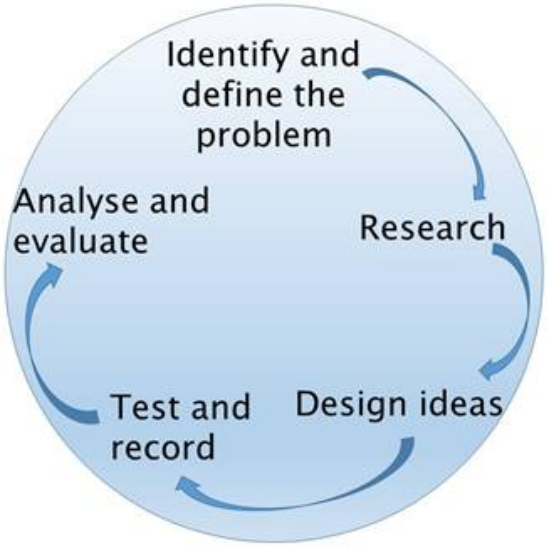
Sea Level Rise Mitigation – Student Booklet

Science Technology Engineering and Mathematics

The Challenge

One of the consequences of climate change that is projected to impact a large number of people globally is sea level rise. The effects of which are already being felt by some in Australia. With the majority of the country's population living near the coast, it is imperative that there is forward planning to help reduce the impact of rising sea level on Australia's population. Your role is to analyse evidence, research the effects and impacts and investigate means of mitigation of sea level rise in Western Australia.



Background Information

It is now widely accepted amongst the scientific community and general population that the Earth's climate is changing. One major global concern relating to climate change is that sea levels are rising and will continue to rise. There are two main reasons for the sea level increase: rising global temperatures causing ice-caps and glaciers to melt, introducing more water into the oceans; and thermal expansion of the oceans due to increased temperatures.

Preventing excessive sea level rise will require a global community effort. Although, even with the best intentions and efforts, the sea level will continue to rise for some time. With the vast majority of Australia's population living close to the coast, it is imperative that planning be put in place to mitigate the effects of future sea level rises.

Human populations are not the only ones affected by sea level rise. Flora and fauna are also impacted particularly marine and estuarine plants and animals. Australia's coast supports animals and plants which are not found elsewhere in the world and it is important that any strategies put in place help to protect these species as well.

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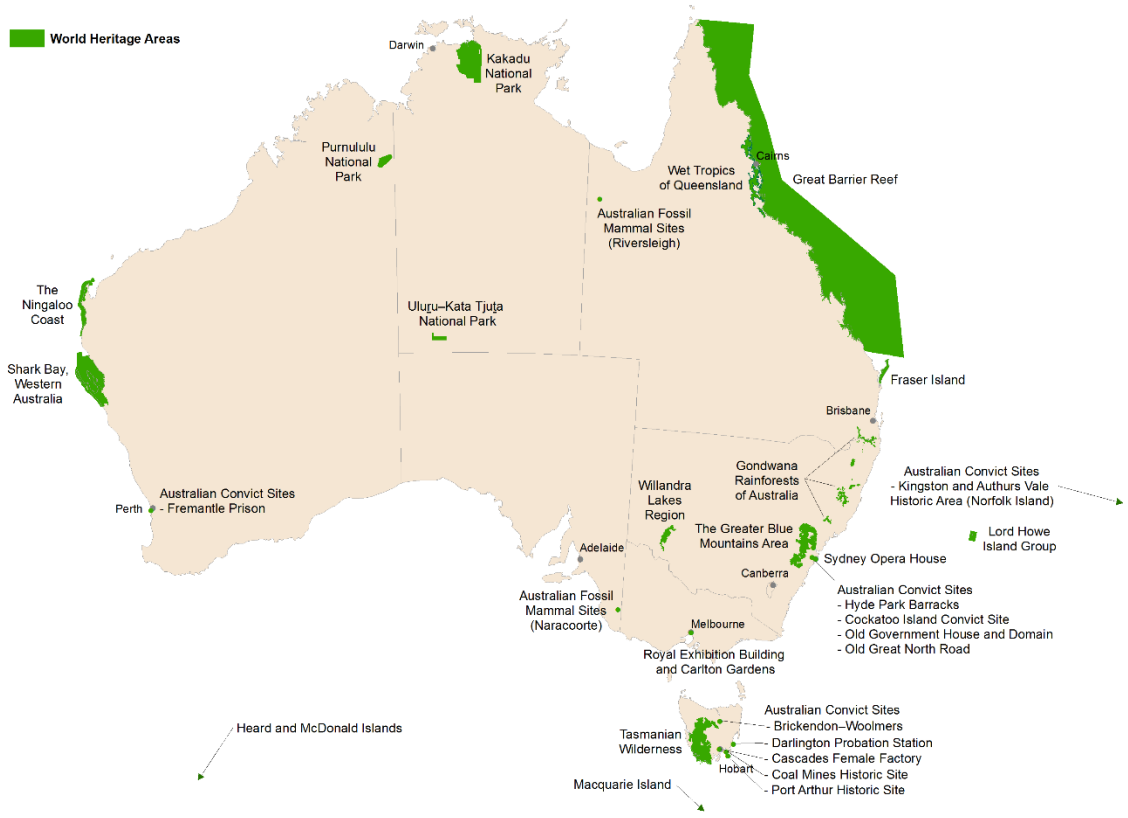

