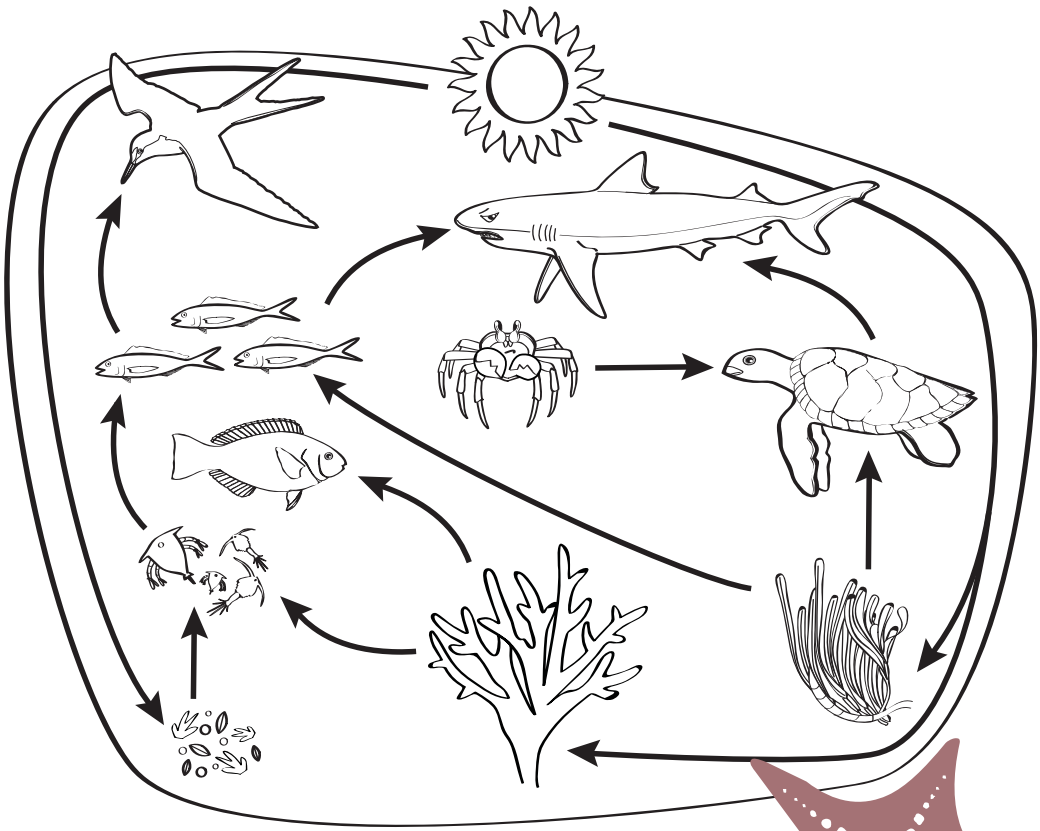
Australian Government
Great Barrier Reef Marine Park Authority

REEF Beat

ACTIVITIES BOOK

Climate change and the Reef



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Notes for Teachers

Reef Beat: *Climate Change and the Reef* is an innovative teaching resource that includes activities and challenges that will stimulate enquiring minds to discover all they can about climate change and its possible effects on our oceans and the Great Barrier Reef. The implementation of the teaching and learning opportunities offered by these engaging activities will enhance and extend student learning. Teachers and students can gain additional support by accessing the ReefED website at www.reefED.edu.au.

The activities within this resource can support you to:

- Reduce your school's ecological footprint.
- Create meaningful lessons that provide students with an understanding of climate change and its potential impacts on the Reef as well as some actions that can be achieved at school to help reduce climate impacts.
- Contribute to the responsible development of active and informed citizens with a better knowledge of the threats that the Reef faces and what we can do to help both at home and at school.
- Contribute to a state-wide focus on sustainability education. In many schools sustainability has been creatively incorporated into the curriculum in each phase of learning and is reflected in many school facilities and actions.
- Engage students and empower them to educate their peers and other members of the broader school community.

The activities are targeted at upper primary and middle school students however all of the activities can be simplified or amplified for students of other stages of learning. This resource aims to engage students via multiple intelligences, targeting essential learning, providing for rich tasks, empowering active and informed citizens and will assist schools working towards reducing their ecological footprint.

Introduction

Reef Beat: *Climate Change and the Reef* is a product of the Great Barrier Reef Marine Park Authority. It provides a detailed informative guide to climate change issues, the pressures facing the Great Barrier Reef and some of the key species that will be affected. This education product also describes what sorts of action we can take, as custodians of the Reef, to live in a more sustainable way to ensure the Great Barrier Reef's protection and conservation for future generations.

The Great Barrier Reef is thought to be 18 million years old. It has stayed relatively stable once sea level settled at its current level. Changes that we are presently seeing, and are predicted for the future, see shifts at a rate unprecedented in the history of the Reef.

The goal of the Great Barrier Reef Marine Park Authority is:

> *To provide for the long-term protection, ecologically sustainable use, understanding and enjoyment of the Great Barrier Reef through the care and development of the Great Barrier Reef Marine Park.*

In working towards this goal the Great Barrier Reef Marine Park Authority's Education Team has developed a range of reef education programs and activities. You can find these at www.ReefED.edu.au.

For enquiries about **Reef Beat: *Climate Change and the Reef***, please contact the Great Barrier Reef Marine Park Authority's Education Team.

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Rationale

Our Great Barrier Reef is an internationally recognised natural icon of beauty and ecosystem diversity. This mass of linked reefs and marine communities covers over 348 000 km^2 and stretches over 2300 km along the north eastern Australian coastline. It is the largest coral reef ecosystem in the world. The Reef Beat resources provide information on what individuals and communities can do to help keep the Reef healthy and minimise the impacts of climate change on this unique natural wonder.

Why get involved / why should you care?

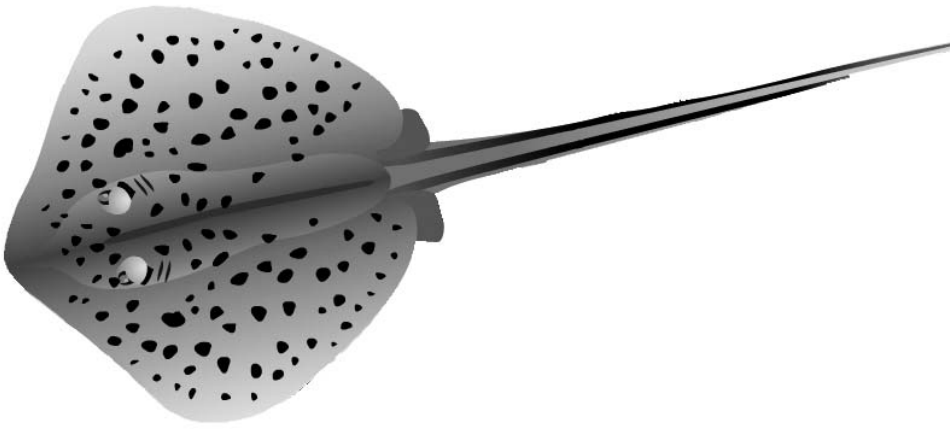
Climate change is a significant threat to the Great Barrier Reef and the little changes we make to our daily routines can make a big difference to the Reef in the future. The Great Barrier Reef Marine Park Authority aims to create an educated and aware community, working together towards a sustainable future for the Reef.

Reef Beat: *Climate Change and the Reef* is a timely and exciting opportunity to provide immediate and ongoing support for schools in assisting young people to become aware and actively involved in a most important challenge, to tackle climate change and protect our Reef for the future.

How to use this resource

This resource is designed to accompany or underpin your school's study of climate change. It is designed to encourage the development of an active informed citizen and will align well to the eco-citizen philosophy contained in the Education Queensland's values education framework.

CONTENTS



Reef Beat Poster 1 – What is climate change?

Key messages of Poster 1: Climate change is real. Extensive scientific evidence from tree rings, ice cores and long-lived corals confirms our Earth is warming. Human activities are contributing climate change and this change is occurring much more rapidly than previous natural shifts in the climate. Climate change is already impacting plants, animals, humans and the environment.

Related resources:

- Reef Beat Poster 1
- GBRMPA animation 'What is climate change?' (provided on Reef Beat DVD)
  www.gbrmpa.gov.au
  www.reefed.edu.au

  This animation presents a very simple explanation of climate change. It is designed for students aged 6-14.
- What is climate change?
  www.teachers.ash.org.au/jmresources/climate/change.htm#learning

  A series of website links to information on climate change, newspaper articles, games and activities.
- Modules for teaching climate change
  www.teachingclimatechange.com.au/

  Nine modules for students in years nine and ten studying society and the environment, geography, science and economics. Models are approximately 50 minutes long.
- Thinking through climate change
  www.wmnet.org.uk/resources/ttcc/

  Uses the example of Shishmaref – a community near the Arctic Circle literally melting away. Modules from simple through to advanced.
- American Museum of Natural History
  www.amnh.org/education/climatechange

  A collection of climate change resources and activities geared around a museum visit but easily adaptable to a classroom setting.

Activity 1: *Use the 'six thinking hats' to consider climate change from different perspectives*

Key learning objective: Students will critically assess evidence for, and feelings about, climate change to understand how different perspectives have arisen on this topic. By considering the issue from many angles, students will better understand the challenges associated with developing effective climate change solutions.

Background: While most people accept that climate change is real, some remain sceptical. Because climate change is such a complex topic, it can be difficult for people to differentiate between fact and fiction. The media tends to present conflicting views and because scientists often disagree on the detail around climate predictions, understanding what is real can be a challenge. Many students will have already been exposed to some climate change information through the media, parents, peers or teachers. By using the six thinking hats tool, students will be able to think about the topic of climate change from many angles and will better understand how differing views have arisen. Students can also critically assess how their own views on climate change were formed.

A valuable exercise would be to complete this activity both at the start and conclusion of the unit so students can recognise how much they have learned.

What you will need:

1. a white board, butcher's paper, or large sheet of cardboard where you can record the six hats brainstorming results
2. six coloured hats (optional)

This table could be used to record the brainstorming results and may be displayed for the duration of the climate change unit as a reference. Further questions, concepts, ideas or answers can be added over time.

Issue	White hat	Red hat	Black hat	Yellow hat	Green hat	Blue hat
What is climate change?						
Is climate change real?						
Climate change impacts – what's happening now						
Climate change impacts – predictions for the future						
Impacts on the Great Barrier Reef						
Climate change solutions						
Solutions for the Reef – Keeping our Reef resilient						
What can we do?						

Instructions:

'Six thinking hats' is a powerful technique that helps students look at concepts from a number of perspectives. It helps to improve thought processes by encouraging students to extend beyond their habitual ways of thinking. This tool was created by Edward de Bono and is discussed in his book '6 Thinking Hats'.

Use six thinking hats to improve the quality of your classroom brain storming. Ask students to look at the climate change issue 'wearing' each of the thinking hats in turn.

Each thinking hat uses a different style of thinking. These are explained below:

White hat: With this thinking hat, you focus on the data available. Look at the information you have, consider what you already know and think about what you can deduce from it. Look for gaps in your knowledge and write them down as questions you would like answered.

Red hat: Wearing the red hat, you consider the topic using intuition, gut reaction, and emotion. Try to think how other people will react emotionally and try to understand the intuitive responses of people who do not fully understand your reasoning. You might consider how animals would feel about their habitats coming under stress from climate change. For older students more complex social and cultural viewpoints could be considered.

Black hat: When using black hat thinking, you should look at things pessimistically, cautiously and defensively. This type of thought is often associated with climate change because people often feel that there is nothing they can do and that it is too late to make a difference. It is important to recognise these feelings as a black hat thought. Understanding black hat thought will allow you to develop solutions that take negative perspectives into consideration.

Yellow hat: The yellow hat helps you to think positively. It is the optimistic viewpoint that helps you to see all the possible benefits and solutions. Thinking with the yellow hat on, you will spot opportunities everywhere. Yellow hat thinking helps you to keep going when everything looks gloomy and difficult. Yellow hat thinking will view solutions to climate change in a positive light and will point out the benefits of taking action towards sustainability.

Green hat: The green hat stands for creativity. This is where you can develop creative solutions to a problem. It is a freewheeling way of thinking, in which there is little criticism of ideas. A whole range of creative outlets can help you here including dance, drama, music and artistic expression.

Blue hat: The blue hat stands for the thinking behind thinking. This hat might consider different ways to think about various aspects of the topic. It might mean you consider climate change impacts and solutions from the perspective of government, commercial fishermen, or perhaps someone who runs tours to the Great Barrier Reef.

Activity 2: *The greenhouse effect in miniature*

Key learning objective: Students will develop an understanding of the greenhouse effect by creating their own miniature greenhouse.

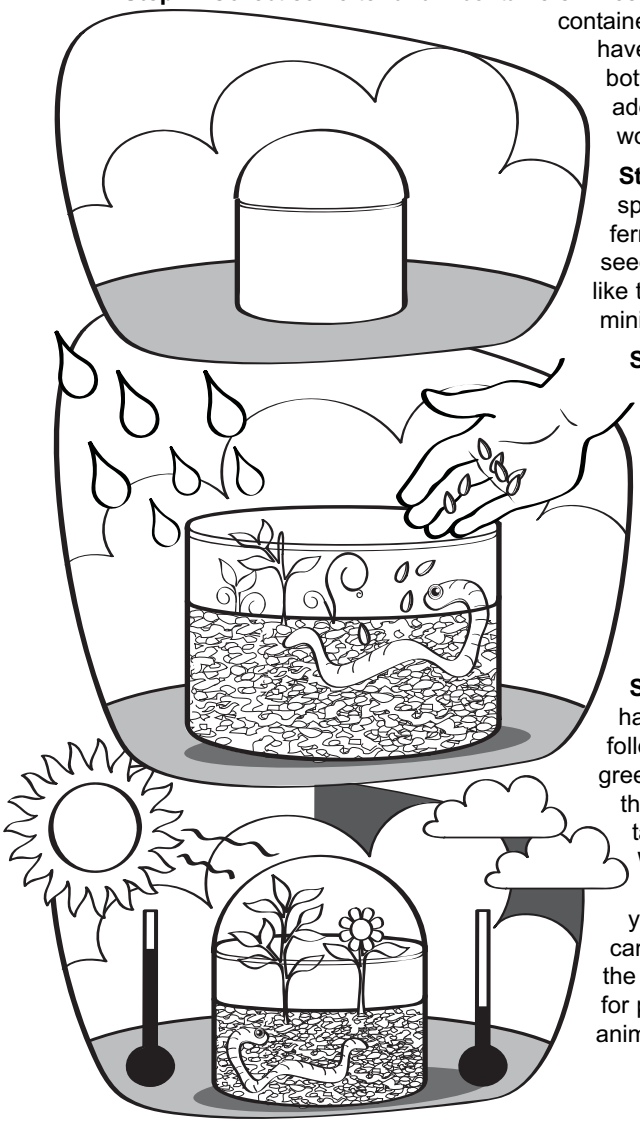
Background: The greenhouse effect is called such because it replicates the warming effect created in a real greenhouse. What better way to contemplate climate change than to build a mini greenhouse and watch its climate change? In this experiment, the clear container traps heat from the sun and moisture from the air. On a larger scale, this is similar to what happens in a full size greenhouse and on a much larger scale it explains why our planet is both dry and icy cold. This activity can be done as a class experiment or in small groups.

