Science
Technology
Engineering and
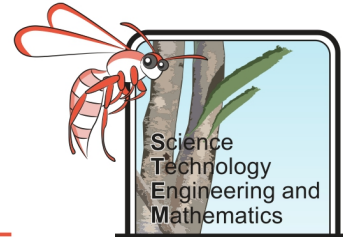Mathematics

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.

Identify and define the problem

Research

Design ideas

Test and record

Analyse and evaluate
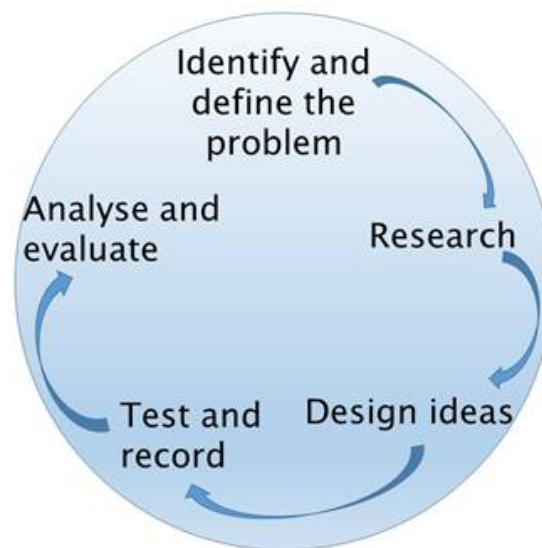
Background Information

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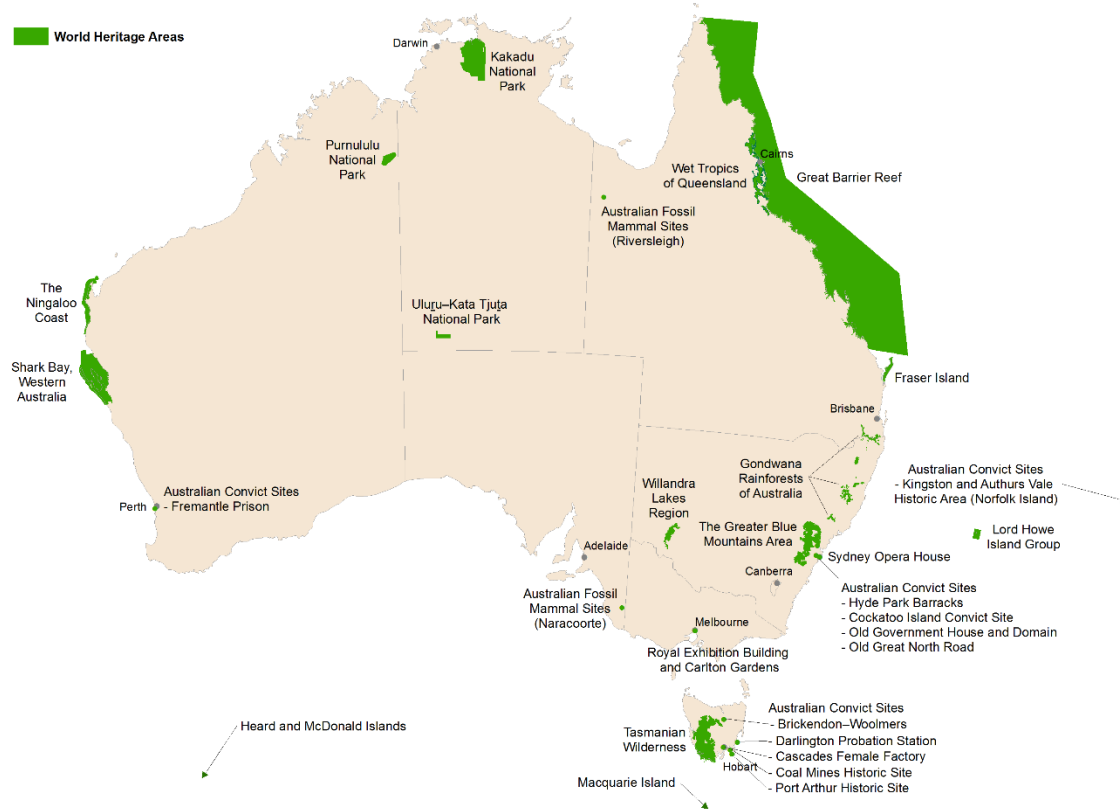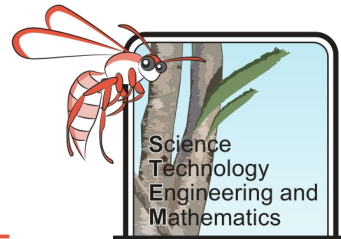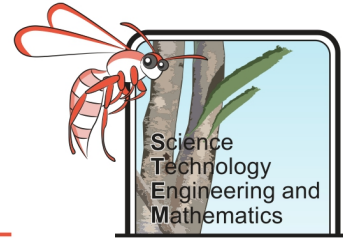
Figure 1. Australia's world heritage sites include Shark Bay and Ningaloo Reef in Western Australia, it is vital that these areas are protected. (State of the Environment, 2016)

