquake and tsunami. Your goal is to find examples of actions taken by Chilean authorities and actions taken by groups from other countries.

b. Of all the examples you have found which do you think is the most significant? Why do you think so?

STUDENT ASSIGNMENT

Tsunami case study: 2009 Samoa tsunami

At 6.49am an earthquake measuring 8.0 on the Richter Scale triggered this tsunami. The earthquake epicentre was located on the Pacific tectonic plate near its boundary with the Australian Plate approximately 200 kilometres south of Samoa.

Dozens of magnitude 4 and 5 aftershocks followed the initial earthquake, continuing through the next day. This area, near the Tonga Trench, is one of the most active earthquake regions in the world. The tsunami struck the islands of Savi'i, Upola, and Tutuila minutes later with waves that were approximately 3 metres high. Smaller tsunamis hit other Pacific islands farther away from the earthquake's epicentre.

The tsunami caused a great amount of damage to property and the natural environment and caused the deaths of over 100 people.

Samoa is an independent country with a population of approximately 220,000. Its neighbour, American Samoa, is a territory of the USA and has a population of approximately 66,000.

1 Where is Samoa?

Use your atlas or Google Earth to find the location of Samoa. Complete the following:

a. In which ocean is Samoa located?

b. What is the latitude of Samoa? Is this closer to the equator than the place where you live? How do you think the climate will compare to where you live?

c. How far is Samoa from the capital city of your state?

d. List all the countries that felt the impact of this tsunami? BBC News may assist.

e. Compare the population of Samoa to where you live.

f. Study a map of Samoa at worldatlas or lib.utexas maps and describe the topography (shape of the land) of the main islands.

g. How would the topography have helped people escape?

2 Why did a tsunami occur?

The location of the earthquake is shown at Natural Hazards.

a. How far was the epicentre (the dark circle) from the plate boundary?

b. How many aftershocks were there? How many were in each magnitude range?

c. Which two plates were involved in this earthquake? In which direction is each moving?

d. Check to see the current earthquakes in this region (South Pacific) at Earthquake Track or check the map of historical seismic activity. Would you say earthquakes are rare or common in this region? Provide evidence from the maps to support your answer.

e. Using a diagram explain how this earthquake leads to a tsunami.

f. Why does the wave become so large as it approaches the coastline?

g. Consider the location of the epicentre and the speed at which tsunami can move and suggest how much warning the residents might have received.

3 What were the impacts of the tsunami?

The tsunami was widely reported in news outlets. For example, it was reported in Britain on the BBC, in the USA on CNN, in Australia on the ABC, in Earth Science publications and in environmental publications such as p7 of Seagrass Watch.

a. Check these reports and list the impacts of the tsunami on people and the impacts on the environment.

b. What actions had saved many people?

c. Study the aerial images at https://disasterscharter.org/web/guest/-/tsunami-in-samoa-islan-9

(i) Describe the settlement pattern on the Samoan islands. How might this pattern increase the impact of a tsunami?
(ii) List the type of damage that occurred on the islands of Savai'I, Upolu and Tutuila.
(iii) Look at the summary images for Samoa and American Samoa. Using directions, describe where the islands were affected.

d. Use a graphic organiser to show the flow on effects of the tsunami.

(i) Look at your diagram and use a colour key to distinguish between short term impacts, midterm impacts and very long-term impacts.
(ii) Use symbols to classify impacts as social, environmental or economic.

Most Samoans work in the service sector (the other main sectors are manufacturing and farming). Tourism is an expanding part of the service sector. About 25 per cent of the nation's earnings (GDP) now come from tourism. Accommodation is often very close to the coastline. About 30 businesses on the south coast of Upola were destroyed by the tsunami. Facilities away from this region were not affected.

The government is encouraging tourists to visit Samoa. Why would they do this? Should tourists continue to visit Samoa? Provide reasons to support your answer.

Responses

The impact of this event included the destruction of buildings, crops and infrastructure (e.g. power, water supplies). This creates an immediate need for food, shelter and water. Clean-up and reconstruction can begin after the urgent immediate needs are met. Aspects such as safe water supplies, homes, roads, power and public buildings can be addressed. Employment opportunities may need to be created but residents may not have spare money to buy goods and services.

Many groups assisted Samoa after the tsunami. For example Oxfam, the Australian Government through AusAID , the World Health Organisation and Red Cross.

In pairs investigate one organisation each and compare their response to the tsunami. Investigation guidelines:

- Classify the organisation as global, national or local. Justify your choice.
- What did the organisation provide – money, expertise or provisions?
- Was the organisation focussed on short term or long-term assistance?
- How would you promote this organisation and encourage people to offer support?

Samoan tsunami

Complete the following word find activity.

