Australian Government
Attorney-General's Department
Emergency Management Australia

EMA Schools Education

Tsunami Activity Sheet
No. 3

Whats the impact of a tsunami on people and the environment?

3. What is the impact of a tsunami on people and the environment?
A tremendous amount of energy is released on impact when a tsunami reaches the coast. Each cubic metre of water weighs about one tonne. Several thousands of cubic metres of water can be washed up on affected coastlines. If a tsunami strikes and people have been warned and evacuated, the number of deaths and injuries are low or even non-existent. In this case, buildings and other structures can be damaged or destroyed and, often, large areas of land become contaminated with sea water. When there is little or no warning, many deaths can occur.

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 tsunamis 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 275 000 people, with many still missing.

How did the earthquake and tsunami occur? http://geo-world.org/tsunami/

Read the general introduction at this site.

1. How does the size of this earthquake compare to others in history?
2. Draw a sketch map of the region affected by the tsunami.
3. Name the countries that felt the quake. Use an atlas to record the distance these countries are from the epicentre.

Click on **causes** and **graphics** and read the information.

1. The movement of which plates were involved in this earthquake? Along what distance and to what depth did the fault move? Draw these plates on your map.
2. Name some of the countries and islands that "sit" on the India Plate.
3. Name some of the countries and islands that "sit" on the Burma Plate.
4. How does the Sunda plate impact on the Burma Plate?
5. Use the graphic of the wave and the height of the figure to estimate the height of the waves in each of the three locations.

Another image showing the plates involved is at the **Earth Observatory** site http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12640

1. Work in groups of three. Look at the photograph of part of Banda Aceh.
2. Print this photograph (using a colour printer, if possible).
3. Now compare it to the same area after the tsunami.
4. How many buildings were in the area shown by the photograph?
5. How many can you see standing after the tsunami?
6. What other features have disappeared?

How long did it take for the tsunami to travel to different areas?
http://staff.aist.go.jp/kenji.satake/Sumatra-E.html

1. What do the red dots represent?
2. Name 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**

3. Where do you expect the greatest impact would occur and why?
4. Use an atlas to locate three places on the Australian coastline that might have felt the greatest impact. Justify your choices.
5. Use the scale on an atlas map to calculate the furthest coastline the tsunami wave travelled (as shown on the map at this site).

This **animation** http://staff.aist.go.jp/kenji.satake/animation.gif shows the extent and movement of the tsunami in part of the Indian Ocean.

The **Indian Ocean colour map images**
http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12645 show the tsunami wave height and wave travel times.

1. Describe the main direction this tsunami wave travelled.
   How did this movement relate to the overall impact on various countries?
2. Use an atlas to name four locations that experienced a tsunami wave greater than 4 metres in height. What size were the waves that reached the Australian coastline?

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

The **20 sets of satellite photographs** at this site
http://homepage.mac.com/demark/tsunami/ are very useful to study the change in as the same location over time (before and after the Indian Ocean 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/

2. 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.

3. 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 millimeters, 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.

4. 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.
   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.

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.

It would be beneficial to display the completed overlay maps in the classroom so that all students can gain a picture of the impact in different areas. Display the maps according to their regions.

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.

a. The **town of Lhoknga**, on the west coast of Sumatra near the capital of Aceh, Banda Aceh.
http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12647
    1. Describe the impact of this wave on buildings, trees, other vegetation, beaches and agricultural areas.
    2. 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.

b. 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.
    1. The town of **Gleebruk**, located roughly 50 km (31 miles) from Banda Aceh [at
    http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12657
    ]
    2. This image is of **Meulaboh**, Indonesia on Jan 7 at
    http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12671 Meulobah is located 95 kilometers from the epicenter of the earthquake. The tsunami completely washed over this peninsula.
    3. Impact at the beaches of **Khao Lak**, Thailand at
    http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12648
    4. 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 then against your maps):

- Trace a copy of this area before the tsunami.
- Label the following:
  Beach
  River
  Agriculture (orchards, aquaculture)
  Road and bridges
  Buildings
- Now complete a second tracing showing the same area after the tsunami. Annotate this sketch with descriptions of the changes to the area.
- Estimate number of buildings destroyed.
- Is there evidence of higher ground? Describe this evidence.
- Write a summary describing the impact on people and the environment.

Read the impact on individual countries at the **BBC impact page** for each country.
http://news.bbc.co.uk/2/hi/in_depth/4126019.stm
Which country/regions suffered the greatest impact? Outline the relationship between their location and degree of impact. Outline the other factors need to be considered and why. (Political, economic, social and environmental).

Other environmental impacts
The enormous energy generated by the earthquake that caused the Indian Ocean tsunami resulted in environmental impacts at different scales.

1. These **NASA images** show how much the Earth's surface moved upwards and sideways as a result of the earthquake.
http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=12646

   a. What was the highest uplift that occurred in the area? How does this compare with the area immediately next to the epicenter?
   b. What was the greatest distance of sideways movement of the Earth's surface? Where did this occur in relation to the greatest uplift?
   c. Do you consider these local, regional or global changes? Justify.

Further environmental impacts can be read at

- http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake#Environmental_impact
- http://www.newscientist.com/article.ns?id=dn6840
- http://www.newscientist.com/contact.ns;jsessionid=ACGFGLJLJGPD?recipient=dn]

Outline the environmental impacts mentioned.

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

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?

Economic impacts

Read the following descriptions to discover the impacts resulting from the tsunami.

General impacts
[http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake#Economic_impact

Impact on shipping [http://abcnews.go.com/Politics/wireStory?id=387928

Impact on food supply
[http://www.fao.org/tsunami/doc/Note_on_South_Asia_Tsunami_ES.doc

1. Outline the economic impacts on this region.
2. Which of these do you think need to be overcome first? Justify.

How did the Indian Ocean tsunami impact Australia?

Read about the impact the Indian Ocean tsunami had on the **Western Australian coastline**. http://www.dpi.wa.gov.au/coastaldata/tidesandwaves/tsunami.html

1. Why did the travel speed of 1000kph 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. Click to see the **tsunami effects around the state** and look at 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**.

http://www.dpi.wa.gov.au/coastaldata/tidesandwaves/tsunami-arrival.html

Summary of the Indian Ocean tsunami

If you would like to read a summary of the Indian Ocean tsunami go to http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake Wikpedia site on Indian Ocean tsunami.

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 – these will help you to organise the different consequences. Begin with first order consequences and then build second and subsequent order consequences to follow. Continue adding information as you develop the wheel.

A sample consequence based on gold discovery in Victoria can be found at http://www.qrc.org.au/_dbase_upl/explore_section_03.pdf on page 13 of the pdf file.

Tsunami in Papua New Guinea

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.

- Go to http://omzg.sscc.ru/tsulab/19980717.html and click on **location map** and **source area**. Describe the location of the earthquake and tsunami.
- Click on **travel time map** and describe how far the waves from this tsunami travelled?
- 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?
- Click on **damage** and visit http://www.ga.gov.au/urban/factsheets/tsunami_png.jsp and http://www.cnn.com/WORLD/asiapcf/9807/18/tidal.wave.02/ Describe the damage in this area
- To look at a 3D view of how the earthquake caused the tsunami, go to http://www.drgeorgepc.com/Tsunami1998PNG.html 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.