Sea Level Rise Mitigation – Student Booklet

Background Research

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

   _____

   _____

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

   _____

   _____

   _____

   _____

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	

Sea Level Rise Mitigation – Student Booklet
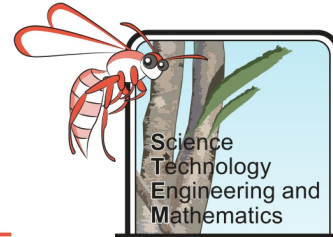
	Possible effect
Marine plants	
Fish	
Other marine animals	

Suggested site: https://www.nationalgeographic.com/environment/global-warming/sea-level-rise/
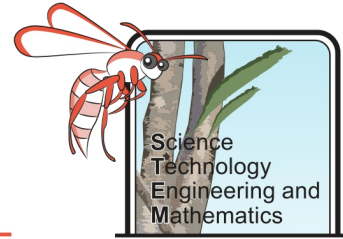
5. What effect could sea level rise have on low lying islands such as Rottnest, The Abrolhos and Garden Island?

_____

_____

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

_____

_____

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

_____

_____

_____

8. Outline examples of coastal erosion management strategies and explain how they work.

_____

_____
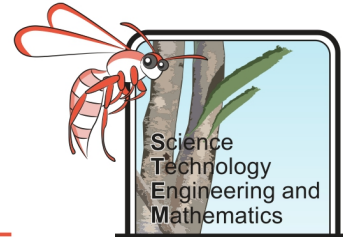
_____

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.

THE ENSO Effect

16. What is ENSO and how does it impact Australia?

17. Use the BOM website to look at El Nino and La Nina patterns in the past:
    http://www.bom.gov.au/climate/influences/timeline/
    Can you see any correlation between the mean sea level over the past 30 years and the ENSO cycle? Use data to support your answer.

    _____

    _____

18. What other natural phenomena may have an impact on sea level, and how would it effect it?

    _____

    _____

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°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

1. Create a table for your experimental results here:
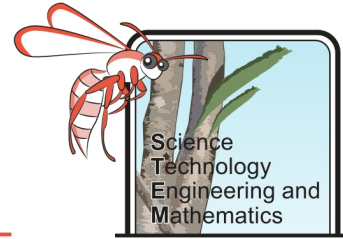
2. Plot the results in a scatter graph with temperature on the x-axis and volume on the y-axis. Add a trend line and remember that trend lines do not have to be straight!