P	A	C	I	F	I	C	T	J	O
A	P	I	A	O	N	O	R	T	H
G	I	N	T	O	D	A	E	U	A
O	S	T	T	D	O	R	M	E	F
P	V	O	L	C	A	N	O	A	T
A	A	U	L	I	U	A	R	R	E
G	E	R	N	T	S	S	U	R	R
O	R	I	C	H	T	E	R	T	S
W	O	S	N	A	R	M	I	H	H
A	S	M	R	O	A	D	W	Q	O
T	I	A	R	N	L	I	N	U	C
E	O	U	P	H	I	L	L	A	K
R	N	G	C	E	A	N	T	K	R
E	P	I	C	E	N	T	R	E	E

Clues

1. Best direction to run from a tsunami.
2. Capital of American Samoa.
3. Capital of Samoa.
4. Clean supplies of this are vital.
5. Damage to this will interrupt transport.
6. Direction in which Indo-Australian plate is moving.
7. Immediate need of those in affected areas.
8. Main business activity in Samoa.
9. Major cause of tsunami.
10. Movement of soil by tsunami wave.
11. Possible cause of a tsunami.
12. Scale used to measure the strength of an earthquake.
13. Slight movement of ground.
14. Tectonic plate involved in many earthquakes.
15. Tectonic plate that contains Australia
16. The point where an earthquake started.
17. Tremor following the main earthquake.

Solution – using left over letters. What does JATWC stand for?

STUDENT ASSIGNMENT

Tsunami case study: 2007 Solomon Islands tsunami

On 2 April 2007 an earthquake measuring 8.1 on the Richter Scale had its epicentre 350 kilometres north-west of Honiara. The earthquake occurred in shallow water in the early morning and was quickly followed by a tsunami.

The waves were up to 10 metres high. Over 50 deaths were reported, and thousands of people were left homeless. A tsunami warning was issued for Australia and Alaska 15 minutes after the earthquake.

1. a. How would being located on the Ring of Fire increase the chance of being affected by tsunami?

   b. When was the most recent earthquake in the Solomons?

Impact

2. The tsunami was reported in news outlets in many countries including Australia via New Zealand (NZ Herald) and Britain through the BBC.

Read the reports and produce a dot point summary of the following:

a. the impact of the tsunami

b. aspects that made recovery difficult.

3. Many villages were not able to withstand the energy of the waves as can be seen on National Geographic.

Study the photos of the village and describe each of the following:

a. the height of the village above sea level

b. the shape of the land

c. the structure of the buildings

d. the chances of the land being affected by daily tides.

4. Locate a map of the Solomon Islands. Annotate the map to show the following effects of the tsunami:

Note: you may need to add some of the islands to your map as there are nearly 1000 small islands in the country and it is difficult to show them all on a map.

- the earthquake epicentre was only 45 kilometres from Ghizo island
- 300 houses destroyed on Choiseul island
- four people missing on Mono island
- waves seen 200 metres inland on Simbo island
- Ranunga island also hit
- water reached 50–70 metres inland on Ghizo
- large boats had been washed ashore and were lying in the middle of the town of Gizo on Ghizo Island
- most affected islands were Ghizo, Simbo and Choiseul
- others affected included Shortlands, Killivrae, Vella la Vella, Rendova and Ranungga.

5. Use distance and direction to describe the damage pattern.

6. Study the wave height distribution map provided by National Oceanic and Atmospheric Administration to identify at least 3 other countries that felt the effects of the tsunami.

Responses

The importance of understanding tsunami was shown in January 2010 when an earthquake of magnitude 7.2 led to a tsunami that particularly impacted the island of Rendova. The three-metre wave ruined the homes of a thousand people but there was no loss of life. People knew the warning signs (the shaking, the noise and drawdown of the ocean) and quickly fled to high ground. This is a good example of how communities can learn from situations and be better prepared in the future.

7. If you were holidaying on a beach in the Pacific what are the key things to remember to avoid being affected by a tsunami?

8. The Australian Government provided assistance through its aid agency AusAID. Find examples of assistance that was aimed at:

- improving health
- providing shelter
- improving management
- assisting transport.

9. Are these examples from the emergency response stage, the recovery stage or preparation for the future?

10. Australian Red Cross organisation continued to work in the Solomons. On the Red Cross website they could report on many activities they had undertaken. Describe two examples of projects that will help communities cope with tsunami in the future.

11. The United Nations produces many maps to provide information to humanitarian relief organisations. Choose all tsunami maps and study a map of damage on Ghizo. Describe the extent of:

- coastal damage
- building damage
- road damage
- standing flood water.

To help with your description refer to direction, distance and closeness to the coast. Words like concentrated, linear and scattered may also help.

12. How would information provided on the map be useful for emergency workers?

STUDENT ASSIGNMENT

Tsunami case study: 2004 Indian Ocean tsunami

This event was one of the most devastating caused by a natural hazard in recent years.

The earthquake that triggered the tsunami occurred west of the Indonesian island of Sumatra and measured 9.0 on the Richter Scale, making it the largest earthquake worldwide in 40 years. The death toll in March 2005 was over 273,000 people.

a. How did the earthquake and tsunami occur?

Refer to the images and text at Natural Hazards.

Study the colour map and read the general introduction at this site.

1. Draw a sketch map of the region affected by the tsunami.

2. Name the countries that were affected. Use an atlas to record the distance these countries are from the epicentre.

3. The movement of which plates were involved in this earthquake? Along what distance did the movement occur? What was the vertical change on the sea floor? Draw these plates on your map.