Bright idea: Give students a range of 'data' on weather and climate conditions (e.g. newspaper clippings, daily weather reports, yearly rainfall charts for your state or territory, or thermometers and barometers they can use to collect their own measurements). Ask them to identify which data relates to weather and which to climate. Have students explain the difference between climate and weather in their own words and to describe both the climate and weather of their town or city. Use local examples and create a map or chart.

What you will need:

1. terrarium containers
2. potting mix or soil from your school's garden
3. worm castings or mulch if available
4. seeds (e.g. snow peas, flowers or vegetables)

Instructions:



Step 1: Collect some terrarium containers. These could be glass jars, plastic bottles, take away containers, or juice cups. It's important that they are clear, have lids that fit and are preferably recycled. Fill the bottom half of the container with soil. You might want to add compost, mulch, or worm castings from your worm farm.

Step 2: Next add seeds or seedlings. Snow pea sprouts are good because they grow quickly but small ferns or flowers are also good options. Water your seeds or seedlings and watch them grow. You might like to add an insect or two. Make sure you put your mini greenhouse somewhere sunny.

Step 3: Record measurements like temperature, humidity and growth. Be sure to record the temperature before you put the lid on so you can see how temperature changes as the greenhouse effect created by the container is enhanced over time. Take readings in varying conditions (e.g. sunny vs. overcast, early morning vs. late afternoon) and consider what factors cause your greenhouse to change. Try adding excess carbon dioxide to your system and see what happens to plants.

Step 4: Graph your results and report on what is happening inside your mini-world. Consider the following questions: How is what's happening in your greenhouse like what is happening on Earth? When did the temperature go up? Why? What happens if you take the lid off? Why? What happens when you add more carbon dioxide? Are the impacts the same for plants and animals?

Bright idea: Show students the GBRMPA animation 'What is climate change?' (provided on Reef Beat DVD) and discuss the causes and solutions of climate change.

Reef Beat Poster 2 – Coral Bleaching

Key messages of Poster 2: Coral bleaching (which can result in coral death) will occur more frequently with climate change. Corals provide food and habitat for coral reef species. If corals on the Great Barrier Reef disappear, the ecosystem will collapse and the Reef as we know it will cease to exist. Corals are the cornerstone of the Reef.

Related resources:

- Reef Beat Poster 2
- 'Coral Bleaching 1' and 'Coral Bleaching 2' animations (provided on Reef Beat DVD)
  www.gbrmpa.gov.au
  www.reefed.gov.au

  These animations present the complex concept of coral bleaching in a simple manner. They utilise different educational approaches and may be used individually or together. Designed for ages 10-18.
- BleachWatch
  www.gbrmpa.gov.au

  BleachWatch is a community-based coral reef monitoring initiative developed by the GBRMPA. This site provides access to resources that will help students identify coral bleaching on the Reef.
- Australian Institute of Marine Science (AIMS)
  www.aims.gov.au/docs/research/climate-change/coral-bleaching/coral-bleaching.html

  A good source of basic information about coral bleaching. Check out the AIMS media releases for some of the latest science stories relating to bleaching.
- Reef Check Game
  www.reefcheckaustralia.org/

  This interactive game allows students to test their ability to identify coral bleaching.

Activity 1: *Research the various pressures facing corals on the Reef*

Key learning objective: Students will understand that corals on the Reef face a range of pressures and that these pressures have a compounding effect. Students will consider the issue from many angles and develop an understanding of the complexity of managing a multi-use marine park.

Background: Coral bleaching occurs when corals are under stress. Things that we do in our catchments impact the Reef and can cause further pressures on corals.

Instructions: Choose a human activity that is putting corals on the Great Barrier Reef under pressure and research answers to the following questions:

- What is the activity?
- Where is it taking place?
- Why is this activity occurring?
- Who is responsible for the activity?
- Who is responsible for managing the issue?
- What are the activity's impacts – social? ecological? economic?
- What is the future outlook for corals on the Reef if this activity continues?
- What is your preferred approach to managing this activity?
- How could you achieve this preferred outlook?

Have students come up with their own ideas or access www.gbrmpa.gov.au or www.reefed.edu.au for further information on the pressures facing corals on the Great Barrier Reef. Some general Reef pressures are presented in Poster 9 (many of these impact corals).

Discussion: Concluding discussions should focus on the concept of compounding impacts. The summer of 2009 provided an excellent example of compounding environmental impacts on reef corals. Students can visit the GBRMPA media centre to read about how the combination of cyclone Hamish, higher than average sea temperatures and freshwater run-off affected the Reef. Read media release 'Weather triple whammy roughs up the Reef' at www.gbrmpa.gov.au/corp_site/info_services/media/media_archive/2009/2009_03_18. Students can think about the combined impacts of human pressures in a similar way.

Bright idea: Show students the GBRMPA animations 'Coral bleaching' 1 and 2 (provided on Reef Beat DVD) and give a short quiz to test what they have learned. Here are some example questions: Where do corals get most of their energy from? (answer: the sun or their zooxanthellae). Corals have a symbiotic relationship or partnership with zooxanthellae. What happens when corals get too hot? (answer: their zooxanthellae move out, the corals lose their colour and can die.) What will happen if climate change makes our oceans too warm for corals?

Activity 2: *Creative exercise on coral bleaching*

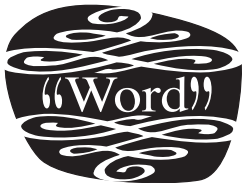
Key learning objective: Students will understand the process and implications of coral bleaching using a 'learning by teaching' approach. By developing their own ways to explain this complex topic, they will gain deeper insight.

Background: Coral bleaching occurs when corals become stressed. A bleached reef is essentially a sick reef. While they can recover, bleached corals can also die. Coral bleaching is one of the most worrying impacts climate change will have on the Great Barrier Reef. If corals bleach more and more frequently, their chances of recovery diminish and the overall health of the entire reef system declines.

What you will need:

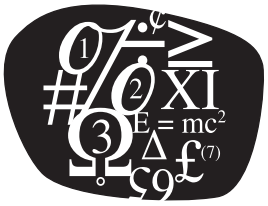
1. butcher's paper
2. textas
3. craft items (e.g. plasticine, fabric scraps, bits of rubbish and other items the students can use creatively)

Instructions: Using the theory of multiple intelligences, ask students to compose a creative piece of material on the topic of coral bleaching. They may use one or more of the following prompts to explain what coral bleaching is, to describe who, what, and where it has an impact and to develop ideas on what we can do to help stop or slow it:



words (linguistic intelligence)

Write a story, poem, report or short speech about coral bleaching. Perhaps use this to teach another class about it.



numbers or logic (logical-mathematical intelligence)

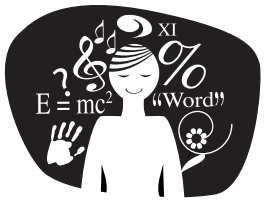
Using ocean temperature information, as well as information on the Reef found online and in zoning maps, calculate the area of Reef likely to be affected by bleaching either across the whole reef or just in one section.

pictures (spatial intelligence)

Create a model, a map or a cross-section of the Great Barrier Reef explaining areas most likely to be affected by bleaching, including its effects on the food chain.

music (musical intelligence)

Create a song, a rap or a television jingle that will educate the public about the threat of coral bleaching and what they can do to help.



self-reflection (intrapersonal intelligence)

Write an essay or newspaper article around your own personal wishes for the future of the Reef. Include in this what the current issues are, what the likely impacts of coral bleaching might be and how this makes you feel.

a physical experience (bodily-kinesthetic intelligence)

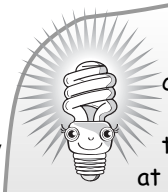
Create a three dimensional reef using any materials you like. This reef should explain the cause and effect of coral bleaching. Alternately, act or dance a scene related to this topic.

a social experience (interpersonal intelligence)

Create a game, an activity or a slogan that will include others in learning about coral bleaching. The cause and effect of coral bleaching must feature in this as a focus.

an experience in the natural world (naturalist intelligence)

Create a food web of a coral reef either as a diorama or a poster to show what other species rely on corals for survival and will therefore be affected by coral bleaching.



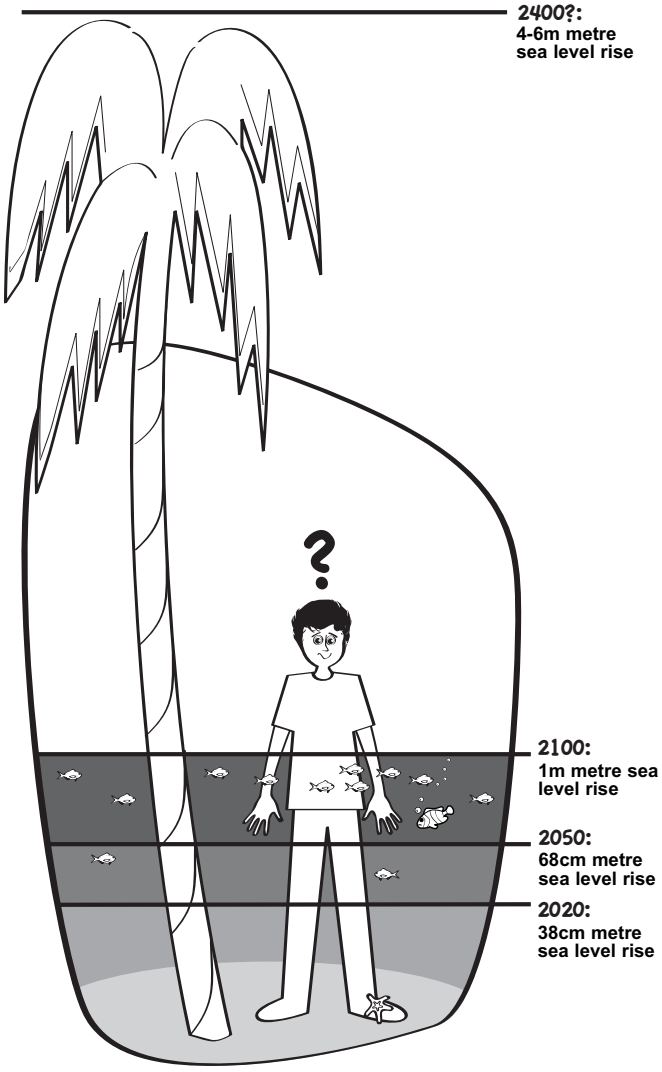
Bright idea – Take your class on a field trip to the Great Barrier Reef to get a first hand look at climate change impacts. If you go during the summer, look out for signs of coral bleaching and report them to the GBRMPA. Learn about GBRMPA's BleachWatch program on our website www.gbrmpa.gov.au
If you can't get out to the Reef, visit www.reefcheckaustralia.org/ and play the Reef Check Game on-line. This is a great way for students to test their ability to identify coral bleaching.

Reef Beat Poster 3 – Climate change impacts on the Great Barrier Reef

Key messages of Poster 3: Climate change is likely to have a wide range of impacts on the Reef. These will affect plants, animals and the chemical and physiological processes that drive ecosystem productivity. Climate change impacts on the Reef will have dramatic effects on humans.

Related resources:

- Reef Beat Poster 3
- Townsville City Council's Spatial Technologies in School's Program. Contact Kenneth Melchert: kenneth.melchert@townsville.qld.gov.au
  Spatial data technology available for schools in the Townsville region (including topographic maps of Townsville
- 'Impacts of climate change' animation (provided on Reef Beat DVD)
  www.gbrmpa.gov.au
  www.reefed.gov.au
  This animation gives an overview of the potential impacts climate change could have on the Great Barrier Reef. Designed for a general audience.
- Climate Change and the Great Barrier Reef
  www.gbrmpa.gov.au/corp_site/key_issues/climate_change
  Learn about the impacts of climate change on the Great Barrier Reef.
- Oceana climate campaign
  www.oceana.org/climate/home/
  Find out all about how climate change affects our oceans.
- ReefBase
  www.reefbase.org/
  Access data and information on the location, status, threats, monitoring, and management of coral reef resources in over 100 countries and territories.



Activity 1: *Sea level rise mapping*

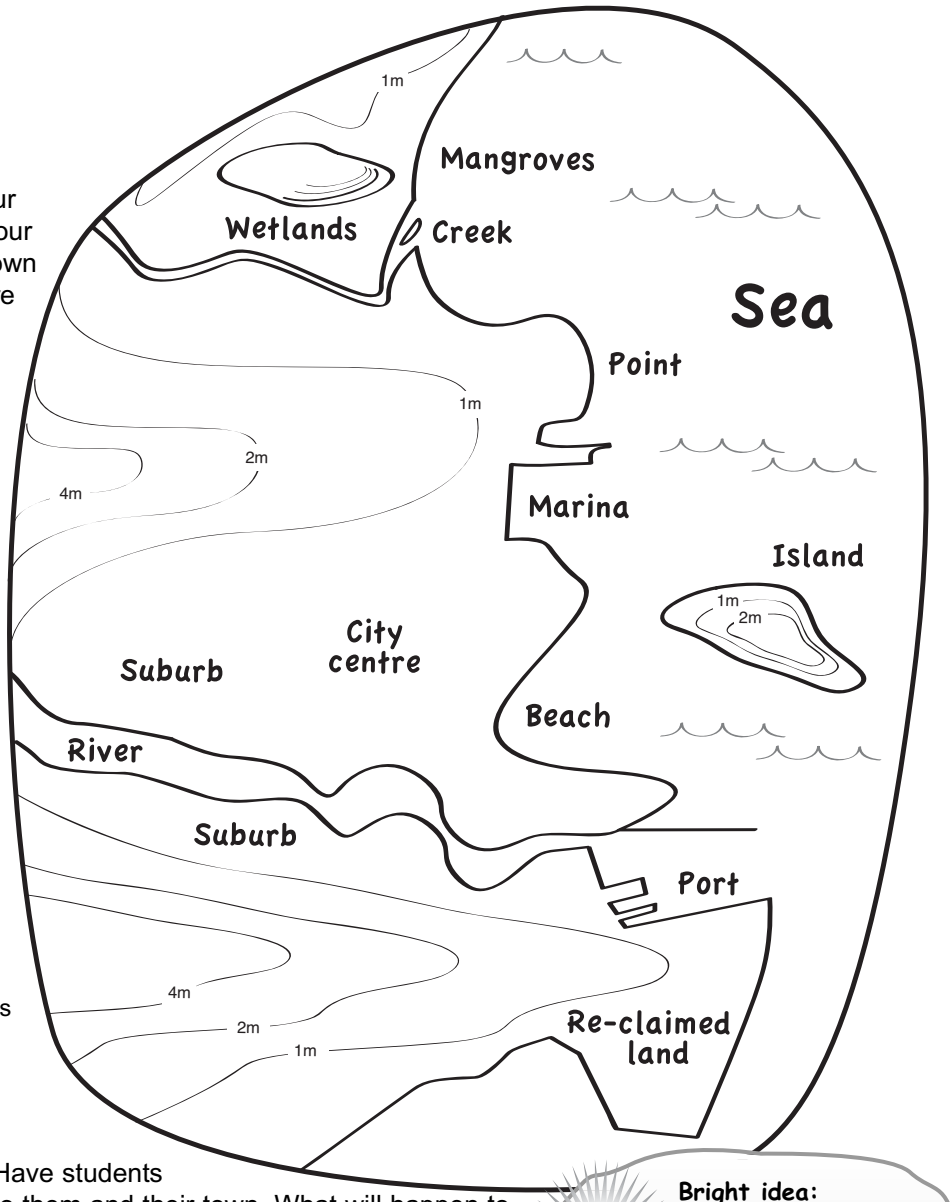
Key learning objective: Students will visualise sea level rise and understand its effects on coastal ecosystems and communities.

