

# **Tsunami Case Studies Activities**

Attorney-General's Department 2010

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## Chile tsunami 27 February 2010

On the 27 February 2010 an earthquake occurred in the Pacific Ocean 115 kilometres north, north east of Concepcion. 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](#)

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.

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

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

**Response to the earthquake /tsunami**

6a. 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?

# Samoa tsunami 29 September 2009

The earthquake that triggered this tsunami measured 8.0 on the Richter scale and its epicentre was approximately 200 kilometres south of Samoa. [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.

- 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 [Earthquakes Hazards Program](#) or check the map of historical seismic activity at [Earthquake Centre](#). 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

<http://www.disasterscharter.org/web/charter/activations>

- (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.

e.

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 Upolu 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 return to 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. Cleanup 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](#).

a. 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?

## Samoaan Tsunami

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 IndoAustralian 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?

## Solomon Islands tsunami 2 April 2007

The Solomon Islands are located on the Ring of Fire in a region that often experiences earthquakes. On 2 April 2007 an earthquake measuring 8.1 on the Richter scale had its epicentre 350 km NW Honiara. The quake occurred in shallow water at 6.40am and was quickly followed by a tsunami. Many people saw sea receding and immediately fled to higher ground. The waves were up to ten metres high. Over 50 deaths were reported and thousands were left homeless. A tsunami warning was issued for Australia and Alaska 15 minutes after quake.

**1a.** How would being located on the *Ring of Fire* increase the chances 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 [ABC](#), New Zealand via ([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 45km 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?

## **Indian Ocean tsunami, December 26, 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 quake worldwide in forty years. The death toll in March 2005 was over 273 000 people, with many still missing.

### **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 Asian tsunami on people and environment?

The 20 sets of satellite photographs at this site

[<http://homepage.mac.com/demark/tsunami/>] [Webmaster Tony Demark at [demark@mac.com](mailto:demark@mac.com)] are very useful to study the change in as the same location over 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 on the satellite 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 [<http://homepage.mac.com/demark/tsunami/>] [Webmaster Tony Demark at [demark@mac.com](mailto:demark@mac.com)] 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 Kalutara 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 2mm = 5 metres. A better way to write this will be 1cm: 25 metres. 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 km (31 miles) from Banda Aceh can also be found at [Earth Observatory NASA](#).

3. This image is of Meulaboh, Indonesia on Jan 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

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.

Read [Seismicity of Western Australia](#) to learn more about the impact the Indian Ocean tsunami had on the Western Australian coastline.

1. Why did the travel speed of 1000 kph slow 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 [Transport WA Gov](#) to see the graphs measuring the wave heights on and after December 26, 2004. 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.

## Papua New Guinea tsunami 17 July 1998

In July 1998, an earthquake off the north coast of Papua New Guinea caused a tsunami at Aitape Village resulting in the loss of 3000 lives.

1. Go to <http://omzg.sccc.ru/tsulab/19980717.html> [Webmaster: [gvk@omzg.sccc.ru](mailto:gvk@omzg.sccc.ru) ] and click on *location map* and *source area*. Describe the location of the earthquake and tsunami.

2. Click on *travel time map* and describe how far the waves from this tsunami travelled?

3. Click on *historical tsunamis* and scroll down to the vertical profile. How does the sea bed and coastal profile intensify a tsunami event in this location? Why would tsunami waves be very dangerous along this type of coastline?

4. Click on *damage* and visit [http://www.ga.gov.au/urban/factsheets/tsunami\\_png.jsp](http://www.ga.gov.au/urban/factsheets/tsunami_png.jsp) [Webmaster: [webmaster@ga.gov.au](mailto:webmaster@ga.gov.au) ] and describe the damage in this area

5. To look at a 3D view of how the earthquake caused the tsunami, go to <http://www.drgeorgepc.com/Tsunami1998PNG.html> [Webmaster: [itmc@pixi.com](mailto:itmc@pixi.com) ] and scroll down to *plate tectonics*. Also read the conclusion at this site to see what has been recommended to save lives in case of future tsunamis. Discuss the reasoning behind this suggestion and its likelihood of occurring.