4. Name some of the countries and islands that 'sit' on the India Plate.

5. Name some of the countries and islands that 'sit' on the Burma Plate.

6. How does the Sunda plate impact on the Burma Plate?

7. What was the wave height at Sumatra, Thailand, Sri Lanka and Somalia?

b. How long did it take for the tsunami to travel to different areas?

Visit Relief Web. There is also an animation at Bureau of Meteorology – Tsunami facts and information and a map showing travel time at Bureau of Meteorology - Travel Times for Indian Ocean Tsunami.

1. Study the maps and name up to three countries that experienced tsunami waves at each hour. Use an atlas and the maps to record this information in the following table.

Tsunami travel time (hours)											
1	2	3	4	5	6	7	8	9	10	11	12

2. Where do you expect the greatest impact would occur and why?

3. Use an atlas to locate three places on the Australian coastline that might have felt the greatest impact. Justify your choices.

4. Use the scale on an atlas map to calculate the furthest coastline the tsunami wave travelled (as shown on the map at this site).

5. Describe the main direction this tsunami wave travelled. How did this movement relate to the overall impact on various countries?

6. Use an atlas to name four locations that experienced a tsunami wave greater than four metres in height. What size were the waves that reached the Australian coastline?

C. What was the impact of the 2004 Indian Ocean tsunami on people and environment?

The sets of photographs at this site December 2004 Tsunami photos before and after are useful for observing changes in one location over a period of time (before and after the December 2004 tsunami). The physical changes caused by this natural event are evident and can be looked at in detail and mapped.

Students should be able to recognise the following features in the images:

- coastal features
- relief
- drainage
- vegetation
- land use (urban and rural)
- transport systems.

Creating and analysing overlay maps

Creating map overlays is a useful method of looking at the extent of change over time. This requires one sheet of unlined paper, one sheet of tracing paper, pencils and clear adhesive tape.

1. Look at the 'before' image of Set 1: Kalutara Beach in Sri Lanka December 2004 Tsunami photos before and after. If you are able, print this image either in colour or black-and-white; otherwise sketch from the image on the screen. Use this print or sketch to draw a map of Kalatura Beach on the unlined paper. You will need to label features such as the coastline and beach, main roads, general areas with housing and vegetation areas. Use colours to distinguish the areas and add this information to your legend.

2. Estimate the scale of this map. Use something known that you can estimate, such as the main road in the top right part of the image. How wide might this road be if there needs to be space for two cars to pass each other, plus some room either side? Can you measure a road near you as a suitable comparison? Once you have done this, use your ruler and some measurements to calculate a scale for the map you have drawn. If you think the road is five metres wide, and you measure the width as two millimetres, then the scale is 2 millimetres = 5 metres. A better way to write this will be 1cm : 25m. Check some features on the image (such as some houses) to see if this is reasonable.

3. Use your scale to measure the following: width of the beach in three locations; the size of the sand dunes in the lower half of the image.

4. Write an appropriate title for your map.

5. Now click on the satellite image to see the same location as the tsunami wave recedes from the coast. Use the tracing paper to draw the changes along the coastline: draw a line to show how far the water has receded; colour and label the sandy areas that have been washed away from the coast.

6. Use adhesive tape to place the tracing paper over the first map, making sure the same areas line up.

7. Use the scale to estimate how far the water has receded. How far has sand been washed out to sea? Compare this image with the second and third set of the same location. Which image do you think shows the area before the wave hit? Outline the evidence you have for this.

8. Look at the images of Kalutara Beach in set 4. Describe the changes that have occurred. Describe the new or altered landforms and features. Have any buildings disappeared in the second image? How many? Where were they located?

9. Write a summary statement about the physical changes at Kalutara Beach caused by the tsunami.

10. Group work

There are 16 other sets of images showing various locations before and after the tsunami.

Set 5, 6, 7, 8, 9, 10, 11 Banda Aceh (8, 9, 11 difficult)

Sets 12, 13, 14 Gleebruk Village, Indonesia (50km from Banda Aceh)

Sets 15, 16, 17, 18, 19 and 20 Meulaboh, Indonesia

Allocate different sets of images amongst the class. Create another overlay map of the image you have been allocated, showing the changes that have occurred. Ensure you have a clear legend, title, scale and source. Write a summary paragraph describing the changes that have occurred at this location as a result of the tsunami.

Further images

The following satellite images represent tsunami impact at other locations. You can see a very high-resolution picture by clicking on the image.

1. The town of Lhoknga, on the west coast of Sumatra near the capital of Aceh, Banda Aceh can be found on Earth Observatory NASA.

    a. Describe the impact of this wave on buildings, trees, other vegetation, beaches and agricultural areas.

    b. It is estimated that, in some locations, the tsunami may have reached up to 15 metres in height when it hit the coast. Compare some buildings around you with this height. What do you think would happen if a 15-metre tsunami hit your location?

2. The satellite images of Gleebruk in Indonesia can be analysed using mapping techniques. Work in pairs and choose one of these to complete the following activity.

    a. The town of Gleebruk, located roughly 50 kilometres (31 miles) from Banda Aceh can also be found at Earth Observatory NASA.

3. This image is of Meulaboh, Indonesia on January 7 at Earth Observatory NASA. Meulobah is located 95 kilometres from the epicentre of the earthquake. The tsunami completely washed over this peninsula.