Background: Have students think about sea level. Which areas are most vulnerable to sea level rise? What types of ecosystems are most vulnerable in the Great Barrier Reef Marine Park? What marine animals or plants are most vulnerable? What about low lying islands? How much beach is left when the tide is high? What would happen if it were even higher? If students need prompting, consider reminding them of who/what lives at the beach or in wetlands and how they will be affected.

What you will need:

1. topographic map of your town (photocopied) or our example of a coastal town (maps for Townsville are provided in the Other Resources folder)
2. textas, pencils, or highlighters in a range of colours

Instructions: Have students look at the map to determine low lying areas. Their experiences should help with this. If the map isn't already coloured, get the students to colour in everything at or below sea level (to illustrate where water currently exists). The contour lines on the map indicate elevation. Using the below table of climate change predictions from the Intergovernmental Panel on Climate Change (IPCC), ask students to use different colours to indicate which areas will be under water by 2020, 2050, 2100 and in the more distant future.



A personal perspective: Have students consider what this means to them and their town. What will happen to your school or community if the ocean rises by one metre? What happens if this occurs in conjunction with king tides or a storm surge in your area? Flooding and severe weather are likely to increase with climate change. Will this affect your findings? Can you find your home on the map? When will your home be impacted by sea level rise?

Table 1. *Sea level rise projections if climate change continues at its current rate*

Projected change	**2020**	**2050**	**2100**	**Eventual sea level rise** (when ice caps melt)
Sea level rise	38 cm	68 cm	1 m	4-6 m*

*If climate change continues at its current rate, we could be committed to this 4-6 m rise by 2100. Based on palaeoclimatic evidence, however, this would take several hundred years to occur completely (e.g. not until 2300 or later).

Bright idea: The concept of parts per million (ppm) is important for students to understand how various concentrations of carbon dioxide will affect our planet. This is a difficult concept to visualise. Think of a creative way to help students conceptualise ppm (e.g. one coloured grain of rice in a million, one tree in a forest of a million, or one drop of coloured water in a million). Discuss the threshold levels of carbon dioxide and other greenhouse gases (in terms of ppm) and their potential environmental impacts. See Poster 3 for images of what the Reef could look like under various concentrations of carbon dioxide and ask students to conduct more specific research on how various ppm will affect coral reefs.

Activity 2: *Climate change futures wheel*

Key learning objective: Small changes in the climate can result in big changes on the Reef. After completing this activity, students will develop an understanding of the flow-on effects of climate change within coral reef ecosystems.

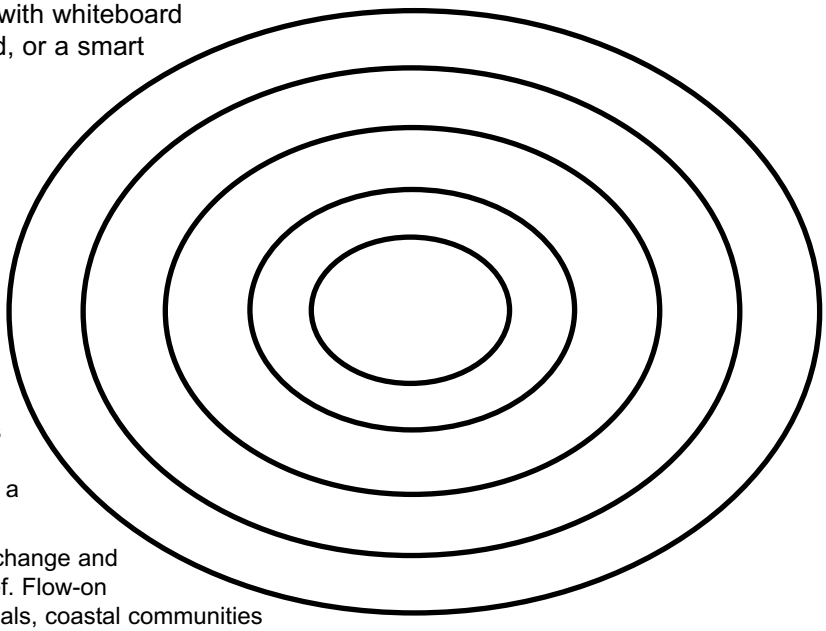
Background: Students should have a basic awareness about climate change and its potential impacts on the Reef. They may have already read

the first three posters and completed some of the activities.

Flow-on effects from climate change will impact every aspect of the ecosystem. For example, if corals are wiped out by bleaching, fish and invertebrates will lose their homes. If plankton is affected by ocean acidification, the entire food web could be destroyed.

What you will need:

1. butcher's paper, clear glass (with whiteboard pens), a black or white board, or a smart board



Instructions:

A futures wheel is a visual way of brainstorming a complicated topic. The topic or issue is placed in the centre, and the consequences placed in the next ring. The knock on effects of these consequences in the next ring, and the final ring would be the likely long-term outcomes of the series of events. The final ring might contain the long-term worst and best case scenarios. You could also divide the wheel in two halves with the 'worst' and 'best' case outcomes on either side. This activity may be completed in a class, in small groups or as individuals.

Students should discuss the topic of climate change and focus on its impacts on the Great Barrier Reef. Flow-on effects would include impacts on plants, animals, coastal communities and reef-related industries.

If the students need prompting, try incorporating the following discussion questions in the brainstorming activity:

- What might happen to Queensland reef industries (like tourism or fishing) if the Reef is not as productive or pretty as it once was?
- What might happen to coastal towns, marinas, wharves, ports and jetties if sea levels rise?
- What might happen to beaches, mangroves, rivers and wetlands if sea levels rise?
- What might happen to towns in cyclone prone areas (including all of Queensland) if the severity and frequency of storms increases? What about islands?

Try to incorporate locally relevant questions or discuss specific impacts on your town or nearby marine ecosystems.

Bright idea: Show students the GBRMPA animations 'Impacts of Climate Change' (provided on Reef Beat DVD) and run a class discussion on shifting baselines and how this idea applies to the Reef. What does shifting baselines mean? A baseline is a reference point from the past – how things used to be. If we allow these reference points to shift, we lose track of our standards and eventually accept the degraded state as being 'natural'. For example, what if people of the future only ever see a bleached reef? How will they know what reefs used to be like? If we don't know what reefs used to be like, how can we know how healthy they are today? Discuss the ways in which climate change could alter the Reef and come up with ways to ensure that future generations never lose sight of the benchmark or reference we have today. What are some ways to measure the state of the Great Barrier Reef as it is today and preserve this knowledge for the future?

Reef Beat Poster 4 – Ocean acidification

Key messages of Poster 4: The key issue in this poster is the fact that changes in ocean chemistry are likely to have a huge impact on corals, shelled animals and plankton (which form the basis of marine food-chains). Ocean acidification is already slowing coral growth and is expected to make corals, shells and some animal skeletons brittle and fragile. It may also impact larval development.

Related resources:

- Reef Beat Poster 4
- 'Ocean acidification' animation (provided on Reef Beat DVD)
  www.gbrmpa.gov.au
  www.reefed.gov.au
- Natural Resources Defense Council
  www.nrdc.org/

  The Natural Resources Defense Council contributed to the ocean acidification poster. Explore issues relating to global warming and the effects on our oceans.
- Ocean acidification network
  www.ocean-acidification.net/

  This site is quite technical but has lots of good information.
- Australian online coastal information
  www.ozcoasts.org.au/indicators/ocean_acid.jsp
- Ridgeway School pupils create climate change animation
  www.youtube.com/watch?v=4HZNhIc2wQ8

  A great claymation on ocean acidification. Created by students for students. Also a good idea for a class project.
- Impacts of ocean acidification on coral reefs and other marine calcifiers
  www.ucar.edu/communications/Final_acidification.pdf

Activity 1: *Grow a sugar reef*

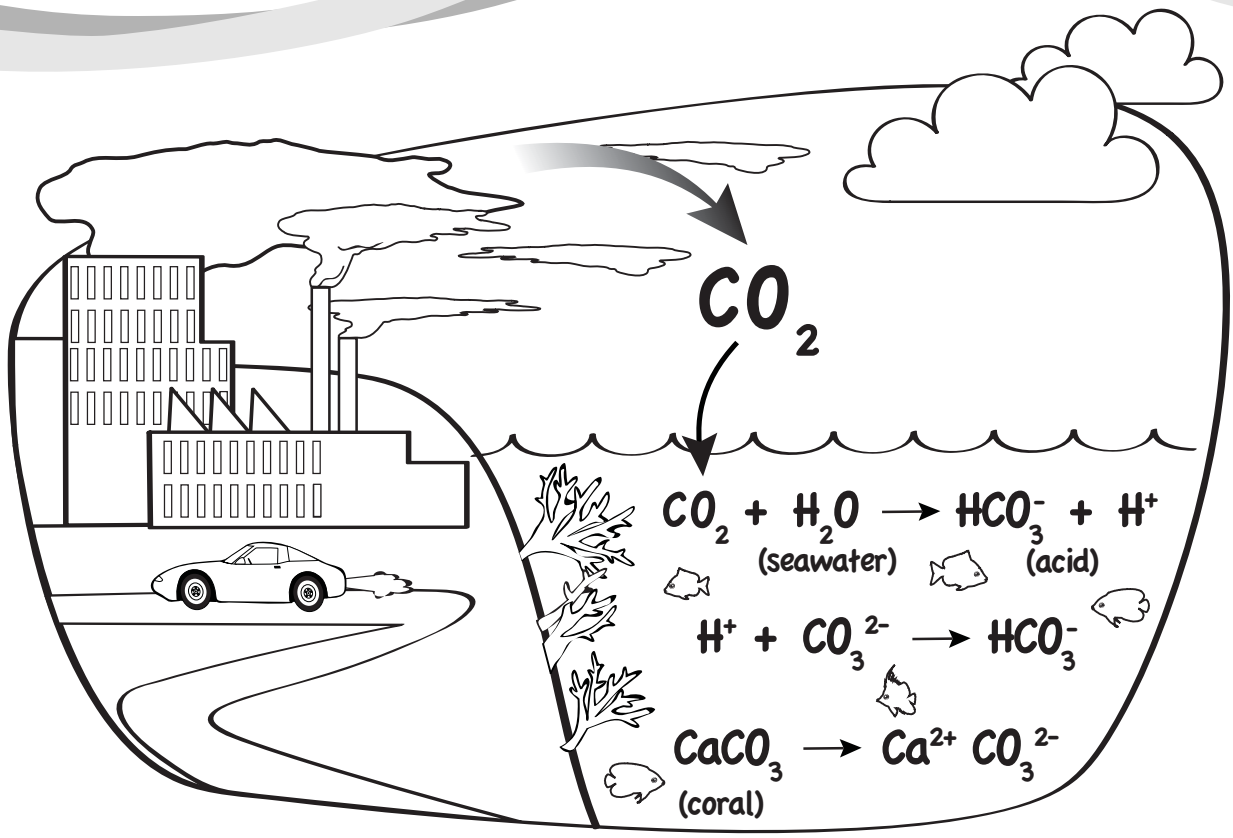
Key learning objective: Students will gain an understanding of how corals grow to form a reef and will learn about the impacts that ocean acidification will have on coral growth. This activity offers an excellent introduction to acid-base chemistry and can easily be incorporated into a chemistry unit.

Background: Corals use a mineral called calcium carbonate ($CaCO_3$) to make their skeletons (other marine animals need calcium carbonate to form their shells). This is similar to teeth and bones needing calcium to be strong. Calcium carbonate is naturally present in the ocean but ocean acidification is depleting this important mineral, causing shells and corals to become weak and brittle – the effect is similar to osteoporosis in humans. Here's what's happening on a chemical level:

Carbon dioxide (CO_2) in the atmosphere is absorbed by the oceans. When carbon dioxide is mixed with water it creates carbonic acid:

carbon dioxide (CO_2) + water (H_2O) = carbonic acid (H_2CO_3)

More carbonic acid (H_2CO_3) in the ocean is making it more acidic. This process is known as ocean acidification. As the oceans become more acidic, some of the calcium carbonate ($CaCO_3$) that would have been available for shell or coral-building, forms a buffer to neutralise the acid (H_2CO_3).



Chemically speaking, a hydrogen atom (H) from the carbonic acid (H_2CO_3) 'steals' the carbonate (CO_3) to form a buffer which will neutralise the acid. In this case the buffer formed is hydrogen carbonate (HCO_3) – also known as bicarbonate. You can think of a buffer as being in between an acid and a base. Buffers stabilise the pH of a substance even when acids or bases are added.

The series of chemical reactions that occur when carbon dioxide (CO_2) is absorbed by the ocean result in less calcium carbonate ($CaCO_3$) being available for shells and reef-building. This slows growth (calcification) of corals and shells. More acidic waters have already slowed growth of some corals on the Great Barrier Reef by 14 per cent since 1990.

As more and more carbon dioxide (CO_2) is absorbed and more carbonic acid (H_2CO_3) is formed, there will be a shortage of carbonate molecules for the acid to 'steal' from seawater. When the oceans become under-saturated with calcium carbonate, these molecules could be stolen from existing shells and reefs, causing them to dissolve.

In this activity, students will create a model 'reef' out of sugar crystals. The sugar ($C_{12}H_{22}O_{11}$) required to form the 'sugar reef' is equivalent to the calcium carbonate ($CaCO_3$) required to build corals. Without the sugar molecules, the rock 'sugar reef' would not be able to form.

What you will need

This activity should be completed in a science lab or a kitchen.

1. sugar (at least twice as much sugar as water)
2. water (the amount will depend on how many 'reefs' you want to make – about 1 cup of water per reef)
3. food colouring (optional)
4. rough cotton string
5. a stick or ruler to hang the string from
6. a heat-proof container (either a beaker or a saucepan)
7. a method of heating (either a bunsen burner or a stove)
8. a heat-proof jar or cup (to grow your rock candy in)

Instructions:

1) Add lots of sugar to boiling water (at least twice as much as the water). Keep adding sugar until the water can't hold any more. When some of the sugar remains undissolved that will indicate that the water is 'supersaturated' with sugar and can hold no more. As a guide, you should use roughly twice as much sugar as water. So for two cups of boiling water you would add at least four cups of sugar. You can also add food colouring to add colour to your crystals. This might be an opportunity to revisit Poster 1 and discuss how corals get their colours. (Removing coloured algae from the water is kind of like the sugar crystals taking up colour from the water).

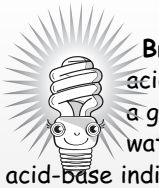
2) Prepare your string by dipping it into the sugar solution and letting it dry.

3) Suspend the string in the water (you can tie the string to a stick laid across the top of your jar or cup). This provides a substrate on which the sugar crystals (which represent corals) can form. A stick or skewer can be used instead of a string. Like sugar crystals, corals also require clean substrate to 'settle' and grow on.