Figure 1. Australia's world heritage sites include Shark Bay and Ningaloo Reef in Western Australia, it is vital that these areas are protected. (State of the Environment, 2016)

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Background Research

1. What are the two main causes of sea level rise?

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Suggested site: https://oceanservice.noaa.gov/facts/sealevel.html

2. What methods are used to measure sea level and why have sea level measurements become more reliable with time?

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Suggested site: https://www.science.org.au/curious/earth-environment/how-we-measure-global-sea-level-changes-0

3. Use the interactive map at http://coastalrisk.com.au/# to explore the impacts of predicted sea level rises:
    - Choose your area (cities and areas at the base, scroll along if you can't see yours right away)
    - Accept the disclaimer
    - It will automatically come up with the predicted 2100 levels, zoom in and move the map around to explore where you live
    - Choose manual and move the bar from 0 to 10 metres to see what happens in different climate change scenarios

4. What effect might sea level rise have on biodiversity?

	Possible effect
Marine mammals	
Coastal birds	
Corals	
Marine plants	
Fish	
Other marine animals	

Suggested site: https://www.nationalgeographic.com/environment/global-warming/sea-level-rise/

5. What effect could sea level rise have on low lying islands such as Rottnest, The Abrolhos and Garden Island?

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6. What effect could sea level rise have on the tourism industry and explain why?

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Suggested site: https://www.csiro.au/en/Research/OandA/Areas/Oceans-and-climate/Sea-level-rise-planning

7. How could rising sea levels impact the people of Western Australia?

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Suggested site: https://theconversation.com/australias-coastal-living-is-at-risk-from-sea-level-rise-but-its-happened-before-87686

8. What is the difference between hard and soft engineering when it comes to coastal management techniques.

	Examples
Hard engineering	
Soft engineering	

Suggested site: https://www.bbc.com/bitesize/guides/z2234j6/revision/1

Dissecting Data

Objective

To analyse historical tidal data for evidence of sea level change in Western Australia.

Method

1. Go to the Bureau of Meteorology website to find the tide gauge metadata and observed monthly statistics: http://www.bom.gov.au/oceanography/projects/ntc/monthly/
2. Select the tab for your state.
3. Select the data for your most local tide gauge or the tide gauge where you feel sea level change will have the largest impact (under Sea Level click 'Table and Plot').
4. Copy the data into Excel to make the sorting of data easier.
5. Find the mean maximum and mean minimum sea level in the month you were born over the last 30 years.
6. Create stem and leaf diagrams using the data for the maximum and minimum sea level **in the month you were born** for:
   a) 30 years– 20 years from present
   b) 20 years – 10 years from present
   c) 10 years – present
7. Compare the stem and leaf diagrams by finding the:
   a) Mean
   b) Median
   c) Mode
   d) Range
8. How does the mean maximum and minimum for each decade compare to the overall mean maximum and minimum over the past 30 years in the month you were born?