4. Impact at the beaches of Khao Lak, Thailand at Earth Observatory NASA. The high-resolution image shows evidence of tourism at this location. This is a popular holiday location with people from Northern Europe. Note the before and after appearance of the beaches.

If you can, print a copy of both of these images (preferably in colour) and complete the following (high resolution images can be gained by clicking below the photographs; it is possible to open both images and compare them against your maps):

a. Trace a copy of this area before the tsunami. Label the following:
    - beach
    - river
    - agriculture (orchards, aquaculture)
    - road and bridges
    - buildings.

b. Now complete a second tracing showing the same area after the tsunami. Annotate this sketch with descriptions of the changes to the area.

c. Estimate number of buildings destroyed.

d. Is there evidence of higher ground? Describe this evidence.

e. Write a summary describing the impact on people and the environment.

5. Read the impact on individual countries BBC impact page for each country.

a. For each of the countries listed note the social (people) and economic (money) impacts.

b. Which country/regions suffered the greatest impact? Outline the relationship between their location and degree of impact.

d. Other environmental impacts

Environmental changes include the major changes in the tectonic plates as covered in part A and the changes to the landscape mentioned in Part C.

Find out about other environmental impacts by reading Wikipedia Indian Ocean earthquake and New Scientist

1. Outline the environmental impacts mentioned.

2. What action can be taken to remedy each environmental problem? How long might this take to achieve (short/medium/long term)? Justify your answer.

3. Which do you think will suffer the greatest impact from a tsunami: a small, steeply-sloped island; a coral island surrounded by a barrier reef; or a low-lying island?

e. Economic impacts

Read the following descriptions from the BBC and Note on South Asia Tsunami to discover the impacts resulting from the tsunami.

1. Outline the economic impacts on this region. Think about the ability to fund rebuilding work, the impact on economic growth and employment opportunities.

2. Which country do you think has been worst hit? Why?

3. Which of the impacts do you think need to be overcome first? Justify.

f. How did the Indian Ocean tsunami impact Australia?

All low-lying coastal areas can be affected by tsunami. A tsunami is recorded on average in Australia every two years, but they are usually too small to be noticed by people.

The threat of tsunami in Australia is low for most of our coastline. There is a medium threat along the northern half of the coastline in Western Australia.

The last tsunami to be noticed in Australia was in 1994 along the northwest coast, following an earthquake in East Java. The biggest ever was recorded at Cape Leveque, Western Australia in 1977. No one was injured by these waves.

Optional activity:

Learn more about the impact the Indian Ocean tsunami had on the Western Australian coastline.

1. Research reasons why the travel speed of 1000 kph slowed down before reaching the coastline.

2. Many locations around this coastline experienced very different wave effects. List some of the differences in the coastline which resulted in more or less wave impact.

3. Go to website http://www.bom.gov.au/tsunami/info/#dec26. Which four locations experienced the greatest wave activity? Describe how these waves might have an impact on the coastline.

4. How might the main direction of the tsunami have resulted in less impact on Australia?

5. Refer to an atlas map showing the Western Australian coastline. Draw a sketch map of this coastline. Now record the time that the tsunami arrived at various coastal locations by going to tsunami arrival time.

g. Summary

Work in groups to summarise the impact of this tsunami by creating a consequence wheel to show the impact of the tsunami on people and the environment. Write the word tsunami in the middle of the wheel. Write the words environmental, social, economic and political extending from the centre. Continue building on this wheel, adding information as you develop the wheel.

STUDENT ASSIGNMENT

My tsunami project

Knowledge

Build a glossary of at least 25 words related to tsunami. For each provide your own definition and the context in which it would be used. You may also like to include a diagram to help explain the term.

Example: Wave length is the distance between the crests of two waves. In the case of a tsunami it is very long – maybe 100 kilometres, which means you have to be aware that there can be some time between waves reaching the shore.

Understanding

Produce an informative, well labelled flow chart to explain the development of a tsunami.
Use a visual organiser to list the many consequences of a tsunami. Classify these consequences according to the following categories:

- Category A: social or environmental or economic.
- Category B: short term or long term.
- Category C: small scale or large scale.