4) After several days you should see sugar crystals forming on the string. It could take a week for the crystals to develop fully. After the crystals have formed there will still be sugar in your solution. Try to make another batch from the same sugary water, however, the process is likely to be slower, if not a dud, without replenishing the sugar concentration.

Discussion: Generally speaking, coral-building and shell-making follow a similar process to the sugar reef-building. The oceans are supersaturated with dissolved calcium carbonate. Shell-making creatures, from tiny plankton to giant clams, use calcium carbonates to make shells. Following up this activity with a discussion about the similarities between the sugar reef experiment and coral-building, will help students visualise the impacts of ocean acidification on corals and shelled creatures. Here are some good discussion questions:

- How does ocean acidification affect levels of calcium carbonate?
- What types of animals have a shell or an external skeleton (exoskeleton) that might be affected by a lack of calcium carbonate?
- What is likely to happen to these animals as calcium carbonate is removed from the oceans?
- How will a lack of calcium carbonate affect oceanic food chains?
- Every time we start a car or turn on the lights, one-third of the carbon dioxide we emit is absorbed by the ocean. How can we all do our bit to halt ocean acidification?



Bright idea – Ocean acidification in a jar. Fill a glass jar with tap water. Add some coloured acid-base indicator such as bromothymol blue to the water until you get a rich colour (a few millilitres of indicator should be suitable for one cup of water). Bromothymol blue is commonly used in classroom experiments and goes from blue (basic) to green (neutral) to yellow (acidic). Your indicator will show you if the water is basic. If you are using bromothymol blue, stop adding your base when the water turns slightly blue. If it is acidic, add dilute sodium hydroxide until it is just slightly basic.

Next, blow into the water using a straw. The water will absorb the carbon dioxide from your breath and will gradually turn more acidic. Students will be able to see when the water becomes acidic by watching the colour change. Explain that the oceans absorb carbon dioxide from the atmosphere in a similar way and this extra carbon dioxide is making them more acidic. This is a good activity to start your ocean acidification unit with as it provides a simple and visual demonstration of the problem. You may wish to ask students to recall what produces carbon dioxide (from Poster 1). This experiment also demonstrates simple acid-base chemistry and could be incorporated into a chemistry unit.

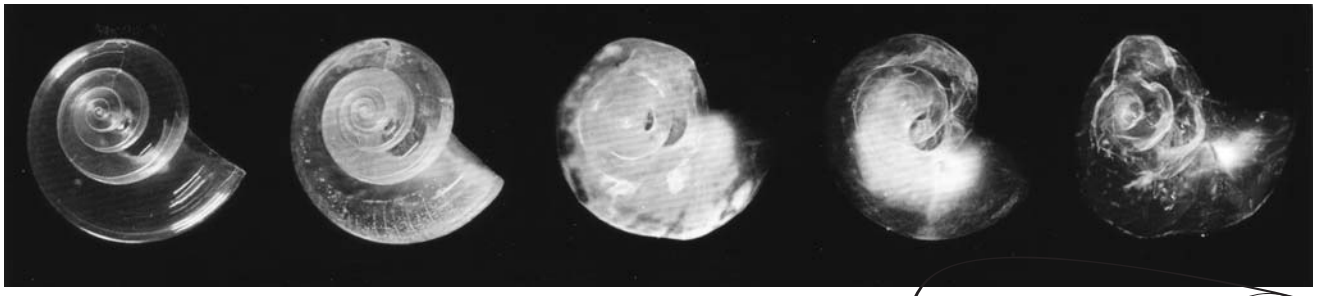
Activity 2: *The rubber egg experiment*

Key learning objective: Students will be able to visualise what could happen to shells and corals in more acidic waters. The rubber egg example is just one possibility of what could happen and is probably an extreme example but this experiment clearly shows a reaction between calcium carbonate shells and acidic waters.

Background: As discussed in the previous experiment (see Background for Activity 1), corals and other marine animals use a mineral called calcium carbonate ($CaCO_3$) to make their skeletons and shells. Carbon dioxide (CO_2) in the atmosphere is absorbed by the oceans. When carbon dioxide is mixed with water (H_20) it creates carbonic acid (H_2CO_3). More carbonic acid (H_2CO_3) in the ocean is making it more acidic. More acidic waters deplete the oceans of calcium carbonate ($CaCO_3$), causing coral skeletons and shells to become brittle, break and even dissolve.

What you will need:

1. hard-boiled eggs (raw eggs can be used as well but will be messy)
2. an acidic substance (e.g. vinegar, soda water, cola, orange juice or lemon juice)



Instructions:

1) Fill a container with your acidic substance (you might like students to trial a range of substances). You could also introduce the concept of a scientific 'control' and fill one container with plain tap water (to make sure the same outcome won't occur in any liquid).

2) Measure the pH of your substance using litmus paper or a pH test kit. You might like students to consider how the pH is related to the time it takes for the shell to dissolve.

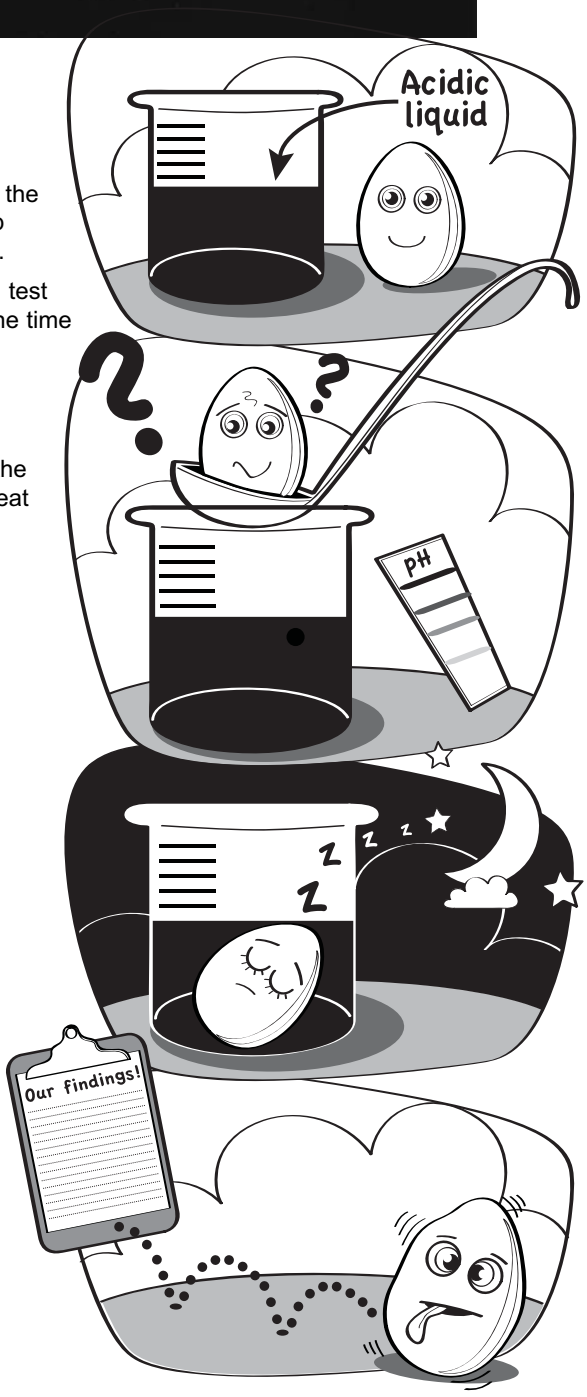
3) Rest the egg in the weak acid overnight.

4) Remove and rinse the egg and record your findings.

Discussion: You have just witnessed an acid at work. Just like the acid dissolved the calcium carbonate egg shell, an acid will also eat through a snail shell or a coral colony. Here are some good discussion questions:

1. What happened to the egg shells? Why?
2. Was there a difference depending on the pH of the substance used?
3. How is pH related to ocean acidity?
4. What does a lower pH mean for marine organisms?
5. How are the atmosphere and the ocean connected?

Bright idea: Have students create their own coral reef ecosystem using recycled materials. Each individual should contribute a component of the system which should work together as a large, three-dimensional reef scape. Encourage the use of rubbish and recycled materials over new materials.



Reef Beat Poster 5 – Corals: living history books of the sea

Key messages of Poster 5: The key messages in this poster are that corals can live to be hundreds of years old. Long-lived corals have witnessed a range of environmental changes and have been used to help construct global climate records. Evidence of climate change has been captured in the skeletons of corals on the Great Barrier Reef.

Related resources:

- Reef Beat Poster 5
- Australian Institute of Marine Science
  www.aims.gov.au/docs/research/climate-change/climate-history/climate-history.html
- Ice Cores and Climate Change - Australian Antarctic Division
  www.aad.gov.au/default.asp?casid=1760
- Studying climate change using tree rings
  www.priweb.org/globalchange/climatechange/studyingcc/scc_01.html

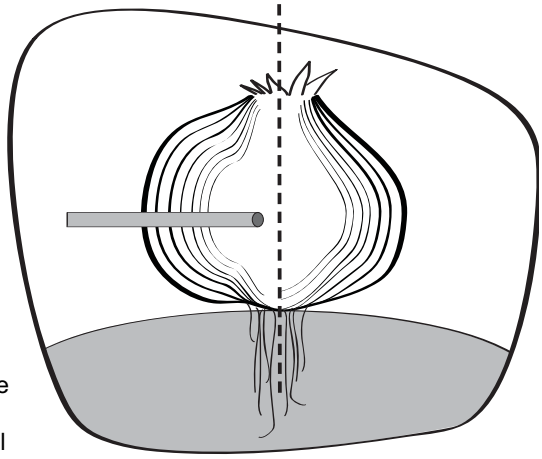
Activity 1: *Coral timeline*

Key learning objective: Students will examine coral cores from the perspective of a climatologist. They will learn how corals grow and how information from coral cores can be used to understand climate and other environmental changes. Students will map their own timeline on a coral core in order to visualise the age of corals.

Background: Corals are colonial organisms with hundreds of thousands of soft bodied coral animals held together by a single coral skeleton (like a number of people living together in the same apartment complex). Massive corals (like the porites bommies pictured in Poster 5) grow in layers. Coral polyps (the soft bodied coral animals) grow on top of already formed coral skeleton, ever outward towards the sunlight. Corals grow in much the same way as trees and like trees, corals deposit annual growth bands that can be detected using x-ray. Lots of information is stored in these growth layers, making corals living history books. Coral skeletons contain information about past climates, rainfall, levels of sediment on reefs and many other environmental conditions. By examining images of coral cores, students can practice thinking like climatologists.

What you will need:

1. an image of a coral core (provided)
2. an onion
3. an apple corer, hollow metal tube, cork borer or any other device that can be used to take a core sample



Instructions:

1. Brainstorming: Discuss the concept of long-lived corals and ask students to brainstorm the concept of historical weather patterns being locked up in ice cores, tree rings and coral skeletons. What kind of information do they contain? How might this information be captured by the tree etc? How might scientists access this information? (answers could include imagery such as x-ray, physical measurements of growth, chemical analysis of the material in each growth ring, etc.) Have students check the glossary for any foreign words.

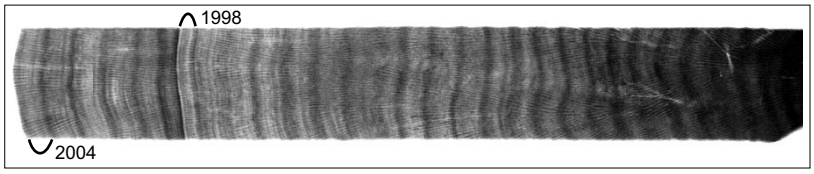
2. Taking a core sample: Ask the students to think about how scientists would go about extracting a core from a massive coral (it's pretty tricky business). Ask them to think about what might happen if the core was taken from the side of the coral rather than the centre and how this could influence results. To illustrate the coring process, get students to take their own core sample using an onion. Each student should have half an onion and a coring device (you could also do this as a class or in small groups if you don't have enough

corers). You might ask students to take one core from the centre of the half onion and one from the side.

3. Collecting information from the core sample: You can ask the students to age their onions. An onion typically generates a new ring every 2-3 weeks (interestingly the number of rings in an onion are equivalent to the number of leaves it has). Ask them to think about what other types of information they could get from their onion growth rings (if they had access to a laboratory).

4. Creating a coral timeline: Provide students with a copy of the coral core image. Explain that one dark and one light band are equivalent to a year's growth. Explain that the years marked on the coral (i.e. 1998 and 2004) can be used as 'anchors' from which to build their timeline. Ask students to mark each year on their coral timeline. Then ask them to mark dates of interest. These could be reef-related, historical or personal (such as the year they were born).

5. Assessing the core sample against weather records: Once the students have marked years on the coral, ask them to conduct research to find historical weather records (e.g. extreme temperatures, flood or drought events) during the coral's life. Because the x-ray image will only show coral growth, students should look at the core to see if weather events have had a visible impact on growth. If there is no visible impact, ask students about other ways of detecting impacts of weather.



Coral stopped growing during the 1998 bleaching event

Discussion:

- Why might coral growth be affected by flood years? Drought years?
- Can you think of any other source of information about past climates? (e.g. glacial records, instrumental records, geological records, etc).
- Why do glacial cores go back further in history than coral cores?
- Who would use this kind of information? What would they use it for?

Bright idea: Building on the activity above, students could create a coral reef timeline using the coral core or the basic template below left. To understand that the history of coral reefs it is important to look at their development over a long time. Students will need to research the history of the Great Barrier Reef. Significant ecological and sociological events should be included (students should be asked to justify why they have included particular events). The scale of the timeline and the events that you deem to be significant are up to the class to decide.

6000 years ago
Sea level stabilised

settlement along
QLD coast

Coral reef timeline

Discussion:

- What key industries or activities have had an effect on coral growth and health (e.g. agriculture, tourism, fishing, etc.)?
- Which technological advances have been relevant to climate change?
- What positive influences or developments have occurred in the last 200 years to assist the future health of coral reefs?

Reef Beat Poster 6 – Something fishy going on here

Key messages of Poster 6: The key issue in this poster is that in addition to corals and other invertebrates, climate change will affect other animals like fish. Fish have a range of roles in the ecosystem (including important roles in the food web and as a food source for humans) and different fish will be affected differently by climate change.