   _____
9. Plot a graph showing the mean sea level for the month you were born for the past 30 years, adding a trend line.
10. Calculate the gradient of the trend line.
11. Does the trend line have a positive or negative gradient?
12. Does the trend line suggest that sea level is rising?
13. Compare your graphs with others who were born in a different month – are their trend lines different?
14. What other natural phenomena may have an impact on sea level?
15. Determine the interquartile range of the sea level on the month you were born for the past 30 years.

Thermal Expansion Investigation

Objective

To determine the relationship between temperature and volume of water. Then to relate this to climate change as a cause for current sea level rise.

Equipment

- Large beaker
- Glass measuring cylinder (around 200mL)
- Bung/stopper to fit measuring cylinder with hole in it and thermometer inserted
- Thermometer/temperature sensor
- Hot plate or Bunsen burner
- Beaker suitable for heating
- Ice bath

Method

1. Heat around 300mL of water in the beaker.
2. Stop heating the water when it is around 70^{o}C.
3. Very carefully pour water into the measuring cylinder, until it is around ¾ full.
4. Place the bung/stopper with thermometer in it into the measuring cylinder.
5. Record the volume and temperature of the water in your results table.
6. Keep recording the volume and temperature every two minutes. If the water is taking a long time to cool you can put the measuring cylinder in the ice bath to speed up the process.

Results and Analysis

Time (min)	Temperature (^{0}C)	Volume (mL)
2		
4		
6		
8		
10		
12		
14		

Time (min)	Temperature (^{0}C)	Volume (mL)
16		
18		
20		

1. Plot the results in a scatter graph with temperature on the x-axis and volume on the y-axis. Add a trend line and remember that trend lines do not have to be straight!

2. What is the relationship between the temperature of the water and its volume?

_____

_____

3. If your line of best fit is a straight line calculate the gradient of the line (show your working)?

_____

_____

Evaluation

1. Were there any potential sources of error in your investigation?

_____

2. How could you improve this investigation?

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3. What are the pros and cons of measuring the relationship between water temperature and volume by monitoring cooling water (as opposed to water that is being heated)?

Pros	Cons

Investigating the Warming Ocean

As the atmosphere warms the oceans warm.

Objective

To investigate what happens to oceanic temperatures as atmospheric temperatures rise. Then to investigate what happens to oceanic temperatures if atmospheric temperatures stabilise.

Equipment

- Fish tank with lid/large clear plastic container with lid
- 2 x thermometers or temperature sensors
- Heat lamp on retort stand with clamp and boss head
- Electrical tape or Plasticine
- Optional: salt (you may like to make your water salty)

Method

1. Secure the thermometers/sensors to the side of the tank, with one located near the bottom (in the water) and the other located near the top (in the atmosphere). Ensure that you can read them from the outside of the tank/container.
2. Half fill the tank/container with water, so that the bottom thermometer/sensor is covered in water and the top is not touching the water.
3. Place the lid on the tank/container.
4. Place the heat lamp around 10 cm away from the tank and turn it on.
5. Every 30 seconds or so gently move the tank, to try to circulate the water (simulating ocean currents). If you have a small fish tank pump use this instead.
6. Record the temperature shown on both thermometers.
7. When the air temperature in the tank has reached 30 ^{0}C move the heat lamp back a little. Try to maintain the air temperature for the next five minutes. You may have to move the heat lamp back and forth a little.
8. Every 30 seconds during those five minutes, record the temperature of the water in the results table.
9. After five minutes turn off the heat lamp. Allow it to cool completely before packing equipment away.