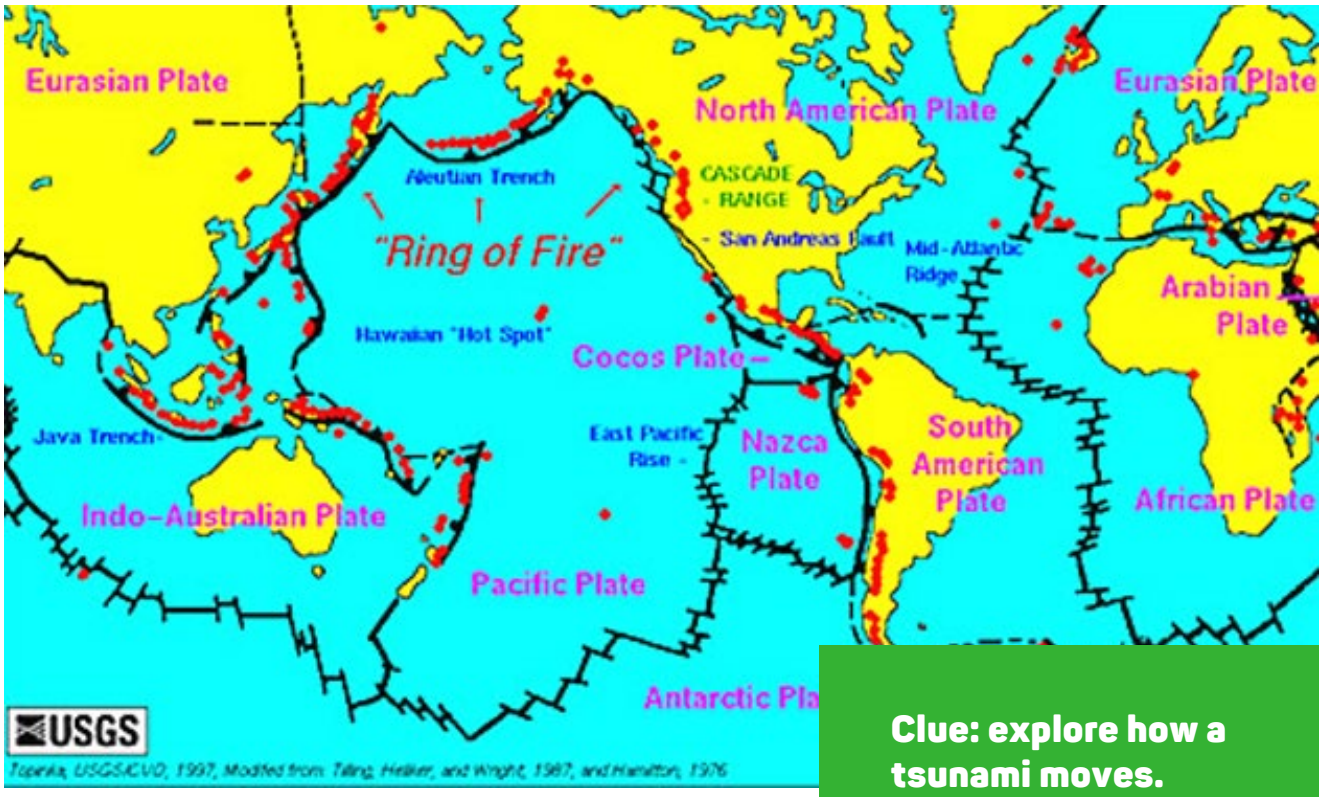
Look carefully at your finished diagram.

- Describe what you observe about the consequences in category A.
- Describe what you observe about the consequences in category B.
- Describe what you observe about the consequences in category C.

Application

Imagine that a severe earthquake has occurred between the Pacific and Nazca Plates – deep in the Pacific Ocean. As a tsunami expert, you need to map out a possible path of the tsunami. Use the map below and show the following:

- the tectonic plate/plates involved in the earthquake
- where the waves would spread to
- a site where the waves will be very large
- a site where the tsunami will be barely noticed.



Clue: explore how a tsunami moves.

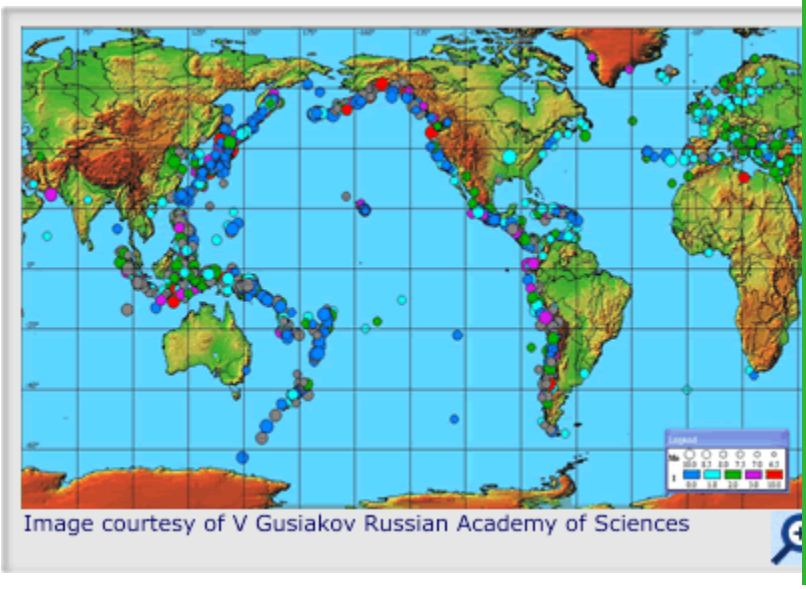
Name the countries that would be affected and show at least two on the map. Is Australia in the path of the waves?

Imagine you are holidaying in the affected region. Outline your action plan. What would be your key advice for the community? Justify.

Real life tsunami stories

Tsunamis can happen in any of the world's oceans, however, most occur in the Pacific and Indian Oceans.

Pacific Ocean



This map shows that tsunami occur frequently in the Pacific Ocean. This region is sometimes called the Ring of Fire because this is where most of the seismic activity in the world takes place.