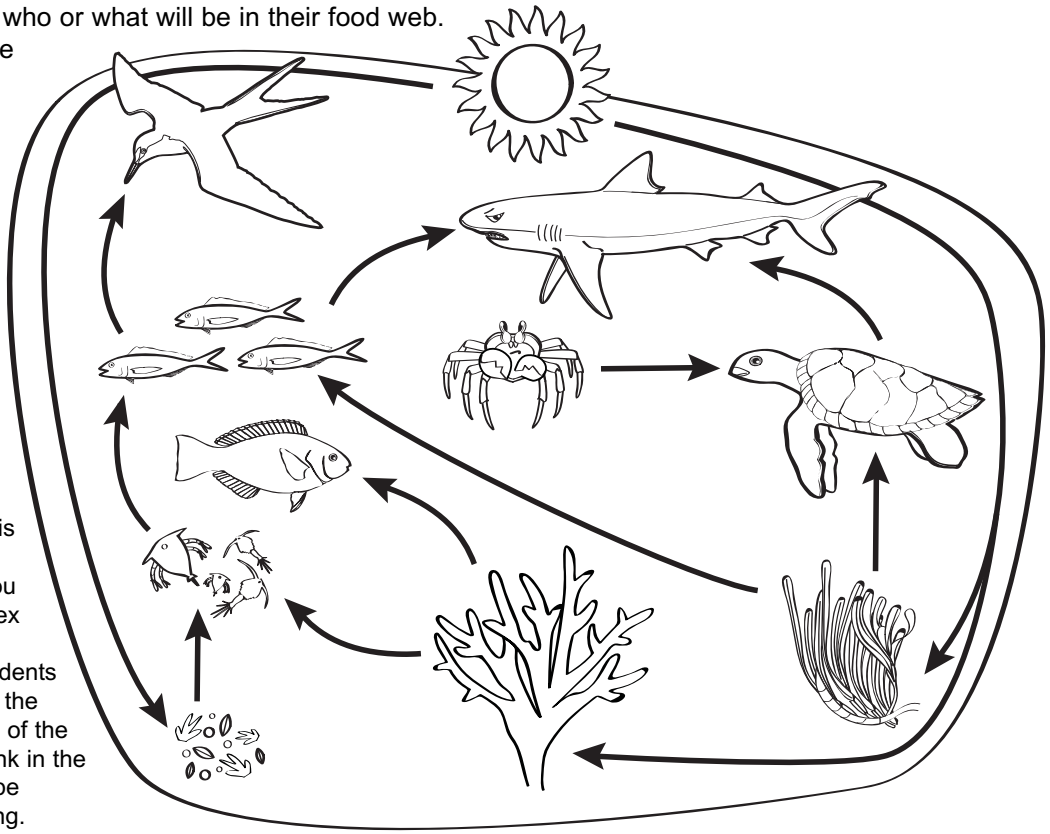
Related resources:

- Reef Beat Poster 6
- Sea around us – fisheries and biodiversity
  www.seaaroundus.org/
- Global currents and terrestrial biomes
  www.theglobaleducationproject.org/earth/global-ecology.php
  Great site with loads of information about ocean currents as well as fisheries.
- Ocean currents, climate and weather
  www.can-do.com/uci/lessons98/Raft.html
  In depth look at how weather and ocean circulation works – includes movies.

Activity 1: *Food web activity*

Key learning objective: Students will be able to visualise what happens when a food web is disrupted. Students will learn how marine food webs are linked and how breaking down only one element can have catastrophic effects on the entire ecosystem. This will demonstrate some of the impacts climate change may have on fish and on the marine food web.

Background: Students need only have a basic understanding of oceanic food webs. Students can decide for themselves who or what will be in their food web. Don't forget to have the source of the original energy – the sun!



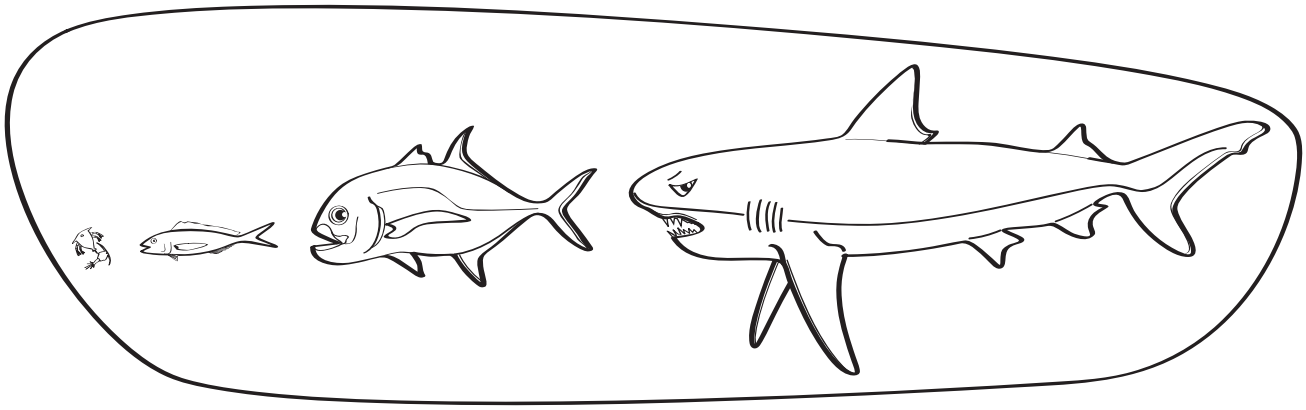
What you will need:

1. big ball of string
2. scissors
3. imagination

Instructions:

- Have students discuss who and what is in a coral reef food web. This can get as complicated as you like – it's a complex thing after all!
- Have different students represent each of the different elements of the food web. Each link in the food web should be connected by string.

- Keep connecting the links (based on who eats who) until you have a very complicated web.
- Next, stage a 'climate change' event. You can use a different one each round. These could include things like: rising temperature causing coral bleaching or algae outbreak, ocean acidification, sea turtle or sea bird nesting failure, or a shift in ocean current patterns.
- Cut the strings directly around the students involved in the event (i.e. the corals for a bleaching event; the shells, crabs or zooplankton for ocean acidification; sea turtles or bird for nesting failures, etc). Students not connected to anything anymore, sit down. You could also discus which parts of the food chain might increase (e.g. with a temperature rise corals would decrease while algae would increase… this means that things that eat coral decrease while things that eat algae could increase).
- Students connected to elements of the food web that are impacted are affected too and their strings are cut. Keep cutting more strings as more parts of the food web are affected.
- Eventually the whole food web should collapse (except maybe the sun and the seagrass or algae).



Discussion: Discuss how and why the food web changed and ultimately, collapsed. Depending on the year level, this discussion can be as simple or complex as you like. You could ask students to think critically about what coral reef food webs will look like under climate change scenarios. For example, scientists are predicting the following: less coral; more algae; fewer coral eating fish; perhaps more algae eating fish – although habitat and hiding places will be lost with the corals; less up-welling of cool, nutrient rich water resulting in less plankton, less food for fish, less fish for sea birds and less birds; and fewer sea turtles due to nesting failures (ask students to think about what eats sea turtles and their hatchlings – e.g. sharks, sea birds, large predatory fish). Discuss how changes to the marine food web could impact humans and how it may change our diet.

Activity 2: *Ocean circulation activity*

Key learning objective: In this activity students will understand that major ocean currents drive productivity in the oceans. They will develop an understanding of the impacts climate change will have on current circulation patterns and how resultant changes will impact fish, sea birds and the marine food web as a whole.

Background: Explain that ocean circulation patterns are likely to be affected by climate change. Ocean currents are very important. They drive the Earth's climate and they connect oceans to each other. Fish and other animals rely on ocean currents to bring them food and disperse their eggs and larvae. Ocean currents can make the air around them warmer or colder (this drives temperatures on land as well as in the sea).

Ocean currents are caused by differences in temperature and salinity between oceans. Currents travel from places where waters are very cold to places where waters are very warm. They also travel from very warm waters to very cold waters. Cold water from the deep ocean is full of nutrients and is an important source of food for millions of marine organisms – from tiny fish to massive whale sharks.

Increasing ocean temperatures and the addition of significant amounts of fresh water from melting ice caps, glaciers and increased storm events could cause a disruption in the patterns of ocean circulation, which in turn could lead to a breakdown in oceanic food webs.

What you will need:

1. the world map provided (you might wish to enlarge it and complete this as a group activity)
2. coloured pencils, pens or textas
3. access to a computer to research ocean circulation

Instructions:

- Have students research the temperatures of the world's oceans and colour in a temperature gradient on the world map in the centre of this book (there is an answer key on Poster 8).
- Ask students to keep in mind how currents move (e.g. from very warm waters to very cool waters and the opposite) and use a pencil, pen or texta to draw arrows on the map showing which way they think the ocean currents are going. When they are finished, they can check their answer on the key on Poster 8.
- As a follow on activity students may add the location of significant fisheries around the world to their map.

Discussion: You can conclude this activity with a range of discussion questions such as: How will currents change with global warming? How will temperatures on land change if ocean currents change? What will happen if cold, nutrient rich water is no longer available to fish and other animals? What kinds of ecological impacts could occur if the base (phytoplankton) of the food chain is smaller? How does ENSO (the El Niño Southern Oscillation) affect these currents?

Bright idea: Have students choose their favourite ocean-dwelling animal and write from the first person (the animal's perspective) a narrative about what is happening to their home. This should be a personal plight and include what people (those who live on dry land) can do to help that animal's future.

Reef Beat Poster 7 – Sea turtles

Key messages of Poster 7: The key issue in this poster is that climate change is affecting iconic marine species such as turtles. Rising temperatures and sea levels are threatening animals that nest on beaches.

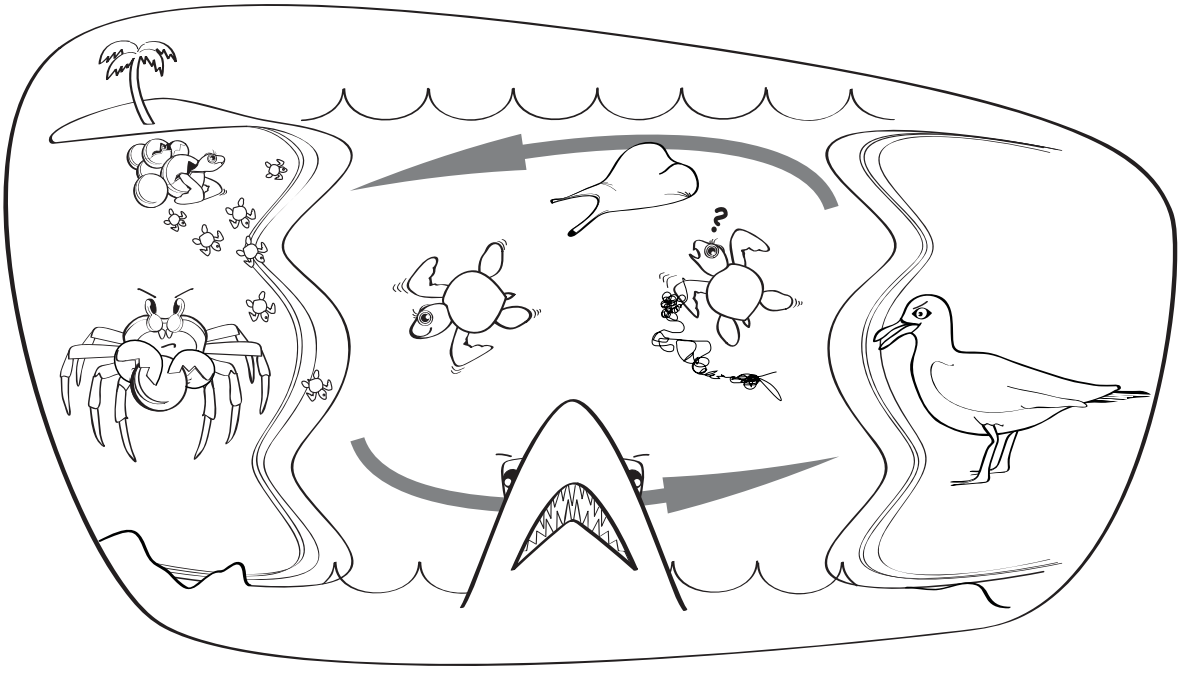
Related resources:

- Reef Beat Poster 7
- Indo-Pacific Sea Turtle Conservation Group
  www.aims.gov.au/ipstcg/index.html
- NOAA: Threats to turtles
  www.nmfs.noaa.gov/pr/species/turtles/threats.htm
  In depth information about threats to turtles in international waters.
- Project Aware: Turtles
  www.projectaware.org/kids/html/seaturtles.asp
  Targeted at younger students (primary), this site has activities, action ideas and art contests about the ocean.
- Caribbean Conservation Corporation – Threats to Sea Turtles
  www.cccturtle.org/sea-turtle-information.php?page=threats
  Plenty of detailed information about the threats that turtles face (in the Caribbean), this is not exactly the same as Australian issues – and there are some graphic images in there.

Activity 1: *Sea turtle survival game*

Key learning objective: In this activity, students will learn that turtles face a range of natural and human threats in their struggle for survival. Students will understand the compounding impacts climate change will have on turtle survival.

Background: All sea turtles are endangered or threatened. For a sea turtle, survival to adulthood means navigating through an array of hazards both natural and human related. Many turtle eggs are eaten by wild pigs, dingos and dogs before they even hatch! Once the hatchlings have emerged, they have to make it past hungry sea birds and crabs on the beach only to face ocean predators like sharks. Only about one in a thousand turtles that hatch actually make it to



adulthood. While the turtles are growing up, they must avoid ghost nets and plastic bags (which look like the jellyfish they like to eat) as well as boat strikes and sickness. If a sea turtle is fortunate enough to avoid all of these hazards and grow to adulthood, it will then face further climate change related threats. Rising sea levels and more frequent and severe storms due to climate change are eroding precious turtle nesting beaches. Increasing temperatures are changing the gender of hatchlings so that populations will have too many females. Eventually, turtle eggs could literally be cooked in their nests. Will turtle populations be able to survive the additional pressures of climate change?

The aim of this game is for students to realise that turtles face many pressures and the effects of climate change will make their life even more difficult. This easy game can be played with any age students.

What you will need:

1. a large area to run around in
2. a way of marking the 'beaches' (such as flags, plastic sports field cones or just people)
3. a whistle is handy too, it saves your voice

Instructions:

- Have a discussion with students about the threats that turtles face. Hopefully they will come up with a lot of the threats mentioned above.
- Some students begin as the turtle eggs. Choose some students to be dingos, dogs and wild pigs. The 'threats' (e.g. dingos, dogs, etc.) are in the middle between the beaches. When you yell "turtle transit" the 'turtle eggs' must run to the opposite beach and not get caught by the predators. Those students that get caught are out.
- In the second round the baby turtles have hatched and must get past the seabirds and the crabs on the beach (choose new students for these roles). Again yell "turtle transit" and the students try and get past the predators. Students that get caught are out.
- Continue playing the game adding new predators such as sharks or new threats such as plastic bags and boat strikes until you have only one lonely turtle left.
- You can include locally relevant threats and even name the 'beaches' in the game after your local turtle nesting beaches.
- You can also add in climate change issues to make the game more interesting for older students.
- Remember to discuss between rounds what happened to the turtles and what we could do to help alleviate human related threats.

Discussion: Discuss the overall threats to turtles and what compounding impacts climate change will have on these already vulnerable populations. Discuss what people can do to reduce threats to turtles and consider which of these ideas are relevant to your local area.

Bright idea: Plastic in our oceans is a major cause of turtle death. Help out turtles by reducing plastic use at school and at home or hold a beach or waterway clean up day. Consider working in partnership with a local business to provide 'turtle-safe bags'.

Activity 2: *Turtle awareness campaign*

Key learning objective: Students will understand the impacts climate change will have on nesting animals including sea turtles. They will link humans with the causes and solutions to climate impacts on turtles. They will use a creative approach to sea turtle conservation, thinking about how future management approaches may differ in a changing climate.

Background: Students will require a general knowledge of human threats to sea turtles. You might want students to conduct research into the impacts of climate change and other human activities on turtles before the class discussion. They can gather some information from Poster 7.