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

   _____

   _____

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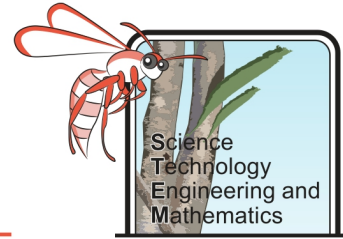
   _____

   _____

5. The global average ocean temperature in the 20th Century was 12^0C (NOAA, 2018), it is predicted that the ocean temperature will rise at least 2 degrees in the next 30 years. Use your data to determine what the percentage increase in volume will be if there is an increase from 12^0C to 14^0C in ocean temperature. (show your working)

   _____

   _____

Evaluation

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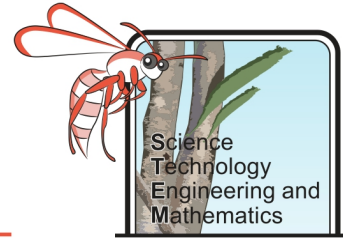
   _____

2. How could you improve this investigation?

   _____

   _____

   _____

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.

Hypothesis

As air temperature rises water temperature will _____. When the air temperature has reached a constant (30 ^{0}C) water temperature will _____.
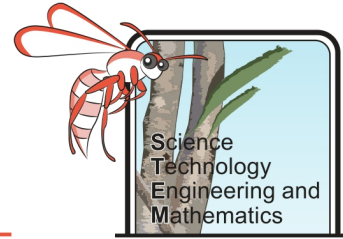This is because _____.

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

1. Create a table for your experimental results here:

2. 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.

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

_____

_____

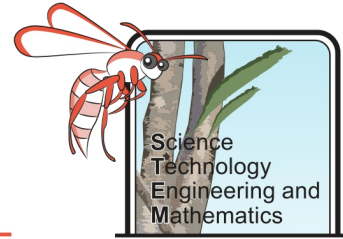4. If atmospheric temperatures stabilised what does your data suggest will happen to ocean temperatures?

_____

_____

Evaluation

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

_____

2. How could you improve this investigation?

_____

_____

_____

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

_____

_____

_____

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.
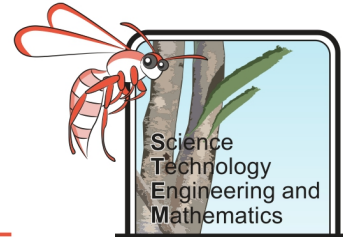
Objective

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			

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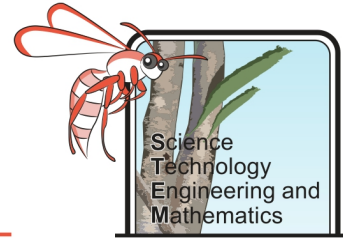
Material	Pros	Cons
Wood		
Solid Concrete		
Concrete Tetrapods		
Boulders		
Steel		
Gabions		
Aluminium		
Vinyl		
Sandbags		

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

Method

1. Use the equipment in the list above, or others available to you, to create a 'beach'.
2. Design models of different sea walls to place on your beach (ensure they are on a similar scale to the beach).
3. Design a fair method of testing the sea walls. Consider how you will collect results so that you can compare the models fairly.

Show your designs and method to your teacher to gain their approval before conducting your investigation.
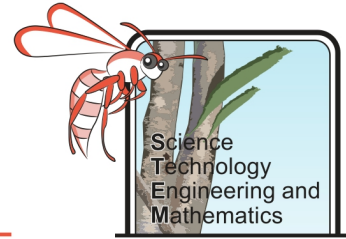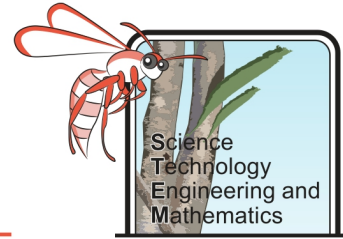
Results and Analysis

1. Present your results in a way that clearly demonstrates your outcomes.

2. Discuss the strengths and weaknesses of each of the models you tested. Which design would be the best to mitigate coastal erosion? Why?

_____

_____

_____

Evaluation

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

    _____

2. How could you improve this investigation?

    _____

    _____

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

    _____

    _____

    _____

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

    _____

    _____