The map shows the location, size and intensity of over 2000 tsunami events that have occurred since 1628 BC. The colour of the circle shows the tsunami intensity. The larger the circle, the greater the event. Most tsunami have been generated along the active tectonic plate boundaries:

Pacific Ocean

The most significant tsunami recorded in the Pacific Ocean are:

- Chile, 2010: An earthquake of magnitude 8.8 on the Richter Scale triggered a tsunami that caused more than 300 deaths and affected millions of people.
- Philippines, 1976: An earthquake caused this tsunami. There were 8,000 deaths.
- Chile and Hawaii, 1960: A series of earthquakes caused this tsunami. There were 2,300 deaths in Chile and 61 deaths in Hawaii.
- Hawaii and Alaska, 1946: This tsunami was caused by an earthquake on Unimak Island, Alaska. Waves up to 35 metres high caused 165 deaths.
- Japan, 1896: A 30 metres wave generated by an earthquake caused 27,122 deaths and destroyed 280 kilometres of the coastline.

Indian Ocean

Tsunami are not as common in the Indian Ocean because the seismic activity is less than in the Pacific Ocean. However, there have still been many major tsunamis recorded in this region:

- **Sumatra, 2004:** This tsunami was caused by an earthquake off the Indonesian island of Sumatra. Tsunami waves up to 25 metres caused more than 225,000 deaths. Five million people across 18 countries were affected.
- **Pakistan, 1945:** An earthquake in the Gulf of Oman caused a tsunami with 13 metres waves in which 4,000 people died.
- **India, 1941:** Five thousand people were killed by the tsunami that was caused by an earthquake.

Key case studies

Chile tsunami, 27 February 2010

This tsunami followed an earthquake measuring 8.8 on the Richter Scale. The epicentre of the earthquake was 115 km north-north-east of Concepcion. The epicentre of this quake was 230 km north of the largest earthquake ever recorded (9.5 magnitude in 1960). This quake was the result of movement between the Nazca Plate on the eastern side of the Pacific Ocean and the South American Plate. The first waves hit approximately 34 minutes after the earthquake. Properties and businesses were damaged and over 200 lives were lost.

Samoa tsunami, 29 September 2009

At 6.49 am an earthquake measuring 8.0 on the Richter Scale triggered this tsunami. The earthquake epicentre was located on the Pacific tectonic plate near its boundary with the Australian Plate approximately 200 km south of Samoa. Dozens of magnitude 4 and 5 aftershocks followed the initial earthquake, continuing through the next day. This area, near the Tonga Trench, is one of the most active earthquake regions in the world. The tsunami struck the islands of Savi'i, Upola, and Tutuila minutes later with waves that were approximately 3 m high. Smaller tsunami hit other Pacific islands farther away from the earthquake's epicentre. The tsunami caused a great amount of damage to property and the natural environment and caused the deaths of over 100 people.

Solomon Islands tsunami, 2 April 2007

On 2 April 2007 an earthquake measuring 8.1 on the Richter Scale had its epicentre 350 km north-west of Honiara. The earthquake occurred in shallow water in the early morning and was quickly followed by a tsunami. The waves were up to 10 m high. Over 50 deaths were reported, and thousands of people were left homeless. A tsunami warning was issued for Australia and Alaska 15 minutes after the earthquake.

Indian Ocean tsunami, 26 December 2004

This event was one of the most devastating caused by a natural hazard in recent years. The earthquake that triggered the tsunami occurred west of the Indonesian island of Sumatra and measured 9.0 on the Richter Scale, making it the largest earthquake worldwide in 40 years. The death toll in March 2005 was over 273,000 people.

Tsunami: The Ultimate Guide

This is a comprehensive, interactive resource that provides everything you need to know about tsunami and the threat in Australia. It has been produced by the Australian Tsunami Advisory Group – the experts in tsunami in Australia – and is arranged into six chapters.

It presents authoritative and engaging information in a highly visual manner with a focus on videos, animations, maps, graphics and interviews with experts. It's easy to navigate with intuitive functionality. Interactive slideshows and timelines allow multiple points of entry to the information. The resource includes three case studies: 2004 Indian Ocean tsunami, 2010 Chile/Hawaii tsunami and 2011 Japan tsunami.

An ideal teaching resource, Tsunami: The Ultimate Guide is aligned to the geography and science curriculums. Available at: https://knowledge.aidr.org.au/resources/the-ultimate-guide-tsunami

DURATION :
Suggested time: seven hours over a number of days

Tsunamis are natural events that impact people and places, especially in the Pacific Ocean and Indian Ocean regions.

The impacts are felt not only at the place or places where a tsunami hits the land but also across the marine environment. A tsunami can have a devastating impact on local residents at specific locations; tourists/visitors to an area can also be impacted.

Managing the impacts on people and places when a significant event occurs requires a global response. Australia is at the forefront of such responses given its location on these ocean edges. The interconnection of research within Australia and globally assists communities in at-risk regions to be prepared and to minimise the harmful effects.

a

What is a tsunami?

DURATION :
40 minutes

Geographical concepts: Environment, place, scale

Aim: To look at **Tsunami: The Ultimate Guide** and study the models that show the formation of a tsunami and the scale of the wave.

Australia experiences a tsunami once every four years, on average. Most Australians are unaware that the country experiences such a hazard with such regularity.