What you will need:

1. a white board to take notes on the brainstorming activity
2. creativity

Instructions:

As a class or in groups have students brainstorm creative ways to help turtles. Ask students to identify which actions would be undertaken by various groups of people (e.g. marine managers, home owners, developers, city councils, etc.). Ask the students to think about which actions fall within their circle of control or influence (what they have direct control or influence over). Ask the students to choose an action they have influence over and develop an implementation plan. For example, the action could be raising awareness about turtles and what people can do to help save them in the school or local community. There are lots of things students could do to raise awareness about turtles. While students should be given the chance to come up with their own ideas, we have included some suggestions here if they get stuck:

- Hold a 'go-green for turtles' day at school and get everyone to dress in green
- Create a brochure for local residents about saving turtles and distribute it through local businesses
- Reduce the number of plastic bags used by creating some eco-friendly 'turtle-safe bags'
- Join a turtle watch program
- Visit a turtle nesting beach like Mon Repos
- Support turtle hospitals by fundraising and donating to them
- Sponsor a recovering turtle at a turtle hospital
- Stencil your school or community stormwater drains with turtle safe slogans such as 'this drain leads to a turtle's dinner table'
- Ask your local radio station if you can record some community service announcements about how people in the community can help local turtle populations (e.g. go slow for those below)
- Paint 'turtle safe' messages on the bins in your school reminding people to make sure their plastic goes into the bin.

Once the plan has been implemented, ask the students to think about or evaluate its effectiveness.

Discussion: Some possible discussion questions include: Given that turtles are already under pressure, what impacts is climate change likely to have on them? What can we do to reduce pressures on turtles? What can marine managers do to reduce pressures on turtles? How much do people know about the threats to turtles? How effective was your plan to help turtles? What else could you do to help turtles?

Reef Beat Poster 8 – Seabirds are feeling the heat

Key messages of Poster 8: The key issue in this poster is the fact that there are many different types of sea birds that will be affected in different ways by climate change.

Related resources:

- Reef Beat Poster 8
- Coastal Birds of the Burdekin Dry Tropics
  www.nqdrytropics.com.au/
  This is a great identification guide to birds in the Burdekin Dry Tropics region. Available from NQ Dry Tropics.
- Migratory birds
  www.environment.gov.au/cgi-bin/sprat/public/publicshowmigratory.pl
  Some birds only visit our shores for part of the year as they travel across the world. Check out this website for a list.
- Birds you might live with
  www.birdsinbackyards.net/
  Information on what kind of birds might share your home.
- Townsville Region Bird Observers Club
  www.trboc.org.au/
  Find out about the birds that live in your area and how you might be able to attract them to your backyard.
- Australian Government – migratory waterbirds
  www.environment.gov.au/biodiversity/migratory/waterbirds/index.html
  Information on waterbirds, their flyways, threats to waterbirds and the conservation activities happening in Australia.
- Closer to Nature
  www.closertonature.com/outdoors/bird-migration.htm
  Answers questions such as how and where do these birds migrate to? The site also discusses survival strategies and bird adaptations.

Activity 1: *Getting to know your local birds*

Key learning objective: After completing this activity, students will better understand the impacts of climate change on their local environment. They will develop an understanding and appreciation of local birds and the threats they face.

Background: This is an activity that can be completed on school grounds, at a local park, at a national park, during a school camp, at a local wetland, at a beach or anywhere outdoors. Students may also want to compare bird life in different habitats (e.g. wetland vs. forest or natural vs disturbed habitat).

What you will need:

1. table for gathering bird information
2. bird watching resources and information such as the NQ Dry Tropics ‘Coastal Birds’ booklet or www.birdsinbackyards.net/
3. binoculars (optional)
4. camera (optional)

Instructions:

- First have students choose the habitat or area and complete a preliminary survey of the habitat.
- You may like students to find out what birds are present in your local area before they set out in order

to recognise them when they get there.

- Ask students to draw up a table (such as the one below) to record information about the birds.

Date	Location	Habitat type (e.g. wetland)	Main type of trees/shrubs	Birds present	Human impacts (e.g. weeds/rubbish)

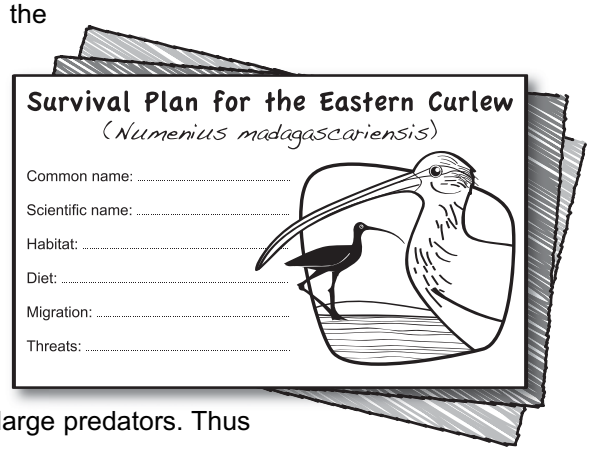
- Next, students collect observations of birds. They may wish to visit the area at different times of day to see if results vary.
- Ask students to create an inventory of local birds. As a class, you may like to create a bird identification book for your local area.
- Once students have compiled a local bird list, they can develop a local bird management plan. The plan should include information about local birds including where they are found, interesting facts, migration patterns (if a migratory species) and ideas about what the local community can do to help protect them.
- As a follow up activity, students could investigate which species of native trees will attract new birds to your school grounds. You could work with your local land care group, council, natural resource management agency or bird watching group to hold a tree planting day at school to attract birds to the area.

Discussion: Conclude this activity with a discussion of the pressures facing local birds. Extend the discussion to include consideration of climate change impacts and how these will affect local birds. Ask students to think about how the local ecosystem would change with the removal of birds.

Bright idea: Discarded fishing line, hooks, plastic bags, bait, rags and other fishing related litter can kill sea birds. Hold a responsible fishing day to raise awareness about responsible fishing practices including rubbish disposal. It's fun too!

Activity 2: *Development of species survival plan*

Key learning objective: In this activity students will learn how global processes such as ocean circulation, distribution of fish stocks and sea bird survival are intrinsically linked. By investigating climate impacts on a global scale, students will understand the need for a world wide solution to climate change.



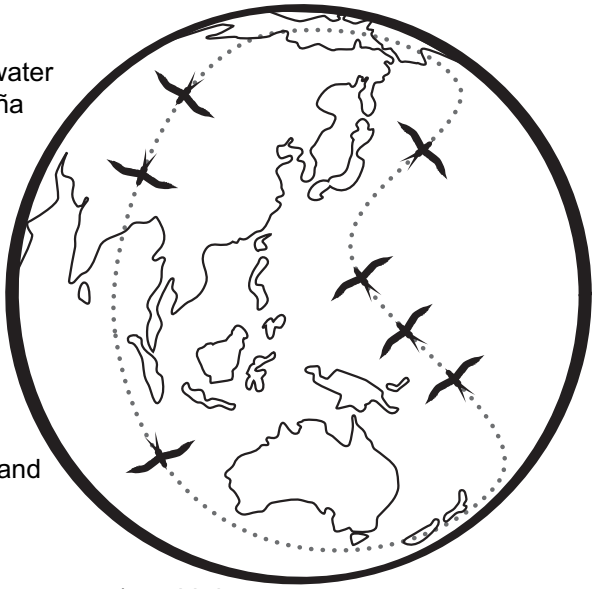
Background: Cold water from the bottom of the ocean (where no sunlight can reach it to warm it up) and from the Earth's poles is carried towards land by ocean currents. These waters are full of nutrients and many important and valuable fish species can be found in these areas. A good example of this is off the coast of Peru in South America where cold water from the deep ocean is pushed to the surface by ocean currents. These waters support millions and million of small fish. The small fish are eaten by bigger fish, sea birds, and other marine life. The bigger fish are eaten by sharks and other large predators. Thus the nutrient-rich waters are the basis for this food chain.

Seasonal shifts in ocean current patterns (like El Niño events) mean that fish and other creatures that rely on upwelling of nutrient rich waters, must move to follow their food supply. Similarly, migratory birds move to follow the large fish stocks they rely on for food. Because migratory birds are affected by climate and environmental changes on a global scale, protecting these species requires world wide solutions.

To understand how seabirds will be impacted by climate change, students need to understand how the climate phenomena of El Niño and La Niña work.

El Niño and La Niña

El Niño and La Niña are major temperature fluctuations in the Pacific Ocean. They are opposite phases of the El Niño-Southern Oscillation, which is like a giant 'see-saw' of the world's weather.



During El Niño a warm current of nutrient-poor tropical water replaces the cold, nutrient-rich surface water. The La Niña phase of the cycle usually comes soon after El Niño, bringing unusually cold water to the Pacific Ocean.

El Niño and La Niña may alternate between every other year and every three years so that the time from one El Niño to the next tends to be between three and seven years.

The hottest and longest El Niños and coolest La Niña on record occurred in 1997. El Niño/La Niña events usually last one to two years. Learning what happens during El Niño is helping scientists predict how animals and plants will respond to climate change.

What you will need:

1. a way for students to research bird migratory patterns (e.g. bird books or Internet access)
2. information on global current patterns, locations of upwelling, locations of major fish stocks.

Instructions:

- Have students select and research a migratory bird species (visit www.eaaflyway.net/ or www.environment.gov.au/cgi-bin/sprat/public/publicshowmigratory.pl for ideas). You might like students to choose a bird that visits your local region during its migration.

Some Queensland birds to choose from might include:

- Bar-tailed godwit *Limosa lapponica*
- Eastern curlew *Numenius madagascariensis*
- Common greenshank Tringa nebularia
- Grey-tailed tattler *Tringa brevipes*
- Red-necked stint *Calidris ruficollis*
- Students should complete a 'species survival plan' for their bird species that covers off on the following topics: migration route and timing, habitat preferences, food sources, threats (including potential climate change threats), legislation protecting the bird and possible ways to reduce threats.
- Your local bird watching club may be able to provide important information on migratory bird sightings in your region.
- Using the world map provided as the background, have students create a poster based on their species survival plan. The poster should present the birds' migration route (including distances and where the bird is found during different months of the year), illustrate the location of potential threats, indicate countries where legislation exists to protect birds, and include ideas for reducing threats and improving conservation of the species on the back or side of the poster.
- Ask students to present their posters to the class. This is good chance to practice public speaking skills as well!

Discussion: After students have presented their posters, engage the class in a discussion about what they have learned about the threats facing seabirds. Discuss how climate change will impact sea birds and what global and local solutions are needed to protect them.

Activity 3: *The Seabirds Game*

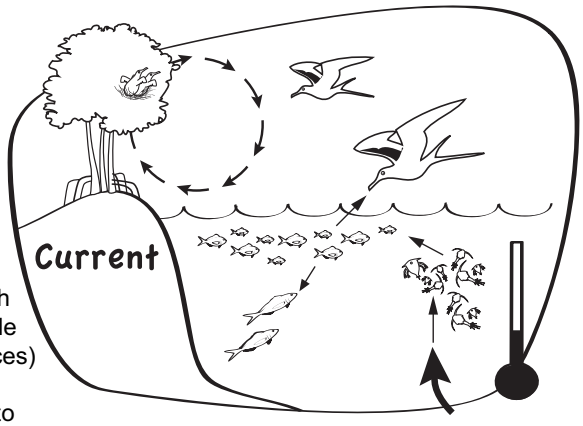
Key learning objective: Students will understand that climate change is making it more and more difficult for seabirds to feed their chicks (therefore the survival of their species).

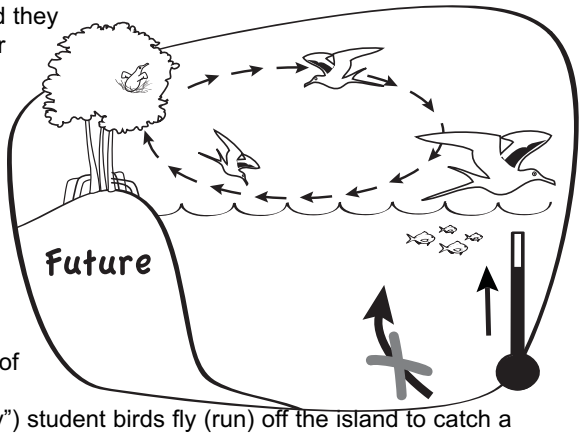
Background: Students need to understand that ocean current upwelling carries nutrient-rich water towards the land. The nutrients feed the plankton; small fish eat the plankton; large fish eat the small fish; seabirds, sharks and other animals eat the fish and so on, creating a food chain driven by ocean currents (which are driven by temperature and salinity). This information is provided in more detail in previous activities.

What you will need:

1. rope or chalk for your circle
2. game cards (sample game cards on page 38).

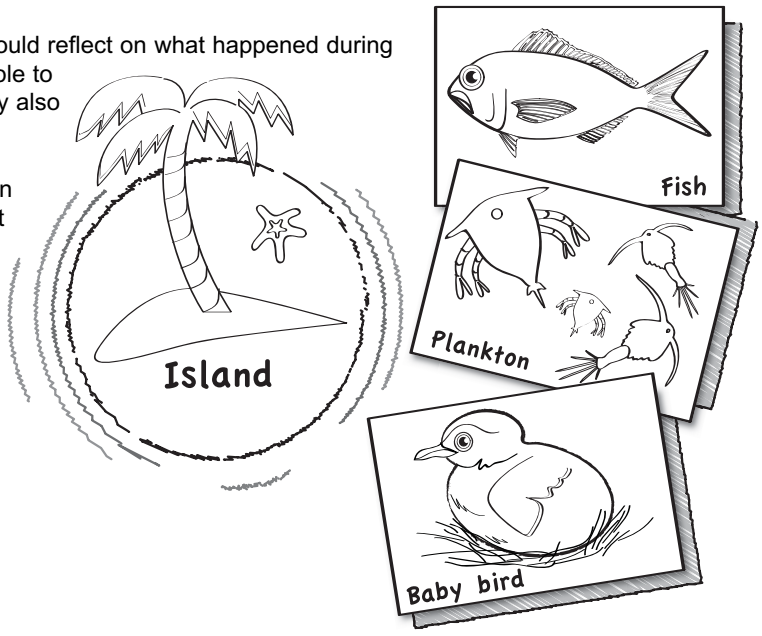
Instructions:





- Set up a large circle, either with rope or with chalk on the ground. The circle represents an island (the breeding ground for sea birds).
- Students may choose to be a certain type of bird, such as a sea eagle, or different students might play the role of different birds (some birds can fly for longer distances) which makes the game more complex.
- The students must fly off the island in search of food to feed their baby birds, if they fail to feed their baby bird they are out of the game. The students must collect fish for food (represented by the cards which you can disperse throughout the waters around the island).
- Food availability is determined by the nutrients, the nutrients are determined by ocean currents. Ocean currents cease to bring nutrients during warm years brought on by either El Niño or the impacts of climate change.
- Start with all of the birds (students) on the island.
- As the game begins, the time is today. There are plenty of nutrients around their island and therefore plenty of fish (scatter fish liberally around the outside of the island).
- On your command (maybe “the baby birds are hungry”) student birds fly (run) off the island to catch a fish for their baby.
- All the babies are fed and everyone is happy. Fish are handed back to you and you remove some. In the next round, climate change has forced a slight shift in ocean currents. The nutrients are now depleted (remove some nutrients as well) and further away from the island so there are less fish (which are also further away).
- Students run out to get fish for the babies and some inevitably miss out and these students are out of the game. To make the game more complex for older students, change the rules so that the first time a student misses out on fish, their baby dies and is removed from the island and the second time they miss out, they die. You can include some discussion here about nesting failure vs population decline.
- The game continues with climate change getting worse and worse and the fish getting fewer and fewer until there are no fish left.
- Make sure you discuss with students what’s happening to the birds, to the environment and to the food chain, throughout the game.