Results and Analysis

Time (min)	Air Temperature (°C)	Temperature of water (°C)
0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0		
8.5		
9.0		
9.5		
10.0		

(add extra rows to another page, if needed)

1. Plot your results in a scatter graph, with time on the x-axis and temperature on the y-axis, using colours or symbols to distinguish the air and water data. Draw a trend line for both air and water.

2. What is the relationship between the time and the air and water temperatures?

_____

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3. If atmospheric temperatures stabilised what does your data suggest will happen to ocean temperatures?

_____

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Evaluation

1. Were there any potential sources of error in your investigation?

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2. How could you improve this investigation?

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3. Outline any ideas you have to investigate the relationship between atmospheric and oceanic temperatures further.

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Hard Engineering – Sea Walls

Background

An engineered solution to help mitigate erosion caused by sea level rise are sea walls. Locations such as Seabird, WA already have seawalls in place to protect housing on the shore. There are many different types of sea walls, some are designed to prevent the sea reaching houses and infrastructure. Others are designed to stop sediment migration. There are other benefits of sea walls including, creating recreational areas for fishing and calmer waters for people to swim. However, sea walls can also have negative effects on the natural environment by changing the space and area in which marine animals live. The materials from which sea walls are built can make a big difference to the cost of the project, as well as impact upon the marine life.

Objective

To investigate different types of sea walls and discuss the pros and cons of each.

Research and Preparation

1. Research different types of sea walls to complete the table below.

Type	How it Works (sketch)	Pros	Cons
Curved			
Vertical			
Mound			

Suggested site: https://en.wikipedia.org/wiki/Seawall

2. Consider the pros and cons of different materials that may be used to build sea walls in terms of cost, need for maintenance, longevity and how environmentally friendly it is.

Material	Pros	Cons
Wood		
Solid Concrete		
Concrete Tetrapods		
Boulders		
Steel		
Gabions		
Aluminium		
Vinyl		
Sandbags		

Suggested site: https://en.wikipedia.org/wiki/Tetrapod_(structure) and https://en.wikipedia.org/wiki/Gabion

Test different models of sea walls to determine how useful they will be at preventing erosion.

Equipment

- Foil roasting tray
- Sand
- Water
- Pebbles
- Lego/Duplo bricks
- Plasticine
- Wood
- Pop sticks
- Ruler/frequency generator for ripple tank
- Marker pen
- Camera

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Method

1. Using a marker pen, mark the halfway line on the bottom of your roasting tray.
2. On one side of the line pour in some sand to create a 'beach'.
3. On the other side of the line carefully pour some water to create a 'sea'.
4. Using either a chopping motion with a ruler, or a frequency generator, create small waves in the water. Itis important that you try to keep these the same *frequency* and *amplitude*. You could do this simply by having one wave per second and raising the ruler a set height each time.
5. If possible, take photos or record the experiment.
6. After 30 seconds stop creating waves, allow the water to settle and note what has happened to your beach.
7. Reset your beach so that the sand is back behind the line if it has moved.
8. Now use the materials available to you to create sea walls and test how effective they are at preventing coastal erosion. You should initially test them using waves of the same frequency and amplitude as used previously, however you should then try different scenarios, such as the waves coming from a different direction and storm surge waves.

Results and Analysis

1. Describe how the waves affected the beach during different scenarios.

Scenario	Before	After
No sea wall		
(type of sea wall used)		
(type of sea wall used)		

2. Which scenario resulted in the most coastal erosion?

_____

3. Which scenario resulted in the least coastal erosion?

_____

4. Was there a big difference between how the sand moved when the waves were coming from a different direction?

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Evaluation

1. Were there any potential sources of error in your investigation?

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2. How could you improve this investigation?

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3. Outline any ideas you have to investigate the effectiveness of sea walls further.

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4. If you were a town planner how would you recommend that coastal areas mitigate coastal erosion?

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