Activity 1: What is a tsunami?

- Show students **Tsunami Basics Slide 2** and discuss any terms that are not understood by the class, such as inundation. Use the image to talk about the scale of the wave. Assume the man is two metres tall or the palms are 10 metres tall. The palms and clothing also give some indication as to the environment where the tsunami took place. Discuss the reaction of the people on this slide.
- **Tsunami Basics Slide 18** explains how a tsunami wave is different from the usual waves in the ocean environment and is formed on the ocean floor as a result of earthquake activity. Play the video (1:15mins) which has excellent diagrams to show the wave development.
- Follow this by showing the animation on **Tsunami Basics Slide 14** (2:13mins) of the wave moving to the coastline and making an impact on the land.
- To check knowledge and understanding ask students to draw a diagram of the way a tsunami wave is formed and its movement. Terms to include on the diagram include: ocean floor earthquake; energy movement; wave generated; wave travels at up to 220 kilometres per hour; wave meets sea floor; energy contained and intensified; wave inundates land; wave draws back, and a further wave occurs. When the diagram is complete, check that students provide it with a suitable title and it is within a border.

b

How are places connected to the tsunami event?

DURATION :
50 minutes

Geographical concepts: Environment, place, scale

Aim: To look at **Tsunami: The Ultimate Guide** and study the models that show the formation of a tsunami and the scale of the wave.

Activity 2: How are places connected to the tsunami event?

- Show students **Tsunami Basics Slide 13** and discuss the location of earthquakes around the world. Encourage students to form an opinion as to where most earthquakes occur – seek a generalisation and then any exceptions. Some students will notice the plate tectonic boundaries and use this as part of their description.

  Ask students to compare this map with **Tsunami Basics Slide 17** which maps the tsunami risk zones. Do students see any similarities or differences?

- With the aid of an atlas, students should complete a timeline of the tsunami events shown and name the places (countries) where tsunamis have occurred. This can be completed in a tabular format, such as has been set out in the following table:

DATE	PLACE (COUNTRY)	OCEAN	REGION
1906	Ecuador	Pacific Ocean	South America
1952			

Using this table, students should then answer the following questions:

- Which ocean has experienced the most tsunami events?
- Which region has experienced the most tsunami events?
- How has the location of these significant events changed since the 1950s and 1960s?
- Which continents of the world are more at risk of tsunami events than other continents?

- Tsunami Basics Slide 20 shows how the energy of the tsunami wave from the 2011 Japanese tsunami spread across the oceans connecting places to the significant event. With the aid of an atlas, students should:
    - Record how long it took the energy impact to be felt on the coastline closest to where you live.
    - Name three countries that experienced the tsunami wave after five hours.
    - Name three countries that experienced the tsunami wave after 10 hours.
    - Name three countries that were waiting to see how the tsunami would impact after 15 hours.
    - Suggest why Papua New Guinea felt a greater impact of the tsunami than did northern Australia.
    - Explain why the west coast of North America was at greater risk than the west coast of South America.

C What impacts can a tsunami have on people and places?

DURATION :
2 hours over a number of days

Geographical concepts: Environment, place, space, interconnection, change

Aim: To look at Tsunami: The Ultimate Guide to study three significant tsunamis in the 21st century and understand the impact of the waves' energy on people and places.

The tsunami wave breaks as it nears land, inundates (floods) the land causing destruction of buildings and transport infrastructure as well as affecting people who can be swept away by the force of the water. Usually there is more than one wave generated. The impact can cost millions of dollars, high death tolls and long time periods to repair. Tsunami: The Ultimate Guide provides details on three recent tsunami events – Indonesian, Chile and Japan.

Activity 3: What impacts can a tsunami have on people and places?

Divide the class into groups of students so that for each tsunami event one group should study the impact on people; another group the impact on places. Groups should be about four students in size.

Work with (guide) the class to decide on the questions to be asked about each tsunami event. Questions could use the '5 Ws' thinking process – what, why, where, when and what if.

When the research is completed those groups studying the same tsunami should come together to pool their understanding and present their information as a short skit ensuring that the essential information is conveyed. These presentations could be done as interviews of eye witnesses, reporting for the news, community leaders informing the local people etc. The class presentations should encourage the use of technology.

Here is a guide to where students should search **Tsunami: The Ultimate Guide** to find relevant data:

- Indian Ocean 2004 – Preparing for **Tsunami Slide 12; Slide 13** (look at the videos on each segment of slide); **Slide 10**
- Chile 2010 – Marine Threat **Tsunami Slides 2-4** (look at the videos on each segment of slide)
- Japan 2011 – Land Threat **Tsunami Slides 4-5** (look at the videos on each segment of slide).

d How do people in Australia connect and respond to the significant event?

DURATION :
1 hour, includes the extension activity

Geographical concepts: Environment, place, scale, interconnection

Aim: To look at **Tsunami: The Ultimate Guide** and consider the impact of tsunamis on Australia and Australians thinking about tsunamis.

The Bureau of Meteorology says there have been more than 50 tsunami events around Australia's coastline since 1788. Fortunately, the impact of these has not been as great as in other parts of the world. Nevertheless, Australians at home, and especially while travelling overseas, should be aware of the potential for a tsunami event and know how to respond if necessary.