Discussion: The follow up discussion should reflect on what happened during the game and ways that birds might be able to adapt to climate change impacts. You may also like your discussion to focus on possible solutions or ways to delay the impacts of climate change on sea birds (e.g. if human fishing pressure was reduced, there might be more fish available for birds).



Reef Beat Poster 9 – A resilient reef is a healthy reef

Key messages of Poster 9: The key issue in this poster is the fact that there are a number of human pressures that are decreasing the overall health of the Reef and making it more vulnerable to climate change. There are also a range of management tools in place to limit stresses to the Reef and make it more resilient. Everyone has a role to play in keeping our Reef as resilient as possible.

Related resources:

- Reef Beat Poster 9
- Operation resilient planet game
  www.jason.org/public/curriculum/ORPGame.aspx?pos=1
  On-line game where students undertake a scientific research project based on environmental resilience. They will pilot remote operated vehicles, work with researchers, gather data and present findings to decision makers.
- Australian Marine Environment Protection Association
  www.ausmepa.org.au/
  When you visit the website just click on news and you will see the media release about the Ships and the Marine Environment plus the Ports and the Marine Environment education materials.
- Reef Resilience
  www.reefresilience.org/home.html
  The place to find information about building resilience into coral reef management strategies.
- Coral Reef resilience and resistance to bleaching
  data.iucn.org/dbtw-wpd/edocs/2006-042.pdf
  This PDF document is published by the Nature Conservancy, is very substantial and is suitable for teachers and older students.

Activity 1: *Getting in the Zone (reef management activity)*

Key learning objective: After completing this activity, students will learn about a range of human impacts on the Great Barrier Reef. They will become aware of problems and will be encouraged to think critically about potential solutions. This activity will give students insight into the challenges of managing a multi-use marine park that is important to many different groups of people.

Background: Human activities have a range of impacts on the Great Barrier Reef. Students can get an overview of these impacts from Poster 9 and may be able to conduct their research or brainstorm other human impacts. Managing a multi-use marine park like the Great Barrier Reef Marine Park, comes with lots of challenges especially considering that different groups value different aspects of the park. Students need to have a background understanding of these issues. This activity will require students to consider the value of the Reef from many perspectives and to think critically about the best ways to manage the Reef.

Students should have a basic understanding of Great Barrier Reef Marine Park zoning. Zoning maps and related information are available from the GBRMPA website www.gbrmpa.gov.au .The basic principle is that different activities are allowed in different zones. You might download the GBRMPA zoning map for your region and discuss what activities are allowed in what areas.

What you will need:

1. GBRMPA zoning map for your region (optional)
2. different hats or tags to represent affiliation with different marine park user groups

Instructions: Have students learn about the challenges associated with managing a multi-use marine park by managing their own marine park. Present students with the following scenario:

Your school has been declared a new marine park. For your marine park, called (insert the name of your school) marine park, you will need to determine what activities can occur in what areas. You need to determine if you will have no-take Green Zones to protect species and habitats or if your park will employ other management tactics. How will you manage fishing, shipping, research, recreation, tourism, and mining within the park? Can you think of other things people may want to do in the park? How will you balance environmental protection with human use? Develop a plan for your marine park. Form into teams to represent each of the stakeholder groups who would have an interest in your marine park and hold a 'public meeting' where everyone gets to express their opinions. Choose a group to run the meeting (e.g. the reef managers).

Stakeholder Groups

- Recreational fishers
- Commercial fishers
- Dive boat (tourism) operators
- Whale watching boats (tourism)
- Coastal business groups (hotels and restaurants etc.)
- Conservation groups
- Scientists and researchers
- Shipping businesses and port authorities
- Permitted marine collectors (such as aquarium fish collectors)
- Members of the general community (e.g. teachers, students, doctors, police officers, etc. – not necessarily people who use the Reef)
- Reef users (like recreational boaters, swimmers, divers, etc.)
- Reef managers

During the public meeting, have students discuss the proposed increase in Green Zones. You may decide to act as the chair of the meeting in order to keep the discussion focused. Here are some possible discussion questions:

- Why would increasing protected areas on your reef improve its resilience?
- What would happen to the fishing industry if zoning changed? What could be done about this?
- How would recreational fishers feel about potentially not being able to fish in their favourite spot? What could be done about this?
- Can zoning regulations be made fair for all groups? If so, how?
- Will there be changes to where shipping is allowed?
- How could you gain community support for this proposal?
- Can you think of other ways to improve the resilience of your reef?
- From the perspective of your designated group, do you support increased reef protection?
- What would make you support this proposal if you don't already?

Discussion: At the end of the public meeting, ask the groups to vote on the proposal and discuss the outcome of the vote. Was the proposal accepted or rejected by the majority of groups? Why? Do you think this was a good outcome?

Bright idea: Stage a series of class debates on the following topics with one group of students representing the group or person responsible for the activity (e.g. the shipping industry or a recreational diver) and the other representing the group responsible for managing the activity (e.g. the GBRMPA or a local council):

- Shipping is far too dangerous to occur on the Great Barrier Reef
- All fishing should stop immediately to save the Reef
- Climate change is the single greatest threat to the Reef
- There is nothing more we can do to save the Reef
- Tourism on the Reef does more harm than good
- Chemicals from farming are destroying the Reef
- Coastal development has no impact on the Reef.

To make this activity more relevant to your local region, get students to come up with the debate topics themselves, using local issues (e.g. a proposed development on important turtle nesting habitat). You might like to change the opposing groups (in the example above, one group could represent the turtles).

Activity 2: *Reef resilience game*

Key learning objective: Students will learn about reef resilience by visualising how reefs are damaged and then regenerated. Students will understand why healthy reefs are more resilient to impacts. Students will be introduced to the concept of reef connectivity and the idea that large networks of reefs are more resilient because they can 'help' each other regenerate from impacts. Connected reefs can share baby corals, fish and other animals through larval dispersal. Students will learn how human actions can help make reefs more resilient.

Background: Students need to have a basic understanding of impacts on the Great Barrier Reef. They should also be aware of some of the actions reef managers, industries and individuals are

taking to help combat these pressures. This information is available in the Reef Beat posters and activities.

What you will need:

1. blank cards (can be made of any material)
2. pens or pencils

Instructions: Based on what they know, have students brainstorm impacts on the Great Barrier Reef and actions that can be taken to address these impacts. Each individual action and each impact should be written on a card. The number of impact and action cards created is up to the class. Encourage students to think of locally relevant issues. If there are more impact cards than action cards, reefs will be in trouble. If there are more action cards than impact cards, reefs will be more resilient. Some examples are listed here:

Reef regeneration cards (positive environmental impacts)

- Your reef experiences a mild summer and no coral bleaching occurs.
- It's a bumper year for coral spawning and your reef corals are replenished.
- A dry season means less dirty water run-off has reached your reef.
- No cyclones this year, your reef is safe.

Impact cards (negative environmental and human-related impacts)

- A category five cyclone directly hits your reef.
- Major flooding occurs and your reef is covered in sediment.
- A ship runs aground. Oil is spilt on your reef and surrounding waters.
- Topsoil run-off and excess noise threatens animals due to a large marina being built near your reef.
- Temperature increases caused by climate change harm turtle populations on your reef.
- Overfishing occurs on your reef and fish populations decline.
- Water pollution from nearby farms impacts corals on your reef.

Action cards (positive human actions)

- International governments tackle climate change so corals on your reef are stronger this year.
- A Reef Guardian School planted 1000 native trees in their catchment, improving water quality on your reef and removing sediment from flood waters.
- A shipping disaster plan is in place and minimal damage to your reef occurs.
- An environmental impact assessment (EIA) is required for coastal development, your reef is resilient.
- Important turtle nesting beaches are protected by a National Park.
- No-take Green Zones are created on your reef and fish populations double.
- Farmers in your catchment switch to environmentally friendly herbicides and your reef is protected.

Bright idea: Learning about marine park zoning

Zones – Turn your school ground into a marine park. Mark out 'zones' on the ground using coloured string or chalk. Provide students with a GBRMPA 'activities guide' showing what activities can be conducted in each zone (the activities guide is available on all GBRMPA zoning maps). Discuss why zoning exists in the marine park (e.g. to protect plants and animals, to allow multiple uses to occur sustainably, to limit extractive activities, etc).

Fishing – Print and cut out the images of reef fish provided (page 40). The images are set up so that if they are printed to A0 scale size paper (841 mm x 1189 mm), the fish will be life size. This is preferable as it will allow students to accurately measure the fish and determine if they are legal to catch. Full size images will need to be printed professionally or on a large format printer. If you aren't able to print full size images, you can print the fish at any size and write an 'actual size' on the front of the fish (based on the size and bag limits provided). For example if you print a coral trout to 20 cm, take a look at the size and bag limits for the species, determine if you want the fish to be considered legal or illegal, then write an actual size for the fish that is either a few centimetres more or less than the size limit for that fish. Once you have printed the fish, print the size and bag limits and attach them to the back of the relevant fish. Distribute fish throughout the marine park zones.

Other activities – Print images (or get students to make cards) of other activities that people might like to do within the Marine Park (e.g. shipping, drilling for oil, diving, boating, filming movies, etc.). Distribute the fish and activities throughout the marine park zones.

Using the marine park – You can ask some students to be fishers and 'fish' for the fish (if they keep illegal fish, they can be intercepted and fined by a park ranger). Some students can be the park rangers and look for people doing the wrong thing in the wrong zones. Some students could be tourists or dive operators, some could be miners, or researchers. Remember to prompt lots of discussion about what is happening in the game and why. At the end, remind the students why zoning rules are in place and what would happen if they didn't exist. You might also like to discuss other management tactics such as fish size and bag limits or pollution regulations.

Break the class into pairs. Each pair is a 'reef'. Ask students to name their reef. Shuffle the action cards and distribute them equally to the reefs (try to give each team at least three actions). Give each team at least one reef regeneration card to use whenever they like (this is like a wild card that can be played at any time to help their reef regenerate). In each round a member of the team leaves to collect an impact card and bring it back to the team. The pair then determines whether or not they have an appropriate action to combat the impact. If the reef does not have an action card that is relevant to the current impact, part of the reef dies (i.e. one student sits down). The second time a reef is impacted, it dies completely and the second student sits down. Reefs can be regenerated using the reef regeneration cards (by turning a card into the teacher the reef can get one student back). In the first round, reefs are isolated and cannot help each other. Keep playing until there is only one reef left. In the second round, reefs may assist each other by sharing action cards (this is similar to how neighbouring reefs can help each other regenerate after an impact by 'sharing' baby corals, fish and other marine life). In the third round you may wish to create a supergroup – a network of reefs that can all assist each other when an impact happens. This shows how a larger reef is more resilient than a smaller reef.

Discussion: Discuss what happened during the game. What damaged reefs? What helped reefs regenerate? Why were healthy reefs more resilient to impacts? (e.g. because they had two students so when damage occurred, part of the reef remained healthy). Why were networks of reefs more resilient in the game? Why are networks of reefs more resilient in reality? (e.g. because they share baby corals and animals to regenerate populations). What were the impacts of both negative and positive human actions on the reefs in this game? How is this similar on real reefs? What did you learn from the game?

Activity 3: *Reef resilience drama*

Key learning objective: Students will visualise the concept of reef resilience by creating and presenting a dramatic interpretation of resilience. This activity will require students to use a creative approach to interpret what resilience means for coral reefs. Students will understand how reefs are damaged and bounce back from damage and the role of human actions in this process.

Background: Students should have an awareness of the fine balance that exists in a coral reef ecosystem. This balance can be upset by disturbance, but if the reef is healthy and resilient, the reef can bounce back to health. Students should be aware of impacts that can damage reefs and actions that can assist with reef recovery. The previous activity is a good segue into exercise.

What you will need:

1. coloured pens
2. paints
3. paper masks (use ReefED ones or make your own)
4. elastic to hold the masks on
5. costumes

Bright idea: Using the glossary provided, have students come up with real life examples of resilience, symbiotic relationships, adaptive management, or any other words or terms you choose.

Instructions:

- Discuss what resilience is and how a healthy reef can bounce back from a natural disturbance such as a cyclone, a heat wave or a flood.
- Discuss the impacts humans can have on coral reefs and ask the students if they think reefs are resilient to human impacts.
- Ask students to write a story or produce a play, interpretive dance, or other dramatic production that depicts reef resilience including impacts and regeneration. This could involve human-related impacts and positive actions and/or environmental impacts.
- The students may create masks or use costumes to represent different characters in the story.
- The stories could contain a message about resilience or what people can do to make reefs more resilient.
- Stage the play at assembly, parade, or to a group of parents in order to explain to your school and community what we can all do to help improve the resilience on the Great Barrier Reef.

Discussion: Ask students what they learned from this production. What kind of things impact reefs? What kind of things help reefs regenerate? What is the role of humans in this cycle? Ask students what messages they tried to convey in their creative production and why. Discuss other ways of helping the rest of the school or community understand the complex concept of resilience and how it applies to coral reefs.

Reef Beat Poster 10 – What you can do

Key messages of Poster 1: The key issue in this poster is that there are many things that everyone can do to help combat climate change. By working together, the little things we do can add up to big benefits for the Reef.

Related resources:

- Reef Beat Poster 10
- Home EnergyWise Kit, order one from the website
  www.dme.qld.gov.au/Energy/home_energywise_kit_1.cfm
  Energy efficiency information and self auditing tools to allow you to reduce your energy consumption.
- Carbon offsetting
  www.carbonoffsetguide.com.au/
  Find out more about carbon offsets and carbon management strategies.
- Carbon offsetting provider
  www.carbonconscious.com.au/site/?gclid=CJektea5yZkCFRwwawoddD4vuQ
  Carbon Conscious Ltd is an Australian company producing carbon credits through 'carbon farming' - the planting of Mallee Eucalypt trees in Australia's wheat belt region.
- Political climate change challenge for older students
  www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge/
  A game where you are president of the European Nations and must tackle climate change, whilst keeping the voters happy enough to keep you in office.
- Intergovernmental panel on climate change (IPCC)
  www.ipcc.ch/
  Objective information about climate change incorporating the latest scientific, socio-economic and technical literature produced worldwide.
- Conservation Volunteers Action for Climate Change
  www.actionforclimatechange.org.au/
  Action for Climate Change is a new program managed by Conservation Volunteers. It is a range of initiatives to assist business and individuals to reduce their impact on the environment.
- Taking it Global and the Youth Guide to Action on Climate Change
  www.climate.takingitglobal.org
  issues.tigweb.org/climate?gclid=CKeqzNqHypkCFRwDagod_BQCuA
  Online community of youth interested in global issues including a document to inspire, involve and inform young people about climate change across the world.
- Auditing tools
  www.sustainableschools.nsw.edu.au/Default.aspx?tabid=76
  www.environment.gov.au/education/aussi/resources.html
  www.greenlearning.ca/climate/solutions/work-and-school/5
- Estimate your ecological footprint
  www.powerhousemuseum.com/education/ecologic/bigfoot/bigfoot2007/
  www.earthday.net/footprint/index.html
  www.myfootprint.org/en/
  www.footprintnetwork.org/en/index.php/GFN/page/calculators/
  How much land area does it take to support your lifestyle? Check out these websites to find out your Ecological Footprint and learn what you can do to tread more lightly on the earth.

Activity 1: *What can I do?*

Key learning objective: Students will learn about specific things they can do to help reduce their impact on the environment and on the Great Barrier Reef. Students will gain an understanding of how their day to day choices impact the Reef.

Background: The health of the Great Barrier Reef is closely linked to the health of the environment as a whole. Many human activities have a negative impact on the environment. Our daily choices determine our environmental footprint (or impact). There are lots of choices we can make that will result in smaller environmental footprints and help reduce the impacts of climate change. These small actions can have big benefits for the environment and Great Barrier Reef. By working together with governments, industries and communities, every person can do their bit to help protect our Great Barrier Reef.

Instructions: Work with students to complete some or all of the following actions. Use the first activity here to have students learn about their ecological footprint. The second activity gives them a chance to conduct their own audit to see where their ecological baseline is. The third activity is about offsetting your carbon emissions, the fourth creates your own 'IPCC' and the fifth is a community-based strategy to become carbon smart.

Action: *Calculate your ecological footprint*

What you will need:

A footprint calculator that suits the age and learning style of your students (or you can trial a range) here are some good ones:

- www.powerhousemuseum.com/education/ecologic/bigfoot/bigfoot2007/
- www.earthday.net/footprint/index.html
- www.myfootprint.org/en/
- www.footprintnetwork.org/en/index.php/GFN/page/calculators/

Instructions: Students measure their ecological footprint individually or as a class.

Discussion: Consider how many planets would be required if everyone used the same amount of resources as you. Figure out ways of reducing your footprint and start doing them!

Follow-up activity: Have students trace their own footprint onto a piece of paper and cut it out. Inside this footprint have students write a pledge of something that they will do in the future (e.g. "I pledge to ensure that my appliances are off at the wall" or "I pledge to walk to school at least twice a week"). Put the footprints somewhere visible so that students remember to keep their pledge.

Action: *Audit your school and home*

What you will need: An auditing tool of your choice, there are lots online:

- www.reefed.edu.au
- Calculate your school's water, transport and energy use, as well as waste, recycling and paper purchasing.
  www.sustainableschools.nsw.edu.au/Default.aspx?tabid=76
- Sustainable future information and auditing tools.
  www.environment.gov.au/education/aussi/resources.html
- Work and School: Energy & Water Audits
  www.greenlearning.ca/climate/solutions/work-and-school/5

Instructions: Students conduct an audit of their school or home. The audit could focus on one area such as water, waste, energy or biodiversity or all of the above. You may need to use different audit tools for each different type of audit. You may want students to focus on one area at a time or make different classes responsible for different areas.

Discussion: Discuss the results of the audit. This is considered your 'baseline' or starting point. Discuss any

environmental actions that have already been taken. Do you think these affected your results? Think of ways of reducing the overall impact of the school or home. Carry out these ideas and then do another audit to see if you have improved.

Follow-up activity: Develop an achievable reduction goal and figure out how to get there. Assign student auditors to continue collecting data, conducting audits and reporting results to the class.

Action: *Learn about carbon offsetting*

What you will need:
Access to the Internet to learn what carbon offsetting is and find out about companies that provide offsets.

Instructions: Decide if you can offset your schools emissions and think up your own carbon offsetting project. You may be able to get some advice from companies that provide offsets. Implement your own offsetting program and report back to the school administration about the per cent of the school's impact(s) that are offset by your project.

Discussion: How many trees would you need to plant to offset the emissions of each classroom? You may need to audit the energy use of each classroom first. What are some other things you could do to offset your carbon emissions? (e.g. install solar power and sell extra power back to the grid, create a carbon sink at your school, purchase carbon offsets from a company, purchase green energy from your energy provider). In addition to carbon offsets, there are other types of offsets such as biodiversity offsets. Would trees confer a biodiversity benefit to your school grounds as well? Estimate the impact your school buildings have on local biodiversity and estimate how many trees (or what other habitats) would be required to offset this. What else could your school do to offset its impact on biodiversity (e.g. habitat for wildlife, get council approval to revegetate a nearby waterway or bit of vacant land, rehabilitate wildlife at your school).

Follow-up activity: Conduct a research project on carbon sequestration. Perhaps your school play ground could become a carbon sink?

Action: *Learn about alternative energy*

What you will need:
Access to the Internet to learn about alternative energy forms. Alternative energy forms can range from conventional (solar, water, wind) to complex (waste dump methane extraction, biofuels).

Instructions: Create your own alternative energy source (e.g. use bicycle power to power a generator, create a solar oven, or develop your own biofuel)

Discussion: Discuss how energy is extracted from natural sources and converted into electricity. What is energy? Where does it come from and where does it go? How is it related to electricity? Where does electricity come from? What is the difference between renewable energy and non-renewable energy? What are some examples of non-renewable energy? What is green energy? Why does green energy create less carbon pollution than other types of energy? Does your school use alternative sources of energy such as solar power? If not, think of ways new energy sources could be incorporated into your school or homes.

Follow-up activity: Get a solar panel for your school or find out what it would take to get your school off the community power grid. You could ask students to design a 'sustainable school of the future' based on their school and work towards achieving that design.

Action: *Hold your own talks on climate change*

What you will need:
Access to the Internet to find out about the Intergovernmental Panel on Climate Change (IPCC) www.ipcc.ch/ or the Kyoto Protocol

Instructions: Hold your own climate talks (e.g. IPCC meeting or international climate change summit). Have students form teams and represent different scientific perspectives or different countries depending on what types of talks you choose. You could provide students with different climate research or viewpoints to present at the talks and then ask the group to come to a consensus opinion (where everyone has to agree). You could then discuss the advantages and disadvantages of a consensus view.

Discussion: The talks may cover a variety of climate change related issues such as water (quality and availability), ecosystems (both terrestrial and aquatic/marine), food (import/exports), energy (sustainable, fossil fuels, biofuels, etc.), coasts (including impacts of sea level rise and increased storm frequency and intensity) as well as human health needs. When you have finished, discuss the process you used to host the meeting and the outcomes of the talks.

Follow-up activity: Have students research the present status of climate change talks.

Action: *Make your community a 'Carbon Smart Community'*

What you will need:
Creativity and motivation

Instructions: Discuss how you can inspire your community to reduce its carbon footprint. You might need a multi-staged approach such as:

1. make people aware of the issue
2. get people to change their behaviour
3. reward people for changing their behaviour and encourage further change

You may decide to use drama, music or information sheets to inspire people, or your may decide to engage people in an event like a tree planting day or a 'clean up our climate' day.

Discussion: How you can improve your community's climate cleverness.

Follow-up activity: Why not get your local council on board? Create a community garden, hold a council compost day, start a butt-busting program to raise awareness about cigarette butt pollution, or hold a clean up event somewhere visible in your community.

GLOSSARY OF TERMS

acid - scientists use something called the pH scale to measure how acidic or basic a liquid is. Although there may be many types of ions in a solution, pH focuses on concentrations of hydrogen ions (H+) and hydroxide ions (OH-). The scale goes from values very close to 0 through 14. Distilled water is 7 (right in the middle). Acids are found between a number very close to 0 and 7. Bases are from 7 to 14. An example of an acid is lemon juice.

acidification - the process of becoming acid or being converted into an acid.

adaptation - the adjustment of living things to environmental conditions. Human adaptation to climate change includes altering the way we grow crops, build homes, consume energy, and manage natural resources. An animal adaptation might be a parrot fish beak like mouth that helps it to scrape algae off rocks efficiently.

adaptive management - adaptive management (AM), also known as adaptive resource management (ARM), is a structured, repetitive process of best possible decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously maximises one or more resource objectives and, either passively or actively, accrues information needed to improve future management. AM is often characterised as "learning by doing."

base - scientists use something called the pH scale to measure how acidic or basic a liquid is. Although there may be many types of ions in a solution, pH focuses on concentrations of hydrogen ions (H+) and hydroxide ions (OH-). The scale goes from values very close to 0 through 14. Distilled water is 7 (right in the middle). Acids are found between a number very close to 0 and 7. Bases are from 7 to 14. An example of a base is laundry detergent.

calcium carbonate ($CaCO_3$) - is a common substance found in rock in all parts of the world, and is the main component of shells of marine organisms, snails, and eggshells.

carbon cycle - the constant movement of carbon through living things, rocks, the oceans, and the atmosphere.

carbon dioxide (CO_2) - is a colourless, odourless gas that is naturally present in the atmosphere. This gas is produced in large quantities by burning plants and fossil fuels, as well as being present in the air that all animals exhale.

carbon footprint - a carbon footprint is the total set of GHG (greenhouse gas) emissions caused directly and indirectly by an individual, organisation, event or product. An individual, nation or organisation's carbon footprint is measured by undertaking a GHG emissions assessment. Once the size of a carbon footprint is known, a strategy can be devised to reduce it.

climate - the average long-term weather (commonly years) in a particular region.

climate models - computer programs that enable scientists to investigate the many factors at work in Earth's climate system. By manipulating variables such as the amount of CO_2 in the atmosphere, scientists try to understand how the climate will respond.

climatologist - a scientist who studies the climate.

coral bleaching - coral bleaching occurs when the coral host expels its zooxanthellae.

coral polyp - soft-bodied, invertebrate animals that form the basis of coral reefs.

cyclone - in meteorological terms, a cyclone refers to an area of closed, circular fluid motion rotating clouds and energy. This is usually characterised by inward spiraling winds that rotate counter clockwise in the Northern Hemisphere (a hurricane) and clockwise in the Southern Hemisphere (a cyclone). Large-scale cyclonic circulations are almost always centred on areas of low atmospheric pressure.

data - refers to pieces of information or facts usually collected as the result of experience, observation or experiment, or processes within a computer system. They may be numbers, words, or images, particularly as measurements or observations of a set of variables. Data is often viewed as the building blocks of knowledge.

ecosystem - a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment.

ectotherm - an organism that regulates its body temperature largely by exchanging heat with its surroundings. A cold-blooded organism also called a poikilotherm.

El Niño - El Niño-Southern Oscillation (ENSO; commonly referred to as simply El Niño) is a global ocean-atmosphere phenomenon. The Pacific Ocean signatures, El Niño and La Niña are important temperature fluctuations in surface waters of the tropical Eastern Pacific Ocean.

endangered - a species is endangered when it is considered to be facing a very high risk of extinction in the wild.

endemic - animals or plants that are found only in one locality or region.

fossil fuels - coal, oil, and natural gas, which formed from the remains of organisms that lived millions of years ago.

global warming - an increase in the average temperature at Earth's surface caused by the buildup of greenhouse gases in the atmosphere.

green - a colloquialism referring to an individual or activity that is positive for the environment.

greenhouse effect - the process by which an atmosphere warms a planet. This takes place when gases allow sunshine to pass through the atmosphere but absorb the heat that radiates back from the surface, keeping it warm.

greenhouse gases - gases that increase global temperatures by absorbing the radiation emitted by Earth's surface. Carbon dioxide is the most important greenhouse gas as far as climate change is concerned. Other greenhouse gases include water vapour, methane, and nitrous oxide.

Intergovernmental Panel on Climate Change (IPCC) - an international scientific panel tasked to evaluate the risk of climate change caused by human activity.

invertebrate - an animal that does not have a vertebral column or backbone.

La Niña - El Niño-Southern Oscillation (ENSO; commonly referred to as simply El Niño) is a global ocean-atmosphere phenomenon. The Pacific ocean signatures, El Niño and La Niña are important temperature fluctuations in surface waters of the tropical Eastern Pacific Ocean.

mass coral bleaching - when many corals over a large area bleach at once.

marine scientist - is qualified at university to do a job which involves researching the sea, its life forms and surrounding coastal areas. They analyse the sea and its interaction with the land, atmosphere and sea floors. They apply their knowledge for use by, among others, governments, universities and environmental assessment bodies.

methane (CH_4) - a colourless, odourless, flammable gas produced by a variety of natural sources, including microorganisms, cattle, and termites.

nitrous oxide (N_2O) - a colourless gas or liquid produced by the combustion of fossil fuel.

ocean acidification - is the name given to the ongoing decrease in the pH of the Earth's oceans, caused by their uptake of anthropogenic carbon dioxide from the atmosphere. Between 1751 and 1994 surface ocean pH is estimated to have decreased from approximately 8.179 to 8.104 (a change of -0.075).

offset (carbon offset) - is a financial way of representing a reduction in greenhouse gas emissions. Carbon offsets are measured in metric tons of carbon dioxide-equivalent (CO_2e). One carbon offset represents the reduction of one metric ton of carbon dioxide, or its equivalent in other greenhouse gases.

paleoclimate - is the study of climate change taken on the scale of the entire history of Earth. It uses records from ice sheets, tree rings, sediment, and rocks (including fossils) to determine the past state of the climate system on Earth.

parts per million (ppm) - units used to measure concentrations of trace gases. Values refer to the number of specified molecules contained in one million molecules of dry air.

permafrost - in geology, permafrost or permafrost soil is soil at or below the freezing point of water (0 °C or 32 °F) and that stays that way for a minimum of two or more years.

photosynthesis - is a metabolic pathway that converts carbon dioxide into organic compounds, especially sugars, using the energy from sunlight.

polyp - polyps are approximately cylindrical and look a bit like an upside down jellyfish. The base end is attached either to the substrate by means of a disc-like holdfast if the polyp is solitary (such as mushroom corals), or is connected to other polyps, either directly or indirectly, if the polyp is part of a colony (such as in most larger corals). The oral end bears the mouth, and is surrounded by a circle of tentacles.

proxy data - data that paleoclimatologists gather from natural recorders of climate variability (e.g. tree rings, ice cores, fossil pollen, ocean sediments, coral and historical data). By analysing records taken from these and other proxy sources, scientists can extend our understanding of climate far beyond the 140 year instrumental record.

resilient - the ability to return to original form after disturbance, adversity, illness. In terms of the Reef this refers to the ability to regenerate to a healthy or nearly healthy state after cyclones, disease, bleaching and other forms of damage.

respiration - the process within living cells that releases CO_2 and water when organic compounds combine with oxygen and break down.

run-off - the water from rain or irrigation that flows over the land surface and is not absorbed into the ground, instead flowing into streams and in some cases, out to the reef.

sustainability - in an ecological context, sustainability can be defined as the ability of an ecosystem to maintain ecological processes, functions, biodiversity and productivity into the future.

symbiotic relationship - close ecological relationship between the individuals of two (or more) different species where both species benefit in some way.

threatened species - species are classified as threatened if they are listed as 'Critically Endangered', 'Endangered' or 'Vulnerable' by the International Union of the Conservation of Nature (IUCN) or a similar system operating at a national scale.

tipping point - the culmination of a build-up of small changes that effects a big change.

turbidity - a measure of the degree to which the water loses its transparency (ie looks "murky") due to the presence of suspended particulates.

vulnerable species - a vulnerable species is a species which is likely to become endangered unless the circumstances threatening its survival and reproduction improve.

water cycle - the cycling of water among oceans and lakes, land, living organisms, and the atmosphere.

water vapour - the gaseous state of water.

weather - the state of the atmosphere at a particular place and time.

zooxanthellae - microscopic dinoflagellates (algae) that live inside the tissues of larger animals, mostly marine animals such as corals, anemones and giant clams.