Activity 4: How Australians connect to a significant event, like a tsunami?

- **Australian Tsunami Impacts Slide 11** lists the significant tsunami events in Australia's history (1805-2011). Ask students to study this slide and respond to the following questions:
    - In which time period do there seem to be most significant tsunami events?
    - Which states of Australia are more prone to the impact of tsunamis?
    - How does the state in which you live rate as at risk of impact from a tsunami?
    - Where do most of these tsunami risks seem to have their source (begin from)?
    - Describe the impacts on people, property and places along the Australian coastline.
    - Is Australia at more or less risk than other places in the world? Refer to **Australian Tsunami Impacts Slide 2 and Slide 7** to support your answer.
- Steep Point on Shark Bay, Western Australia experienced flooding from a tsunami in 2006. **Australian Tsunami Impacts Slide 10** provides data on this event. Do you rate this event as significant compared to other tsunami events worldwide? Explain your answer.

Extension activity

After the Indian Ocean tsunami (2004), Australians responded to the plight of the Asian people with the donation of funds and the provision of man power. Undertake an Independent Inquiry, using the Internet, to write a paragraph to show how Australia and Australians supported the local people of Indonesia, Sri Lanka, Thailand and the many islands affected by the series of tsunami waves.

e How does global research help manage these significant events?

DURATION :
1 hour

Geographical concepts: Place, scale, interconnection, change

Aim: To look at **Tsunami: The Ultimate Guide** to see the various methods used by the authorities in Australia and overseas to detect, evaluate and monitor tsunami events.

A range of tsunami experts are interviewed who show how the tsunamis are detected and monitored across the oceans, so that warning systems can be activated in time to reduce the risk to people and places.

Activity 5: How does global research help manage these significant events?

- Use **Warning System Slide 3** (1.39mins), and any of the other slides that give details, to create a flow diagram for Australia's warning system.
    - Start with the identification of a potential tsunami event – **Warning System Slides 5-6**
    - show the Australian authorities – Joint Tsunami Warning Centre (Bureau of Meteorology Melbourne, Geoscience Canberra) – **Warning System Slides 7-8**
    - the warnings given (no threat, watch, warning) – **Warning System Slide 9, Slides 15-17**
    - equipment used to detect if tsunami waves are occurring – **Warning System Slides 11-14**.
- Using **Warning System Slides 6, 12 and 14**, and a base map of the world (Pacific Ocean complete), ask students to shade the areas where earthquake (seismic) monitoring equipment is operational, where deep-ocean stations exist, and where coastal stations can be found. Each aspect should be coloured individually, a key should be provided, a title developed to express the aspects shown and the source of the information noted. Check that the map has BOLTSS – border, orientation (north indicator), legend (key), title, scale, and source.

- Describe the spatial distribution of the warning systems set up across the world. Spatial distribution is the way in which a phenomenon is spread across space. Use place names, names of continents, latitude and/or plate tectonic boundaries to help describe the pattern.

f

Would you know what to do if a tsunami occurred near you?

DURATION :
1.5 hours

Geographical concepts: Environment, place, scale, interconnection, change

Aim: To look at Tsunami: The Ultimate Guide to share an understanding of tsunamis with a group of Australians perhaps unaware of the term 'tsunami'.

Although severe tsunamis are rare to Australia, nevertheless Australians at home, and especially those travelling overseas, should be aware of the potential for a tsunami event and know how to respond if necessary.

Activity 6: Be alert, act quickly

Tilly Smith, an English school girl holidaying in Thailand on December 26, 2004, reacted appropriately with the lessons learnt at school. Listen to her tell of her experience on Preparing for Tsunami Slide 10 (video 5:08mins).

- Divide the class into groups (3-4 maximum size) and ask them to prepare a poster for a specific audience on their knowledge of tsunamis and how to respond should you find yourself in such an environment. The theme be alert, act quickly should be the focus of the presentation. Other aspects to include are tsunami signs (feel, see, hear), warning levels, distances to move and heights to climb, and evacuation signage.

  Preparing for Tsunami Slides 1-11 provides information to assist with this task.

  A group could create a poster for Foundation year students; for a school display targeting families about to holiday overseas in Asia or along Australia's coastline; for a community centre display etc.

- Each group of students should evaluate the effectiveness of their presentation by seeking the opinions of members of their audience, from class members and by a self-evaluation having compared their own work with that of other groups. This evaluation should be written as a paragraph highlighting the positive aspects of their presentation, the challenges faced in preparing the presentation and suggested ways in which the presentation could be improved.

Related links

Geoscience Australia, 'What is a tsunami'
http://www.ga.gov.au/scientific-topics/hazards/tsunami

International Tsunami Information Center
http://itic.ioc-unesco.org/index.php

Geoscience Australia, Major historic tsunami
http://www.ga.gov.au/scientific-topics/hazards/tsunami/reports

Bureau of Meteorology, Tsunami information
http://www.bom.gov.au/tsunami/info/index.shtml

Pacific Tsunami Warning Center
http://ptwc.weather.gov/

Bureau of Meteorology, Australian Tsunami Warning System
http://www.bom.gov.au/tsunami/about/atws.shtml

/ End.

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